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FORSKNINGSSTRATEGI FÖR MILJÖTEKNIK

Redovisning av regeringsuppdrag till Formas och VINNOVA

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VINNOVAs uppgift är att ***främja hållbar tillväxt*** genom finansiering av ***behovsmotiverad forskning*** och utveckling av ***effektiva innovationssystem***.

Genom sitt arbete ska VINNOVA tydligt bidra till att Sverige utvecklas till ett ledande tillväxtland.

I serien VINNOVA Policy publiceras material som återger VINNOVAs synpunkter och ställningstagande i olika frågor. Det kan röra strategiskt viktiga remissvar, regeringsuppdrag, verksamhetsplanering eller andra dokument där VINNOVA gör policymässiga ställningstaganden.

Forskning och innovation för hållbar tillväxt.

Forskningsstrategi för miljöteknik

Redovisning av regeringsuppdrag till Formas och VINNOVA

2007-02-01

Förord

Forskningsrådet Formas och VINNOVA har på uppdrag av regeringen utarbetat en gemensam forskningsstrategi för miljöteknik. Denna rapport redovisar bakgrund, utgångspunkter och överväganden för strategin. Vidare redovisas förslag till strategiska åtgärder och satsningar i Formas och VINNOVAs egna verksamheter samt i samverkan med andra aktörer. Förslagen är inriktade mot miljöteknikområden med stor tillväxtpotential.

Syftet med forskningsstrategin är att ta ett samlat grepp om forskning och utveckling av miljöteknik inom Formas och VINNOVAs verksamhetsområden. Strategin avser att främja framtagandet av ny kunskap och stärka kompetensen inom miljöteknikområdet och främja svensk konkurrenskraft på den globala marknaden för miljöteknik.

Formas och VINNOVA i denna strategi valt att utgå ifrån en vid definition av miljöteknik:

> *Miljöteknik innefattar sådana produkter, system, processer och tjänster som ger tydliga miljöfördelar i förhållande till befintliga eller alternativa lösningar sett i ett livscykelperspektiv.*

Definitionen omfattar inte bara teknik och tekniska system i sig, utan även ett helhetstänkande kring hela tillförselkedjor till och med återvinning eller hantering av restprodukter, d v s hela livscykeln. Definitionen ligger i linje med definitionen i EU:s ETAP (An Environmental Technologies Action Plan for the European Union). Med denna breda ansats förskjuts fokus från produkter mot hela system, resurseffektivitet och hållbar utveckling. Miljöteknik omfattar med denna definition många kunskapsområden och tekniker, och berör många aktörer.

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Sammanfattning

Forskningsrådet Formas och VINNOVA har fått i uppdrag av regeringen att utarbeta en gemensam forskningsstrategi för miljöteknik. I föreliggande rapport redovisas bakgrund, utgångspunkter och överväganden för strategin. Vidare redovisas förslag till strategiska åtgärder och satsningar inom Formas och VINNOVAs verksamhetsområden, också i samverkan med andra aktörer.

Syftet med forskningsstrategin är att ta ett samlat grepp om forskning och utveckling av miljöteknik inom Formas och VINNOVAs verksamhetsområden. Strategin avser att främja framtagandet av ny kunskap och stärka kompetensen inom miljöteknikområdet och främja svensk konkurrenskraft på den globala marknaden för miljöteknik. En gemensam vision är formulerad.

Vision

> *Sverige är internationellt konkurrenskraftig i utveckling av produkter, system, processer och tjänster som möter höga krav på resurseffektivitet och miljöprestanda för hållbar utveckling och tillväxt.*

Visionen ställer krav på att kompetens med avseende på miljöaspekter och resurseffektivitet har utvecklats. Behov och efterfrågan på marknaden, d v s användares val och preferenser, måste beaktas. Vidare krävs att helhetssyn och systemaspekter varit vägledande för insatserna.

Formas och VINNOVA har valt en vid definition av miljöteknik, i linje med definitionen i EUs miljöhandlingsprogram ETAP.

Definition

> *Miljöteknik innefattar sådana produkter, system, processer och tjänster som ger tydliga miljöfördelar i förhållande till befintliga eller alternativa lösningar sett i ett livscykelperspektiv.*

Med denna breda ansats förskjuts fokus från produkter mot hela system, resurseffektivitet och hållbar utveckling. Miljöteknik omfattar med denna definition många kunskapsområden och tekniker, och berör många aktörer. De förslag som lämnas här avser inte att ta upp eller diskutera prioriteringar i de program som bedrivs av andra forskningsfinansiärer, men tar upp möjlig samverkan med andra aktörer.

Förslagen

I. Ökat fokus på miljöteknik i forskning

Miljöteknisk forskning lyfts fram och synliggörs tydligare i Formas och VINNOVAs verksamhetsområden. Vidare bör behov av och förutsättningar för forskning hos och i samarbete med små och medelstora företag (SMF) särskilt uppmärksammas.

Nya miljötekniska satsningar ska präglas av en helhetssyn med inriktning mot systeminnovationer och systemlösningar med hög miljörelevans. De ska också präglas av en öppenhet för frågeställningar som har svårt att finna finansiering inom dagens forskningsprogram. Hög prioritet ska ges åt livscykeltänkande.

Förslag 1

Främja miljöteknikforskning över disciplin-, teknik- och branschgränser genom finansiering av:

- tvärdisciplinär och gränsöverskridande forskning med hög vetenskaplig kvalitet och hög miljörelevans, som även inkluderar
- samhällsvetenskaplig forskning, som ger kunskap om behov, marknader, användarpreferenser, regelverk, styrmedel mm i ett europeiskt och globalt perspektiv

Förslag 2

Öka möjligheterna för SMF att medverka i och samfinansiera innovativa projekt med hög miljörelevans genom att:

- I finansiering av miljöteknikforskning skapa möjligheter att inkludera demonstration av tekniken, i synnerhet när SMF medverkar i projekten.
- Stödja forskning kring vidareutveckling av metoder och verktyg för hållbar produktframtagning med särskild inriktning mot behov hos SMF.
- Ställa forskningsresurser till förfogande till SMF, genom samverkan med industriforskningsinstitut, en fortsatt satsning på program av såsom Forska&Växa samt samverkansprogram såsom Formas-BIC.

II. Satsning på svenska styrkeområden

I det svenska innovationssystemet har sex styrkeområden identifierats:

- *Hållbart samhällsbyggande:* mer övergripande områden som hållbara byggnader och renoveringar samt hållbara städer (Sustainable Buildings, Sustainable Renovation och Sustainable Cities), samt mer specifika teknikområden som byggsystem för trä, styr- och övervakningssystem, samt tekniker för lokal energiförsörjning.
- *Hållbara transporter* – fordon, trafiksystem, logistik – nya motorer och ny teknik för framdrivning, nya drivmedel, teknik och system för

kollektivtrafik och sjöfart, samt nya metoder och system för effektiva och mellan olika transportslag samordnade transporter.

- *Miljöskyddsteknik:* rening av vatten och avlopp, rökgasrening, marksanering, avfallshantering och återvinning – genom samverkan mellan samhälle, forskning och företag finns det goda möjligheter att främja utveckling och export, och inte minst demonstrera goda exempel.
- *Användande av biologiska naturresurser:* nya processer för att ta tillvara flera komponenter och/eller energi på ett effektivt sätt, nya material från förnybara råvaror, nya funktionella kompositer, yt- och barriärmaterial, förpackningar och smörjmedel).
- *Lätta och avancerade material:* många tillämpningsområden, t ex i applikationer där vikten är av betydelse för energi- eller bränsleförbrukning, material som ger lite avfall eller kan återvinnas, samt avancerade material för t ex elektronik, medicinteknik, solceller och sensorer. Även här har nya processer för effektivare produktion betydelse.
- *Energi*: ny teknik för energitillförsel - solel, vindkraft, fjärrvärmeteknik, biobränsleteknik, bioraffinaderier för bränsleproduktion - och teknik för effektivare energianvändning - som effektiva industriella processer, effektiv byggnadsteknik och belysningsteknik mm. Ansvaret för forskningen ligger för detta område på Energimyndigheten, men samverkan bör eftersträvas.

Förslag 3

För var och ett av dessa styrkeområden utarbetas konkreta forsknings- och utvecklingsinsatser med avseende på bl.a. prioriterade delområden, systemaspekter och tvärvetenskap.

Insatserna ska utgå från en brett förankrad vision och utvecklingsstrategi för respektive område, vilket också bör resultera i prioritering och fokusering av den samlade nationella insatsen. Förnyelse- och innovationspotential, forskningspotential, affärspotential och miljövärde är viktiga parametrar i sammanhanget. De nyligen utarbetade branschprogrammen, som berör flera av styrkeområdena, ska också beaktas.

- Möjligheterna till finansiering från EU:s ramprogram identifieras inom ramen för varje utvecklingsstrategi. Medfinansieringsfrågan utreds för respektive område. Den av VINNOVA nyligen presenterade EU-strategin kan utgöra ett verktyg för att förstärka Sveriges position.
- Identifiera sådana produkter och tjänster inom området som lämpar sig för s.k. innovationsupphandling, varmed menas offentligt köp av varor eller tjänster som ännu inte existerar eller som behöver förbättras och således förutsätter forskning och innovation för att uppfylla specifikationerna.
- Frågor om regleringar, standarder, miljönormer, byggnormer, skattefrågor etc som har betydelse för utvecklingen inom respektive område identifieras och förs vidare till ansvariga organ.

III. Samverkan för forskning om miljöteknik

Ett flertal aktiviteter och projekt med avseende på miljöteknik och angränsande områden pågår för närvarande hos olika aktörer som har i uppdrag att verka för hållbar utveckling. En ökad samverkan mellan dessa myndigheter, forskningsfinansiärer, näringsliv och andra aktörer är därför av stort värde.

Förslag 4

Tillsammans med berörda myndigheter, forskningsfinansiärer och andra aktörer:

- utveckla forsknings- och utvecklingsinsatser med avseende på styrkeområden enligt förslag 3
- utveckla samarbetet mellan berörda aktörer, t ex i form av att generera gemensamma, tvärgående forskningssatsningar
- utarbeta vision och utvecklingsstrategi för miljöteknik för hela värdekedjan enligt förslag 3
- främja internationella forskningssamarbeten dels inom Norden, med länder i Baltikum och inom EU, men också globalt med länder med stora eller potentiellt stora marknader
- tillse att gränsdragning mellan myndigheter vid behov modifieras så att alla viktiga delar av miljöteknikområdet täcks in

1 Inledning

Forskningsrådet Formas och VINNOVA har fått i uppdrag av regeringen att ta fram en gemensam forskningsstrategi för miljöteknik. Denna strategi ska bland annat ligga till grund för att finna gemensamma samverkansområden mellan Formas och VINNOVA.

Denna rapport redovisar bakgrund, utgångspunkter och överväganden för strategin. Vidare redovisas förslag till strategiska åtgärder och satsningar i Formas och VINNOVAs egna verksamheter samt i samverkan med andra aktörer. Förslagen är inriktade mot miljöteknikområden med stor tillväxtpotential.

1.1 Uppdraget

Formas och VINNOVA har i sina regleringsbrev för 2006 fått i uppdrag att

> *tillsammans utarbeta en forskningsstrategi för miljöteknik i samråd med näringslivet och andra berörda aktörer. Förutsättningarna för samfinansierad forskning mellan staten och näringslivet skall belysas samt hur små och medelstora företags medverkan skall kunna underlättas. Strategin skall beakta de prioriteringar som finns i ETAP samt möjligheterna till samverkan med Sveriges miljöteknikråd - SWENTEC och Nuteks program för miljödriven affärsutveckling. Forskningsstrategin skall redovisas till regeringen senast den 1 november 2006.*

Inlämningsdatum har senare ändrats till den 1 februari 2007. I forskningspropositionen Forskning för ett bättre liv, 2004/5:80, anges att särskilda medel ska avsättas för gemensamma forskningsinsatser, total 45 miljoner kronor för år 2007 och 2008.

1.2 Genomförande

Arbetet har haft en styr-/samordningsgrupp bestående av representanter från Formas (Hans-Örjan Nohrstedt och Conny Rolén) och VINNOVA (Lars Wärngård och Anna Hallgren). En arbetsgrupp bestående av Anna Hallgren, Conny Rolén och Leif Magnusson, Energia AB har haft det operationella ansvaret för framtagandet av strategin.

Två större workshops/seminarier har genomförts där representanter från forskning, näringsliv, myndigheter och organisationer medverkat. Syftet

med dessa möten har varit att inhämta synpunkter från berörda aktörer om inom vilka områden forskningsbehovet är störst och i vilka former forskningen bör ske. I samband med den första workshopen initierades ett 15-tal ”fokusgrupper” med uppgift att diskutera forskningsbehov och inleda forskningssamarbeten inom olika delområden. I fokusgrupperna har medverkat såväl forskare från universitet och högskolor som representanter för företag och organisationer. Formas och VINNOVAs arbetsgrupp har vidare vid flera tillfällen haft andra möten med myndigheter, forskningsfinansiärer, forskare, företag och andra intressenter. Bland annat har ett samlat möte med myndigheter och forskningsfinansiärer hållits.

Ett antal uppdrag har lagts ut för att ge underlag till strategiarbetet. ITPS (Tokyo) har inom ett uppdrag beskrivit japansk forskningsstrategi inom miljöteknikområdet. En översikt genomförd av ITPS (Washington) över miljöteknikens läge i USA har också använts som underlag.

IVL har haft i uppdrag att studera bl.a. miljöteknikens drivkrafter i stora växande ekonomier med fokus på Kina, Indien och Brasilien.

En intervjuundersökning om svenska företags syn på utmaningar, behov och viktiga insatsområden inom miljötekniken har genomförts av inno Scandinavia AB.

Som bakgrund och underlag till det nuvarande strategiarbetet har slutsatser och förslag i den nationella innovations- och forskningsstrategi för området miljödriven teknikutveckling, som VINNOVA år 2003 utarbetade i samverkan med andra forskningsfinansiärer och berörda myndigheter (redovisat i VP 2003:4), använts. Parallellt med framtagandet av VP 2003:4 tog NUTEK fram en strategi för miljödriven näringslivsutveckling, vilken också har utgjort underlag för arbetet.

2 Utgångspunkter

2.1 Vad är miljöteknik?

Inom miljöteknikområdet har man gått från ett tidigare fokus på att minska ofta lokala utsläpp till att rikta uppmärksamheten mer mot globala problem och hållbar utveckling. Idag handlar åtgärder för bättre miljö mer om effektivare användning av resurser och att minska användningen av miljö- och hälsoskadliga ämnen. Stora delar av västvärlden befinner sig i denna fas. Däremot har många av de snabbt växande ekonomierna, som Kina, Indien och flera länder i Östeuropa, liksom jordens fattiga länder, fortfarande stora behov av rening av rökgaser från uppvärmning, tung industri och fordon samt rening av avlopp, åtgärder som i stor utsträckning är genomförda i rika delar av världen.

Miljöteknik i meningen teknik som renar avgaser/utsläpp till luft, vatten och avlopp, eller behandlar eller oskadliggör olika typer av restprodukter eller avfall är etablerade branscher med stor internationell marknad, med ett flertal svenska aktörer. Här finns behov av fortsatt utveckling mot ökade prestanda och det är angeläget att tekniken kommer till användning i utvecklingsländer.

Lagstiftning och politik har stor betydelse som drivkraft för utvecklingen av ny teknik med bättre miljöegenskaper, men den allmänna teknikutvecklingen drivs i hög grad av efterfrågan på olika marknader där flera andra faktorer än miljö har stor vikt:

- bränsleförbrukning har betydelse vid val av fordon, men fordon väljs ofta för utseende, prestanda, säkerhet och bekvämlighet. Stimulanser har dock givit starkt ökad försäljning för miljöfordon
- miniatyrisering och krav på ökade prestanda driver på mot minskad strömförbrukning i apparater och elektronik vilket innebär minskad miljöbelastning, men drivkraften i utvecklingen har varit andra typer av prestanda eller lägre kostnad för utveckling och produktion
- ”digitala papper”, kommunikationsteknik, bredbandsinternet, mobilt internet ger fördelar i snabb åtkomst till information och på sikt minskat pappersbehov för tidningar, reklam och kontor (men ökat välstånd och ökad datoranvändning i växande och folkrika ekonomier leder å andra sidan till ökad papperskonsumtion)
- fjärrövervakning och styrning av utrustningar med hjälp av datorer och kommunikationsteknik som avser minska kostnader och förbättra drift minskar samtidigt energibehov och resor för personal

- komfort, status och bekvämlighet spelar stor roll vid utformning av byggnader – trots effektivare ny teknik finns en utveckling mot högre energianvändning i bostäder och lokaler som en följd av ökande ytor, stora glaspartier, luftkonditionering och golvvärme för komfort.

Exemplen illustrerar att ny och utvecklad teknik kan leda till såväl miljöfördelar som ökad miljöbelastning. Även om andra funktionskrav oftast är styrande tas det i allt högre grad hänsyn till miljöaspekterna vid all teknikutveckling.

Att definiera vad som är miljöteknik är inte en självklarhet. Teknik som utvecklats direkt för att minska påverkan på miljö och hälsa, som reningsutrustningar eller förnybar energiteknik, är självfallet miljöteknik. Men även teknik som utvecklats för att möta efterfrågan på exempelvis transporter eller bekvämt boende, och som samtidigt innebär minskad resursförbrukning eller minskade utsläpp av skadliga ämnen, kan sett i ett helhetsperspektiv få stor betydelse för att minska påverkan på miljön även om andra utgångspunkter varit de drivande för utvecklingen.

En viktig roll för ökad användning av miljöteknik ligger hos slutanvändare/konsument. Behov och efterfrågan på produkter, tjänster och system driver utvecklingen mot ökad miljöbelastning. En alltmer ökad insikt om globala miljöfrågor driver samtidigt krav på ett långsiktigt uthålligt samhälle. Människors val och värderingar har därför stor betydelse. Det behövs nya kompetenser hos alla aktörer i ett innovationssystem för att tillgodose alla behov – från kundpreferenser, produktionsfaktorer, affärslogiker till resurssnåla systemlösningar.

Tjänstesektorn har en stor och ökande roll i svenskt näringsliv liksom i alla industriländer. Tjänster kan innebära betydande affärsmöjligheter på miljödrivna marknader och ingår i ökande omfattning i svenska system och produkter, inte minst i utvecklingen mot ökad förädling i näringslivet. En typ av tjänst som länge förts fram inom miljödiskussionen är funktionsförsäljning som innebär att en leverantör i ställer för en produkt säljer en funktion, t.ex. förflyttning i stället för ett fordon.

Med alltmer öppnade gränser och samspel i globala tillförselkedjor handlar det inte bara om att utveckla produkter och tjänster utan även om förutsättningar att finna nya resurseffektiva och miljövänliga lösningar för hela system, på ett sätt som passar olika marknader. Man brukar tala om att det handlar om att det behövs ”systeminnovationer”, om att finna helt nya sätt att åstadkomma önskade nyttigheter eller funktioner.

Den starka kopplingen mellan individer och olika institutioner i samhället innebär att det kan krävas förändringar i de mjuka systemen i form av ”institutionella innovationer”. För att introducera nya lösningar på

marknaden kan det krävas förändringar såväl i samhällssystemen som i tänkesätt.

Sammantaget kan det konstateras att ny teknik ofta ger betydande effektiviseringar och minskad energianvändning, men att den också kan innebära ny typ av efterfrågan med nya energibehov och nya risker för miljöpåverkan. Ökat välstånd leder till ökad konsumtion av resor, varor samt livsmedel som transporteras lång väg. Detta understryker behovet av helhetsperspektiv och systemtänkande i forskning och utveckling av all ny teknik och att miljöaspekter då alltid beaktas.

2.2 Definition av miljöteknik

Utifrån ovanstående resonemang har Formas och VINNOVA i denna strategi valt att utgå ifrån en bred ansats och en vid definition av miljöteknik:

> *Miljöteknik innefattar sådana produkter, system, processer och tjänster som ger tydliga miljöfördelar i förhållande till befintliga eller alternativa lösningar sett i ett livscykelperspektiv.*

Definitionen omfattar inte bara teknik och tekniska system i sig, utan även ett helhetstänkande kring hela tillförselkedjor till och med återvinning eller hantering av restprodukter, dvs hela livscykeln. En sådan definition av miljöteknik är helt i linje med definitionen i EU:s ETAP (An Environmental Technologies Action Plan for the European Union, COM(2004) 38 final):

> *”Miljöteknik – som i denna handlingsplan omfattar all teknik som är mindre skadlig för miljön än tillgängliga alternativ – är ett sätt att uppnå detta. Dit hör teknik och processer för att begränsa föroreningar (t.ex. kontroll av luftföroreningar och avfallshantering), mindre förorenande och mindre resursintensiva varor och tjänster, och metoder för effektivare resursförvaltning (t.ex. vattenförsörjning och energisparteknik). Denna definition innebär att miljötekniken genomsyrar alla ekonomiska verksamheter och sektorer.”*

Definitionen i ETAP utgår i sin tur från definitionen av ”environmentally sound technologies” i Agenda 21. Där anges (citerat ur ETAP):

> *”att miljöanpassad teknik skyddar miljön, är mindre förorenande, utnyttjar alla resurser på ett mer hållbart sätt, återvinner en större andel av det avfall och de produkter som den ger upphov till och hanterar restavfall på ett bättre sätt än den traditionella teknik som den ersätter. Miljöanpassad teknik*

kan också vara process- och produktteknik som ger upphov till små mängder avfall eller inget avfall alls, och därmed förebygger föroreningar. Den omfattar också processextern teknik för avskiljning av föroreningar efter det att de har bildats. Den miljöanpassade tekniken utgörs inte bara av enskilda metoder, utan kan även vara hela system som omfattar know-how, förfaranden, varor och tjänster, utrustning samt organisatoriska rutiner och ledningsrutiner"

Med den breda ansats för miljöteknik som används i denna strategi förskjuts fokus från produkter och apparater mot hela system, resurseffektivitet och hållbar utveckling.

3 Teknik för en global marknad

Sverige är en liten aktör när det gäller marknad och miljökrav. Regleringar, styrmedel och marknadskrav formuleras i stor utsträckning av EU och av en global marknad samt genom internationellt samarbete. Sverige anses dock vara en internationellt viktig miljöpolitisk nation.

Vägledande för förslaget till strategi är att det i hög grad är miljöteknik för en global marknad som bör vara i fokus. Den svenska marknaden är liten, men Sverige kan öka sin marknadsandel internationellt genom framsynta statliga insatser, genom lagstiftning/regleringar, stimulanser, styrmedel, samhällelig upphandling med hänsyn till miljöprestanda samt genom stöd till forskning och utveckling. Den inhemska marknaden kan också utgöra en viktig möjlighet för små och medelstora företag att etablera sig och sin teknik inför större internationella satsningar. Ett samspel mellan aktörer i Sverige på en nationell arena kan innebära möjligheter till prov, utvärdering och introduktion av teknik inför en introduktion på andra marknader.

För att utveckla innovationer för en internationell marknad krävs kunskaper om förutsättningar på andra marknader med avseende på kunders och användares förhållningssätt och preferenser i olika länder och kulturer, om nationella regelverk och styrmedel och hur de fungerar, och om samspelet mellan individuella och samhälleliga drivkrafter och mellan olika aktörer i hela kedjan från naturresurs till slutanvändning.

3.1 Globala perspektiv

Efterfrågan på miljöteknik är starkt växande på den globala marknaden. Det gäller såväl med den vida innebörden av miljöteknik som med den mer avgränsade med reningsteknik, avfallshantering och återvinning. Stora frågor i ett globalt perspektiv är klimat, övergödning och gifter från avlopp, emissioner till luft från trafik/värme- och elproduktion, brist på rent vatten, förlust av biologisk mångfald och förlust av odlingsbar mark (p g a erosion, försaltning och ökenutbredning) samt miljögifter använda inom jordbruk och i varor.

Det finns flera starka drivkrafter till att miljötekniken växer sig starkare.

- Klimatfrågan som är ett globalt problem får stor uppmärksamhet idag, inte minst politiskt. Många länder har i Kyotoöverenskommelsen åtagit sig att genomföra olika åtgärder för att minska utsläppen av växthusgaser.

- En annan fråga som har fått stor uppmärksamhet är trygg energiförsörjning. För att minska riskerna, och för att minska utsläpp av växthusgaser, innehåller energipolitiken i EU, USA och Japan kraftfulla satsningar på förnyelsebar och uthållig energitillförsel – från sol, vind, vågor och bioenergi – liksom satsningar på effektiviseringar hos användare.
- Den snabba ekonomiska tillväxten, befolkningstillväxten och urbaniseringen skapar i många regioner akuta problem med luftföroreningar, utsläpp till vatten samt övergödning och därmed mycket stora behov att investera i reningsanläggningar, avfallshantering m.m.
- Agenda 21 pekar även mot andra mycket stora globala problem – bland annat fattigdom som hinder för utveckling samt brist på rent vatten i stora delar av världen. Många pekar på att det behövs genomgripande omställningar för att klara utmaningarna.
- Miljögifter, så som tungmetaller, klorföreningar, läkemedelsrester mm, innebär fortfarande stora hot även om framgångsrika åtgärder i industriländer har minskat exponeringen av många ämnen i bl a konsumtionsvaror och livsmedel. Det finns också behov av mycket omfattande åtgärder för att sanera mark från nedlagd miljöfarlig industri i hela världen.
- Ny teknik öppnar för helt nya lösningar inom många områden. Miniatyrisering kan ge möjligheter till minskad energiförbrukning, och IT och kommunikationsteknik ger verktyg för effektiviseringar i många led i produktion och användning av teknik

Utmaningarna finns på många plan, inte bara relaterat till miljö och hållbarhet. För svenskt näringsliv och det svenska samhället innebär även globaliseringen av marknader och produktionssystem stora utmaningar. Lagar och regler formas i många viktiga avseenden i EU och det svenska handlingsutrymmet har begränsats. Produktionssystemen har blivit alltmer globala med specialisering och masstillverkning i länder med gynnsamma förutsättningar. Många traditionella svenska stora företag ingår nu i internationella koncerner.

Insikten om miljöproblemen och de stora utmaningarna har drivit fram samhälleliga åtgärder på ett internationellt, nationellt och lokalt plan, som i Kyoto-överenskommelsen, genom avgaskrav på fordon, genom europeiska insatser i olika direktiv och regelverk, och genom nationella krav. Det handlar även om många andra styrmedel som exempelvis påverkar genom normer och standarder, genom att förändra relativpriser eller genom att underlätta marknadsintroduktion.

Likaså är människors oro för tillståndet för natur, klimat och miljö en stark drivkraft för att individer ska välja med utgångspunkt från miljö och hållbarhet. Det gäller i deras olika roller som köpare och användare av

produkter och system, i företag och myndigheter. Såväl samhällsåtgärder som individers/ företags/myndigheters val skapar efterfrågan på miljöprestanda.

3.2 EU

3.2.1 Allmänt

EU har en gemensam miljöpolitik i det nu aktuella sjätte miljöhandlingsprogrammet som innehåller ramdirektiv och som pekar ut områden, riktlinjer och övergripande projekt. Prioriterade frågor är klimatfrågan, natur och biodiversitet, miljö och hälsa, samt resursanvändning och avfall. Det finns däremot ännu inga gemensamma regler om miljöskatter och –avgifter.

Miljöhandlingsprogrammet anger sju så kallade tematiska strategier, som kommer att vara en tung del av implementeringen av programmet. Två av dessa är ”hållbara produktionsmönster” samt ”hållbar användning av och förvaltning av naturresurser samt återvinning”. Inte minst dessa två kommer att vara av vikt för svensk teknikutveckling. Inom hållbara produktionsmönster vill man förbättra samarbetet med företag och uppmuntra till innovation av produkter. IPP, Integrated Product Policy är en del av detta område. IPP bygger på ett livscykelperspektiv, och avser att inbegripa många områden som: produktionsmetoder, transporter, handelsregler och miljöstyrning.

Inom hållbar användning och förvaltning av naturresurser samt avfall ingår bland annat främjande av utvinnings- och produktionsmetoder och teknik för att stödja eko-effektivitet, genom bland annat forskning och tekniköverföring. För att förebygga avfall vill man satsa på miljövänlig och hållbar produktdesign.

Miljöteknik berörs även i direktiv om kemikalier samt elektriska och elektroniska produkter, som tar upp frågor om användning av olika kemikalier och substanser och producenternas ansvar för miljö, hälsa och omhändertagande av avfall.

För att minska utsläppen av växthusgaser inom energiproduktion och transporter söker EU uppmuntra användningen av förnybara bränslen och fossila bränslen med lägre kolhalt. En mekanism för att påskynda utvecklingen är det gemensamma systemet som sätter tak för utsläpp av koldioxid samt innebär ett system för handel med utsläppsrätter. Vidare har mål satts upp för ökad användning av förnybar elproduktion, användning av biobränslen och biodrivmedel. Energieffektivitet i byggnader är också ett utpekat område.

3.2.2 ETAP, Environment Technology Action Plan

ETAP, den gemensamma handlingsplanen för miljöteknik, syftar till att utnyttja teknikens möjligheter att minska trycket på naturens resurser, förbättra livsmiljön samt stimulera tillväxt. Målen är att undanröja hinder, att EU ska ta en ledande roll i utvecklingen av miljöteknik och att samla alla aktörer. En grund för planen är det sjätte miljöhandlingsprogrammet, liksom en vid definition av miljöteknik, se kapitel 2.

ETAP omfattar 28 åtgärder (s k actions) att genomföra för kommissionen, medlemsländer samt ett antal andra aktörer och gemensamma organisationer på EU-nivå. De är indelade i tre huvudområden:

a) att gå från forskning till marknad,
b) att förbättra marknadsvillkoren, samt
c) att agera globalt.

Merparten av alla åtgärder berör främjande av miljöteknik, medan forskning och utveckling främst tas upp i de första tre: ökad och fokuserad forskning, demonstration och tekniskspridning, koordinering av insatser, etablering av ”teknikplattformar” i sjunde ramprogrammet samt utveckling av gemensamma standarder och normer.

3.2.3 Forskning i det sjunde ramprogrammet

Miljöteknik och miljöfrågor berörs inom många av delprogrammen i det sjunde ramprogrammet för forskning, teknikutveckling och demonstration under åren 2007 - 2011. Tydligast tas miljötekniken upp i ett av delprogrammen, ”Environment (including Climate Change)”, men då främst i form av den direkta miljötekniken, som reningsteknik. Dock har frågor kring miljö och uthållighet stor plats i motiven till ett flertal program. Det gäller i synnerhet energiprogrammet, men även program som tar upp transportteknik, ny produktionsteknik, biovetenskaper och användning av råvaror från skog och jordbruk m.fl. Likaså ger satsningarna inom informationsteknik och kommunikationsteknik samt inom nanoteknik nya verktyg och möjliggörande tekniker som kan bidra till effektiviseringar i alla led av framställning och användning av ny teknik.

3.2.4 Möjligheter för Sverige – men behov av motfinansiering och nationell samverkan

En självklar följd av utvidgningen av EU är att den inre marknaden har växt starkt, inom alla områden. Det gäller särskilt för den direkta miljötekniken och energiförsörjningen eftersom det finns ett stort behov av utbyggnad av infrastruktur i länderna runt Östersjön och Östeuropa. Sett ur ett FoU-perspektiv innebär utvidgningen nya möjligheter till samarbeten både för forskning och svenska företag.

Samtidigt aktualiserar detta behovet av att motfinansiera EU-stöd med svenska forskningsmedel och samordning av svenska insatser, för att göra det möjligt att delta i forskningssamarbeten och i utvecklingsprojekt. Detta gäller exempelvis inom reningsteknik och bioenergi där svenska företag i många fall är för små för att kunna delta i internationella FoU-projekt eller i internationella anläggningsprojekt. Flera av dessa områden kan omfattas av den av VINNOVA nyligen presenterade EU-strategin.

3.3 USA

Enligt en översikt framtagen av ITPS konstateras att det idag sker en stark tillväxt inom det som kallas Clean Tech, bland annat inom energiteknik, materialteknik, processteknik, samt etablerad mogen industri inom den direkta miljötekniken. Clean Tech omfattar både direkta reningstekniker och ny teknik med höga miljöprestanda inom exempelvis energiteknik. USA är också ledande inom många grundläggande vetenskapsområden av central betydelse för utveckling av miljöteknik.

Fortfarande gäller att tillförselsäkerhet ges stor vikt i satsningar på ny energiteknik, även om klimatfrågan i synnerhet på delstatsnivå fått ökad vikt. I linje med detta sker en stark satsning på transportområdet, minskat fossilberoende och ökad effektivitet.

Några slutsatser från rapporten är att:

- det sker en utveckling mot tjänster i resurshantering snarare än tekniktjänster, inom t.ex. avfall och den direkta miljötekniken
- marknadsbaserade mekanismer får en ökad roll
- en stark drivkraft är att ny teknik ger nya möjligheter till teknik med minskad resursförbrukning, förnybar elproduktion eller minskade emissioner
- det finns en ökande medvetenhet hos företag och individer som driver på utveckling av miljöteknik i bred mening

En allmän beskrivning av förutsättningar med avseende på miljöteknik i USA gavs i en bilaga till VP 2003:4, sammanställd av ITPS i Los Angeles. Drivkrafterna på miljöområdet från federal nivå i USA kan till stor del kopplas till strävanden efter ett minskat oljeberoende och en ökad ekonomisk tillväxt. Samtidigt konstateras att miljöpolitik på federal nivå inte har lika hög prioritet som i Sverige och att satsningarna främst styrs av önskan om säkrare energitillförsel.

På både federal och delstatlig nivå finns det dock många exempel på program som på olika sätt stödjer investeringar i miljövänlig teknologi, särskilt lösningar som innebär energieffektiviseringar eller tillämpning av förnyelsebara energikällor, vindkraft, solenergi, biobränslen.

Rapporten gjorde bedömningen att svenska företag har stor möjlighet att exportera miljöteknik och erfarenheter till USA inom områden som exempelvis:

- energieffektiva produkter, exempelvis vitvaror
- förnyelsebara bränslen för transport och energiproduktion
- miljödesign (även allmän svensk design, IKEA och HM har exempelvis stora framgångar)
- miljövänliga material (exempelvis trä, också här är IKEA ett bra exempel)
- resurseffektivisering, återvinning och slutna kretslopp i tung processindustri
- återvinning, sammansatta tjänster inom avfallshantering samt marksanering
- säkerhet, arbetsmiljö och hälsa

3.4 Japan

3.4.1 Aktuell forskning och utveckling inom miljöteknik enligt studie av ITPS

ITPS har på uppdrag av Formas och VINNOVA beskrivit strategier för forskning inom miljöteknik i Japan. Rapporten finns i sin helhet i bilaga 2, Research strategies on environmental technology in Japan.

Rapporten ger en grundlig genomgång av statligt finansierad miljörelaterad forskning som bedrivs under olika departement. Miljöforskningen har ökat kraftigt under de senaste åren. ”Environmental science” tillhör de fyra ”primära prioriterade områdena i den nya femårsplanen för forskning inom vetenskap och teknik. I området ingår bl.a. 3R (Reduce, Reuse and Recycle), utnyttjande av biomassa, klimatforskning samt risker och säkerhet förknippade med kemikalier.

Rapporten redogör också för insatser som görs för att främja tillämpning av tekniken, exempelvis i industriella klusterinitiativ, ”Eco-Towns”, samt ett initiativ för verifiering av information om miljöteknik som stöd för implementering och kommersialisering.

Slutsatser som dras i rapporten är att:

- miljöteknikmarknaden växer snabbt
- stora internationella framgångar för ny miljöteknik, som hybridfordon och solceller
- stor vikt ges till nydanande tekniker som nanoteknik
- starkt fokus på 3R och teknik för minskad klimatpåverkan

- ökad medvetenhet om internationellt beroende och att miljöfrågor måste lösas inom regionen och globalt
- Samarbeten mellan samhälle och näringsliv i bland annat Eco-Towns ges stor vikt i arbetet med införande och kommersialisering
- Sverige bör kunna dra lärdomar från Japan när det gäller att närma sig länder i Asien, både när det gäller marknader och att söka forskningssamarbete.

Även för Japan gavs en beskrivning av förutsättningar med avseende på miljöteknik i en bilaga till VP 2003:4. Hög befolkningstäthet och starkt beroende av importerad energi skapar behov av en övergång till mer hållbara lösningar, effektivare och renare teknik i produkter och i synnerhet i fordon, elproduktion och industriprocesser, minskade avfallsmängder och återvinning ur avfall, teknik för energiförsörjning. En stark exportindustri ser affärsmöjligheter i miljödrivna marknader. Drivkrafterna för miljösatsningar i Japan liknar i övrigt i många avseenden dem i Sverige.

De åtgärder som är aktuella liknar dem som genomförs eller diskuteras i Europa. Några skillnader som anges i rapporten är en kanske större teknikoptimism, en omfattande företagsdriven forskning, tydligare program för och uppföljning av resurseffektivitet i stora företag.

Sverige ligger sannolikt före Japan när det gäller återvinning, men det sker en stark utveckling där. Sverige ligger också före när det gäller insikt om konsumenters preferenser, användarbeteende och strukturella hinder för en hållbar utveckling. När det gäller samordning mellan miljöpolitik och FoU-satsningar förefaller det dock vara en starkare koppling i Japan.

Några slutsatser som drogs i rapporten är:

- Investeringar i miljörelaterad teknik anses vara en viktig tillväxtfaktor i Japan. Unika lösningar för en framtida grön marknad ses som en viktig konkurrensfaktor.
- Miljökvalitet är en stark drivkraft i det ökande forskningsstödet till institut och universitet. Det sker en ökad samordning och strategisk planering för statliga forskningssatsningar, med stor vikt vid klimat- och miljöaspekter.
- Staten arbetar aktivt för upphandling av gröna produkter och ny grön teknik enligt den nya lagstiftningen om miljöanpassad offentlig upphandling (exempel: introduktion av miljövanliga bilar och solceller).
- Även företag satsar allt mer på grön upphandling och på att införa miljökrav i tillförselkedjorna. Resurs- och materialeffektivitet utifrån ett livscykelperspektiv ges stor vikt i många företag.
- Konsumenternas efterfrågan på ”gröna” produkter är dock svag. Kunderna är inte beredda att betala mer, miljöprestanda är inte en konkurrensfaktor.

- Svensk miljöpolitik och miljöteknik är starka "varumärken" i Japan.

3.5 Stora, växande ekonomier – Kina, Indien, Brasilien

I en underlagsrapport från *IVL, Research, Development and Demonstration Strategies on Environmental Technology*, bilaga 3, redovisas aktuella frågeställningar kring tillväxt och miljö. Rapporten tar sin utgångspunkt i och beskriver situationen i tre exempel på stora växande ekonomier, Kina, Indien och Brasilien.

Gemensamt för dessa länder, och för många andra folkrika länder, är en stark omflyttning från landsbygd till städer. För att klara miljö och drägliga levnadsförhållanden för både stadsbefolkning och landsbygd kommer det att krävas en mycket omfattande utbyggnad av infrastrukturen: avloppsrening, försörjning med rent vatten, el, bostäder, samt vägar och kommunikationssystem.

En annan gemensam faktor som sätter starkt tryck på miljön är en snabbt ökande medelklass med växande välstånd. Den ökande konsumtionen av varor, nya konsumtionsmönster och det ökade innehavet av bilar kommer att sätta ett starkt tryck på miljön och på naturresurserna. Detta kan redan märkas i en ökad kinesisk aktivitet att säkra oljetillförsel och en ökad efterfrågan på metaller som exempelvis visat sig i ett ökat stålpris på världsmarknaden. För de tre länderna nämner rapporten bland annat:

3.5.1 Kina

- Stark satsning på forskning och industriell tillväxt
- Stor utbyggnad av infrastruktur pågår
- Snabbt växande medelklass
- Många företag ineffektiva, brister i miljöavseende
- Samtidigt ökande miljömedvetande, skärpt lagstiftning
- Barriärer mot utländska företag genom standarder, lagar
- Resursknapphet, stort tryck på marknader för olja, metaller (men goda tillgångar på kol som alternativ för el- och drivmedelsproduktion)

3.5.2 Indien

- Hårt tryck på markresursen, saltanrikning i bevattnad mark, växtgifter, övergödning i vatten
- Brist på rent dricksvatten, dåligt utbyggd avloppsrening
- Snabbt växande medelklass och konsumtion

3.5.3 Brasilien

- Liknande problem som Indien med högt tryck på mark, dåligt utbyggd rening och brist på rent vatten
- Stora klyftor, med både modern industri och rikedom, och många mycket fattiga människor

4 Svenska förutsättningar

Sverige har i flera avseenden goda förutsättningar för utveckling och tillväxt inom miljöteknik. Det finns en stark medvetenhet och stort intresse bland enskilda, i politiken, samt i lagstiftning och hos myndigheter. Sverige har varit ett av de länder som legat främst när det gäller olika åtgärder för att komma till rätta med utsläpp och med giftiga ämnen i produkter och i industriella processer. Sverige har varit pådrivande i det internationella arbetet.

Andra styrkefaktorer är att Sverige har:

- en etablerad industri direkt inriktad på miljöteknik, inom behandling av luft/avgas, vatten/avlopp, samt förnybar el- och värmeproduktion
- hög kunskap och kompetens, inom forskning, utbildning, myndigheter och företag

När det gäller miljöteknik i den vidare meningen har Sverige en stark position inom flera områden, med etablerad industri, forskning och utbildning. Ett exempel är området hållbara transporter. Vi har en stark fordonsindustri och ligger långt framme i utveckling och införande av förnybara drivmedel. Andra exempel är materialteknik i vid mening, där vi har både skogsindustri och stålindustri med hög förädling och en stark position på världsmarknaden, energiteknik där vi har en lång industriell tradition och även framgångsrik forskning inom nya energitekniker, samt byggande där Sverige har stor kunskap om inte minst byggande i kallt klimat och i fjärrvärmeteknik.

Men det finns också brister och svagheter i det svenska innovationssystemet både ur miljömässigt och ekonomiskt perspektiv. Den svenska hemmamarknaden är liten i ett internationellt perspektiv, och många av företagen inom reningsteknik, avfallsteknik och förnybar energi är små på världsmarknaden. Vi har inom många områden ett fåtal stora företag som dominerar och har tillgång till forskningsresurser samt har tillräckliga resurser för samarbete med akademisk forskning. En annan svaghet är att den industri som utvecklar processteknik för tunga branscher till stor del sålts, flyttat till andra länder eller avvecklats.

4.1 Möjligheter för Sverige

Vilka möjligheter finns det då för svenskt näringsliv inom miljöteknik på den internationella marknaden?

En naturlig utgångspunkt för en diskussion är de växande behoven och marknaderna som följer av en stark tillväxt i folkrika länder och de därav följande hoten mot miljö och klimat. Det handlar då dels om behov av infrastruktur och utrustningar för miljöteknik för rening av avlopp, vatten och avgaser – dels om resurs- och energieffektiv teknik generellt, inklusive förnybar energitillförsel.

Vilka områden vi ska satsa på i Sverige har diskuterats i flera sammanhang. Exempel på områden som nämnts vid sidan av den direkta renings- och miljöskyddstekniken är förnyelsebar elproduktion och värmeproduktion från biobränslen och avfall, samt förnyelsebara drivmedel och fordonsteknik för dessa.

I Teknisk Framsyn, både det ursprungliga projektet 1999 och i den andra omgången 2004, tas olika svenska styrkeområden upp. I syntesrapporten 2004 samt i underlagsrapporten ”Inspiration till innovation” nämns miljö- och livscykelteknologi och ett flertal områden inom energi- och materialteknik som områden med goda svenska förutsättningar. Miljö- och livscykelteknologi omfattar LCA-tänkande, design mot användare och produktion, produktion, teknik för miljösanering samt luftrening/vattenrening.

Ett pågående projekt som tar upp dessa frågor är IVA-projektet ”Miljöarbetets nya arena” med finansiering från Mistra och Naturvårdsverket. Projektet ”syftar till att lyfta resurs- och miljöfrågorna och sätta dem i ett brett och framtidsinriktat perspektiv som omfattar såväl globala som svenska miljöutmaningar. Detta görs genom att beskriva dagens och framtidens globala resursflöden och analysera hur dessa påverkar Sverige, såväl miljömässigt som ekonomiskt. Kartläggningar av Sveriges komparativa fördelar inom innovationssystem och FoU ska bidra till att svara på var och hur miljöentreprenörskapet kan utvecklas”.

I VINNOVA VP 2003:4 nämns bland svenska styrkeområden ”gröna material” och bioenergi, hållbara transporter, lätta och avancerade material samt hållbart samhällsbyggande, grundat på en diskussion kring svenska konkurrensfördelar.

Med utgångspunkter därifrån och från övriga studier, samt från det underlag som tagits fram inom det nu genomförda strategiarbetet, i underlagsrapporter och vid möten beskrivs nedan områden som kan bedömas ha goda möjligheter för svensk utveckling och fortsatt tillväxt.

4.1.1 Hållbart samhällsbyggande

Det finns en stor inhemsk och global marknad för ett hållbart samhällsbyggande med energieffektiva, resurssnåla och sunda

boendemiljöer och arbetsplatser. Sverige ligger långt framme och har goda kunskaper om system och komponenter för energieffektiva byggnader. Vi har också genom vårt klimat, miljö- och energimedvetna brukare, tradition samt regelverk en kunnig hemmamarknad och bra förutsättningar för att introducera ny teknik med bra miljöprestanda. Exempel på internationellt intressanta områden med goda svenska styrkor är systeminriktade områden som hållbara byggnader och hållbar renovering samt hållbara städer (Sustainable Buildings, Sustainable Renovation och Sustainable Cities), samt mer specifika teknikområden som byggsystem för trä, styr- och övervakningssystem, teknik för energieffektivisering samt tekniker för lokal energiförsörjning, t, ex biobränslepannor, pelletsteknik, solvärmeteknik, bränsleceller, små kraftvärmeanläggningar.

4.1.2 Hållbara transporter

Inom hållbara transporter – fordon, trafiksystem, logistik – har vi i Sverige en lång tradition av utveckling och tillverkning av personbilar, lastbilar, flygplan och tåg, liksom många underleverantörer. Exempel på områden där hållbarhet kan vara ett konkurrensmedel är utveckling av nya motorer och ny teknik för framdrivning, nya drivmedel, teknik och system för kollektivtrafik och sjöfart, samt nya metoder och system för effektiva och mellan olika transportslag samordnade transporter.

4.1.3 Miljöskyddsteknik: reningstekniker, avfallshantering

Som redan konstaterats finns det en mycket stor och starkt växande marknad för miljöskyddstekniker i exempelvis östra Europa och i de snabbt växande ekonomierna i Asien och Sydamerika. Sverige har en väl utbyggd infrastruktur och hög standard inom områden som rening av vatten och avlopp, rökgasrening, marksanering, avfallshantering, återvinning och miljöförbättrande åtgärder inom areella näringar. Sverige har en etablerad industri, om än med, i ett internationellt perspektiv, relativt många små företag. En särskild styrka som bl.a. lyfts fram i IVAs studie ”Miljöarbetets nya arena” är den kunskap och erfarenhet som finns i den offentliga sektorn, exempelvis i de kommunala företag som driver anläggningar och system. Genom samverkan mellan samhälle, forskning och företag finns det goda möjligheter att främja utveckling och inte minst demonstrera goda exempel.

4.1.4 Användande av biologiska naturresurser

Inom områdena gröna material och bioenergi finns ett ökat internationellt intresse för att använda odlade växter och träd effektivare och bättre än idag, bl a i bioraffinaderier.

Sverige har goda förutsättningar att utveckla kunskap och ny resurseffektiv teknik, genom en stark forskning och goda kunskaper inom biologi, fysik,

kemi och materialteknik samt en stark industriell bas. Exempel på tillämpningar med tillväxtmöjligheter är:

- nya processer för att ta tillvara flera komponenter och/eller energi på ett effektivt sätt (bioraffinaderier/biokombinat, kopplade till skogsindustri, drivmedelstillverkning eller fjärrvärme)
- nya material: fibrer och kompositer med växtfibrer och biopolymerer/polymerer från förnyelsebar råvara
- utveckling av nya funktionella material och förpackningar, med nya egenskaper eller för att ersätta petroleumråvara

4.1.5 Lätta och avancerade material

Lätta och avancerade material kan innebära stora miljövinster i flera avseenden:

- Låg vikt och hög styrka är en viktig konkurrensfaktor för material, och kan gynna miljön genom minskade transportbehov, minskad råvaruförbrukning, och lägre bränsleförbrukning i fordon.
- Material som ger lite avfall och som kan återvinnas, eller är lätt nedbrytbara kan ge miljövinster i många led i livscykeln.
- Nanoteknik och kemi/fysik/biologi lovar stora möjligheter till ny resurseffektiv teknik inom t.ex. elektronik, medicinteknik, solceller och sensorer

Sverige har en stark industriell tradition och forskning med god kompetens inom metallindustri och skogsindustri. Det finns också kvalificerade materialanvändare och teknikutveckling inom fordons-, flyg-, energi-, vitvaru- och förpackningsindustri. Exempel på tillämpningsområden för nya material med hög miljörelevans är material för fordon, förpackningar och fritidsutrustningar. Andra exempel berörs under utnyttjande av biologiska naturresurser och transporter ovan.

4.1.6 Energi

Energi är på systemnivå en viktig del i flera av ovan nämnda styrkeområden. Energieffektivitet och energiteknik för elproduktion, värmeproduktion och transporter är också i sig svenska styrkeområden. Det gäller både ny teknik för energitillförsel (som solel, vindkraft, fjärrvärmeteknik, biobränsleteknik, bioraffinaderier för bränsleproduktion) och teknik för effektivare energianvändning (som effektiva industriella processer, effektiv belysningsteknik mm). Ansvaret för energiforskningen ligger på Energimyndigheten, men med tanke på att energiteknik ingår som en naturlig del i flera av de områden som betecknas miljöteknik bör ett brett samarbete inom energiområdet eftersträvas.

4.2 Hot och svårigheter

Men det finns också ett antal uppenbara hot och svårigheter utöver de redan nämnda. De alltmer globala tillförselkedjorna och de internationella marknaderna gör det svårare för enskilda företag som bara är en länk i kedjan att påverka eller nå ut med ny teknik. Det krävs kunskap om marknader och resurser för att etablera sig, inte minst när det gäller avlägsna marknader. Ett ytterligare hot som ofta tagits upp är också att forskningen flyttar efter produktionen eller flyttar närmare marknaderna efterhand som företagen blir alltmer globala. Här pågår en konkurrens mellan länder, med olika former av stöd till företag som etablerar ny verksamhet.

5 Samverkan för miljöteknik

Miljöaspekter ges stor vikt i den forskning som stöds av Formas och VINNOVA inom olika teknik- och tillämpningsområden. Detsamma gäller för många andra forskningsfinansiärer i Sverige, till exempel Mistra, Energimyndigheten, Naturvårdsverket och Vetenskapsrådet.

Många av industriforskningsinstituten bedriver forskning och annan verksamhet med miljöinriktning, flera av dem även i samverkan med och med stöd till små och medelstora företag. Exempelvis kan nämnas IVL som har en omfattande miljöforskning med finansiering från bl a Naturvårdsverket, SP som har omfattande uppdrag inom energitekniktillämpningar, IVF med etablerat nätverk kring miljöaspekter i produktutveckling, Skogforsk som arbetar med driftteknik, råvaruutnyttjande och logistik inom skogsnäringen samt JTI som har en etablerad och mångårig verksamhet inom biogasteknik.

Av stor betydelse för genomslag för miljöteknik är att forsknings- och utvecklingsresultaten når olika aktörer och användare och att kunskaper kommer in i utbildningen på alla nivåer. Det handlar då inte bara om teknik, utan även kunskaper om marknader och vilka val människor gör. Vidare har regelverk, standarder och normer, styrmedel mm givetvis en stor betydelse för i vilken takt eller omfattning miljöteknik kan nå ut och ge förbättringar. Här finns också ett samspel så att ny teknik ger möjligheter till att efterhand införa ökade krav i lagstiftning eller normer.

Det är därför svårt att dra en skarp gräns mellan forskning och utveckling för miljöteknik och andra insatser för att främja denna. Det sker ett samspel mellan många aktörer och det krävs insatser i hela värdekedjan för att åstadkomma tillämpning av tekniken eller för att främja tillväxt. Olika myndigheter och organisationer spelar här en viktig roll. Till exempel arbetar Nutek med insatser inom miljödriven produkt-, affärs- och näringslivsutveckling. Naturvårdsverket har som Sveriges centrala miljömyndighet en viktig roll bl.a. när det gäller miljölagstiftning. Sida har erfarenhet av att stödja miljöteknik i u-länder och inom Sidas forskningsavdelning SAREC finns erfarenhet av stöd till miljöteknikforskning i Asien. ALMI ska främja utvecklingen av konkurrenskraftiga små och medelstora företag. SWENTEC, Sveriges nya miljöteknikråd, ska stärka svenska företags affärsmöjligheter och konkurrenskraft inom miljöteknik, bl.a. genom att stärka samordningen av statens insatser på området. I detta sammanhang blir det därför viktigt att diskutera möjligheter till samarbete och samverkan mellan

forskningsfinansiärer, myndigheter och andra aktörer samt att hitta lösningar för samfinansiering mellan forskningsfinansiärer och näringsliv.

5.1 Samverkan och samfinansiering med näringslivet

Förutsättningarna för samfinansierad forskning mellan staten och näringslivet samt hur små och medelstora företags medverkan skall kunna underlättas har varit en del av uppdraget och har också tagits upp under arbetets gång i flera sammanhang. Frågan har diskuterats vid de två workshops som arrangerats, i intervjuer med företag, samt i de arbetsgrupper som initierades vid den första workshopen.

Ett tjugotal miljöteknikföretag har inom strategiarbetet telefonintervjuats av inno Scandinavia AB med avseende på företagens syn på utmaningar, behov och viktiga insatsområden. Se bilaga 4, Företagens syn på utmaningar, behov och viktiga insatsområden.

Underlag har vidare inhämtats från andra forskningsfinansiärer och myndigheter i anslutning till möten med dessa. IVAs projekt ”Miljöarbetets nya arena” har givit ytterligare underlag.

En allmän synpunkt är att många företag och företagarorganisationer lägger stor vikt vid miljöaspekter, en följd av både tryck från marknaden och från samhället. Miljöledningssystem har införts i många företag, miljöredovisningar kompletterar den ekonomiska redovisningen, och miljökrav och miljödeklarationer har blivit etablerade i handel mellan företag. Många företag har deltagit i olika nätverk, insatser och verksamheter som genomförts eller samordnats av Nutek och Exportrådet. Vidare finns det ett flertal olika regionala initiativ där företag samverkar eller deltar i nätverk med inriktning mot miljö och energi, t.ex. i Skåne, Göteborg, Stockholm och Västernorrland.

Andra exempel på samverkan där företag deltar är Miljöstyrningsrådet och ByggaBo-dialogen (samverkan mellan staten, kommuner och byggnadsindustrin i form av frivilliga avtal). Ett globalt samarbete mellan stora företag för att främja uthållig utveckling sker i organisationen The World Business Council for Sustainable Development (WBCSD). Några stora svenska företag finns med bland de 165 medlemmarna.

I Formas och VINNOVAs gemensamma förslag till miljöteknikstrategi är det främst forskningssamarbete mellan forskare och företag som är i fokus. Etablerad samverkan med inslag av miljöteknik finns i flera olika former inom VINNOVAs verksamhet. Forska&Växa är ett program med stöd till FoU-insatser i samverkan mellan små och medelstora företag, SMF, och forskning. Flera av projekten avser miljöteknik i den vida meningen. Vidare genomförs samarbetsprojekt inom olika kompetenscentrabildningar, där

företag deltar med egna insatser. I dessa senare fall är det främst större företag som deltar, men det finns många exempel med deltagande från SMF.

Formas finansierar forskning vid universitet, högskolor och forskningsinstitut och har inte lika omfattande samverkan med företag som VINNOVA. Inom området hållbart samhällsbyggande har Formas dock ett etablerat samarbete med Byggsektorns Innovationscentrum (BIC) i avsikt att ”i samverkan arbeta för att svensk byggforskning får en stark ställning nationellt och internationellt i arbetet för hållbar utveckling och ekonomisk tillväxt genom hållbart byggande”.

Slutsatser från de olika kontakter som tagits samt från underlagen är att samverkan med stora företag är etablerad inom forskningsfinansieringen, inom miljöteknik liksom inom annan tillämpad och behovsmotiverad forskning. Det finns också ett stort intresse från SMF, men de är samtidigt tydliga med att de har stora svårigheter med att gå in med den medfinansiering i forskningsprojekt eller forskningsnära utvecklingsprojekt som normalt krävs i de projekt som Formas och VINNOVA finansierar. Många företag, liksom regionala nätverk, lyfter snarare fram behovet av stöd och riskvilligt kapital för mer marknadsnära insatser, för teknikutveckling och marknadsintroduktion, insatser som banker och riskkapital bedömer ha för hög risk.

6 En forskningsstrategi för miljöteknik

Formas och VINNOVA avser med forskningsstrategin att ta ett samlat grepp om forskning och utveckling om miljöteknik och att lyfta fram den inom olika forskningsområden. Förslagen ska också ses som en komplettering till andra forskningsstöd med miljöteknikrelevans, exempelvis genom stöd till forskning som spänner över flera områden och forskning som är systeminriktad.

I forskningsstrategin behandlas också frågan om hur forsknings- och utvecklingsresultat förs vidare till praktisk tillämpning genom insatser i olika delar av innovationskedjan, t ex i form av demonstrationsprojekt, implementeringsåtgärder och marknadsintroduktion.

Syftet med den föreslagna forskningsstrategin är att främja framtagandet av ny kunskap och stärka kompetensen inom miljöteknikområdet, främja svensk konkurrenskraft på den globala marknaden och skapa hållbar tillväxt. En gemensam vision är formulerad.

Vision

> *Sverige är internationellt konkurrenskraftig i utveckling av produkter, system, processer och tjänster som möter höga krav på resurseffektivitet och miljöprestanda för hållbar utveckling och tillväxt.*

Detta har uppnåtts genom:

- att nödvändig kompetens med avseende på miljöaspekter, resurseffektivitet, teknik, marknader samt användares val och preferenser utvecklats och tagits tillvara i förädlingskedjan och hos alla aktörer, såväl offentliga som inom näringslivet
- att helhetssyn och systemaspekter varit vägledande för insatserna
- att aktörer samarbetat för att samordna effektiva insatser i hela värdekedjor
- att en hög kompetens utvecklats inom viktiga möjliggörande tekniker som kan bidra till effektiviseringar i alla led av framställning och användning av ny teknik, som t ex IKT, bioteknik och nanoteknik
- att det skapats inhemska pionjärmarknader genom prov och demonstrationer av miljödriven teknik – i produkter, tjänster och system
- en aktiv och omfattande samverkan över landets gränser för en hållbar utveckling

Utgångspunkter för förslaget till forskningsstrategi

Miljöteknik omfattar, med den valda ansatsen, många kunskapsområden och tekniker och berör många aktörer. Det pågår omfattande nationella och internationella satsningar på grundläggande forskning, mer tillämpningsnära teknisk forskning samt utveckling och demonstration av teknik där miljömotiv och hållbar utveckling har en central roll.

En viktig uppgift för strategin är att främja forskning och utveckling av ny teknik som möter såväl användares höga funktionskrav som höga krav på miljöprestanda. Det är därför viktigt med ökade kunskaper om samspelet mellan teknik och användares beteende och preferenser.

Formas och VINNOVA har i uppdrag att främja hållbar utveckling respektive hållbar tillväxt och har i pågående verksamheter ett flertal satsningar och program som finansierar forskning av hög relevans för miljötekniken. Vidare är den energiforskning, fordonsforskning och forskning inom den direkta miljötekniken (reningsteknik, återvinning etc) som finansieras av andra aktörer i hög grad motiverad med hållbarhets- och miljöargument och faller till stora delar in under den valda definitionen av miljöteknik.

Den forskningsstrategi som formuleras här avser inte att ta upp eller diskutera prioriteringar i de program som drivs av andra forskningsfinansiärer, men tar upp möjlig samverkan med andra aktörer.

Strategin har utgått från olika aspekter som diskuterats ovan:

- den vida tolkningen av miljöteknik – i linje med den som används i ETAP – lyfter fram behovet av ökat fokus på användare och resurseffektivitet, som effektiva tekniker i exempelvis bebyggelse, resor/transporter, livsmedelskedjan och varuförsörjning, som ett komplement till teknikinriktade satsningar
- det är angeläget att stimulera tvärvetenskaplig forskning med avseende på systeminnovationer och innovationer som går på tvären och som har stor miljörelevans
- utveckling av ny teknik behöver ta hänsyn till hela livscykeln, från utvinning av råvara till omhändertagande av avfall och restprodukter, att utvecklare använder ”ekodesign” och hjälpmedel för att bedöma och värdera miljökonsekvenser vid tillverkning, användning och slutligt omhändertagande när tekniken tjänat ut
- det finns behov av en stärkt tvärgående, multidisciplinär forskning kring samlad miljöpåverkan i globala förädlingskedjor.
- det finns behov av samhällsvetenskaplig forskning kring exempelvis behov, styrmedel och regelverk. Det finns också behov av kunskaper om förutsättningar med avseende på kunders och användares förhållningssätt och preferenser i olika länder och kulturer Vidare

behövs kunskap om samspelet mellan individuella och samhälleliga drivkrafter och mellan olika aktörer i hela kedjan från naturresurs till slutanvändning
- satsningar bör främst inriktas mot svenska styrkeområden och områden med svenska konkurrensfördelar samt områden där det kan bedömas föreligga ett behov av att utveckla nationell kompetens
- Aktuella forsknings- och utvecklingsinsatser bör i stor utsträckning genomföras i samverkan och samfinansieras med näringslivet

En ytterligare allmän utgångspunkt är att det finns ett stort behov av att stärka förutsättningarna för SMF att utveckla ny teknik, och att det är angeläget att i samverkan med andra finansiärer och med SMF själva finna former som underlättar för SMF att delta i FoU-projekt och att dra nytta av forskning, t ex genom mer marknadsnära insatser.

6.1 Förslagen

6.1.1 I. Ökat fokus på miljöteknik i forskning

Miljöteknisk forskning lyfts fram och synliggörs tydligare i Formas och VINNOVAs verksamhetsområden. Vidare bör behov av och förutsättningar för forskning hos och i samarbete med små och medelstora företag (SMF) särskilt uppmärksammas.

Nya miljötekniska satsningar ska präglas av en helhetssyn med inriktning mot systeminnovationer och systemlösningar med hög miljörelevans. De ska också präglas av en öppenhet för frågeställningar som har svårt att finna finansiering inom dagens forskningsprogram. Hög prioritet ska ges åt livscykeltänkande.

Förslag 1

Främja miljöteknikforskning över disciplin-, teknik- och branschgränser genom finansiering av:

- tvärdisciplinär och gränsöverskridande forskning med hög vetenskaplig kvalitet och hög miljörelevans, som även inkluderar
- samhällsvetenskaplig forskning, som ger kunskap om behov, marknader, användarpreferenser, regelverk, styrmedel mm i ett europeiskt och globalt perspektiv

Förslag 2

Öka möjligheterna för SMF att medverka i och samfinansiera innovativa projekt med hög miljörelevans genom att:

- I finansiering av miljöteknikforskning skapa möjligheter att inkludera demonstration av tekniken, i synnerhet när SMF medverkar i projekten.
- Stödja forskning kring vidareutveckling av metoder och verktyg för hållbar produktframtagning med särskild inriktning mot behov hos SMF.

- Ställa forskningsresurser till förfogande till SMF, genom samverkan med industriforskningsinstitut, en fortsatt satsning på program av såsom Forska & Växa samt samverkansprogram såsom Formas-BIC.

6.1.2 II. Satsning på svenska styrkeområden

I det svenska innovationssystemet har sex styrkeområden identifierats:

- *Hållbart samhällsbyggande:* mer övergripande områden som hållbara byggnader och renoveringar samt hållbara städer (Sustainable Buildings, Sustainable Renovation och Sustainable Cities), samt mer specifika teknikområden som byggsystem för trä, styr- och övervakningssystem, samt tekniker för lokal energiförsörjning.
- *Hållbara transporter* – fordon, trafiksystem, logistik – nya motorer och ny teknik för framdrivning, nya drivmedel, teknik och system för kollektivtrafik och sjöfart, samt nya metoder och system för effektiva och mellan olika transportslag samordnade transporter.
- *Miljöskyddsteknik:* rening av vatten och avlopp, rökgasrening, marksanering, avfallshantering och återvinning – genom samverkan mellan samhälle, forskning och företag finns det goda möjligheter att främja utveckling och export, och inte minst demonstrera goda exempel.
- *Användande av biologiska naturresurser:* nya processer för att ta tillvara flera komponenter och/eller energi på ett effektivt sätt, nya material från förnybara råvaror, nya funktionella kompositer, yt- och barriärmaterial, förpackningar och smörjmedel).
- *Lätta och avancerade material:* många tillämpningsområden, t ex i applikationer där vikten är av betydelse för energi- eller bränsleförbrukning, material som ger lite avfall eller kan återvinnas, samt avancerade material för t ex elektronik, medicinteknik, solceller och sensorer. Även här har nya processer för effektivare produktion betydelse.
- *Energi*: ny teknik för energitillförsel - solel, vindkraft, fjärrvärmeteknik, biobränsleteknik, bioraffinaderier för bränsleproduktion - och teknik för effektivare energianvändning - som effektiva industriella processer, effektiv byggnadsteknik och belysningsteknik mm. Ansvaret för forskningen ligger för detta område på Energimyndigheten, men samverkan bör eftersträvas.

Förslag 3

För var och ett av dessa styrkeområden utarbetas konkreta forsknings- och utvecklingsinsatser med avseende på bl a prioriterade delområden, systemaspekter och tvärvetenskap.

Insatserna ska utgå från en brett förankrad vision och utvecklingsstrategi för respektive område, vilket också bör resultera i prioritering och fokusering av den samlade nationella insatsen. Förnyelse- och innovationspotential, forskningspotential, affärspotential och miljövärde är viktiga parametrar i sammanhanget. De nyligen utarbetade branschprogrammen, som berör flera av styrkeområdena, ska också beaktas.

- Möjligheterna till finansiering från EU:s ramprogram identifieras inom ramen för varje utvecklingsstrategi. Medfinansieringsfrågan utreds för respektive område. Den av VINNOVA nyligen presenterade EU-strategin kan utgöra ett verktyg för att förstärka Sveriges position.
- Identifiera sådana produkter och tjänster inom området som lämpar sig för s.k. innovationsupphandling, varmed menas offentligt köp av varor eller tjänster som ännu inte existerar eller som behöver förbättras och således förutsätter forskning och innovation för att uppfylla specifikationerna.
- Frågor om regleringar, standarder, miljönormer, byggnormer, skattefrågor etc som har betydelse för utvecklingen inom respektive område identifieras och förs vidare till ansvariga organ.

6.1.3 III. Samverkan för forskning om miljöteknik

Ett flertal aktiviteter och projekt med avseende på miljöteknik och angränsande områden pågår för närvarande hos olika aktörer som har i uppdrag att verka för hållbar utveckling. En ökad samverkan mellan dessa myndigheter, forskningsfinansiärer, näringsliv och andra aktörer är därför av stort värde.

Förslag 4

Tillsammans med berörda myndigheter, forskningsfinansiärer och andra aktörer:

- utveckla forsknings- och utvecklingsinsatser med avseende på styrkeområden enligt förslag 3
- utveckla samarbetet mellan berörda aktörer, t ex i form av att generera gemensamma, tvärgående forskningssatsningar
- utarbeta vision och utvecklingsstrategi för miljöteknik för hela värdekedjan enligt förslag 3
- främja internationella forskningssamarbeten dels inom Norden, med länder i Baltikum och inom EU, men också globalt med länder med stora eller potentiellt stora marknader
- tillse att gränsdragning mellan myndigheter vid behov modifieras så att alla viktiga delar av miljöteknikområdet täcks in

Bilaga 1
Svenska aktörer inom miljöteknik

Formas och VINNOVA är delar av ett system som har till uppgift att stödja utvecklingen mot ett hållbart samhälle och en hållbar tillväxt. Forskning och utveckling är ett viktigt led i en sådan utveckling. Här görs ingen samlad genomgång över samtliga aktörer i de olika leden, utan endast en översikt över de myndigheter, forskningsfinansiärer och andra aktörer som har störst betydelse för forskning inom och kommersialisering av miljöteknik.

Regeringen

Flera departement har ansvar för frågor som på olika sätt berör miljöområdet. Det tydligaste ansvaret för frågor som berör regelverk, näringsliv, samt forskning och utveckling inom miljöteknik finns hos miljödepartementet och näringsdepartementet. Andra departement som ansvarar för frågor som berör miljö och teknik är, jordbruksdepartementet (areella näringar och livsmedel) och utbildningsdepartementet (finansiering av forskning).

Samhället har främst påverkat genom lagstiftning, ofta riktat mot olika utsläpp till luft, vatten och mark. Stöd till forskning och utveckling med direkt inriktning mot teknik med goda miljöprestanda har främst gällt energisystem och fordon/drivmedel.

Myndigheter och andra statliga aktörer

Ett flertal myndigheter har uppdrag och verksamhet som på olika sätt berör hållbar utveckling och miljöfrågor. De ansvarar för genomförande av regeringsbeslut, utformar regelverk och utövar tillsyn – och därmed påverkar marknad och tillämpningsmöjligheter för miljöteknik.

Några myndigheter och aktörer med direkta uppdrag inom miljöteknik, för att främja utveckling av miljödriven utveckling av företagen och för att främja export av miljöteknik, samt med viss forskningsfinansiering, redovisas nedan.

Avslutade insatser

I spåren av Rioöverenskommelsen uppmärksammades vikten av att se till hela livscykeln och sättet att hantera avfall har stor betydelse för den samlade miljöpåverkan, liksom den samlade användningen av naturens resurser i hela kretsloppet. I början på 90-talet inrättades

Avfallsforskningsrådet (som övergick i Avfallsforskningsnämnden vid Naturvårdsverket) som finansierade forskning kring metodutveckling (bl.a. LCA), omhändertagande av avfall samt återvinning/återanvändning av restprodukter.

En annan satsning med sikte på all produktutveckling och på att se till helheten var programmet Miljödriven Produktutveckling (MPU) som under 1998 - 2001 genomfördes av dåvarande NUTEK (innan VINNOVA skapades ur delar av NUTEK). MPU-programmet genomfördes i nätverk med främst mindre företag och forskargrupper. Erfarenheterna förs vidare i arbetet kring miljödriven affärsutveckling vid NUTEK.

En myndighet med ett tidsbegränsat och nu avslutat uppdrag med direkt inriktning på miljöteknik var Miljöteknikdelegationen (1997 - 2000). Deras prioriterade områden var export av miljöanpassade varor och tjänster, transporter, byggsektorn, livsmedel/lantbruk, samt ekologiskt återställande av mark.

NUTEK

Nutek har till uppgift att bidra till en hållbar ekonomisk tillväxt och välstånd över hela landet genom fler nya företag, fler växande företag och fler starka regioner.

Nuteks arbete med ”Miljöstyrning i småföretag” och ”Metodik för miljöanpassad produktutveckling” har ökat kunskapen om vilka affärsmöjligheter en allt mer miljömedveten marknad erbjuder. En erfarenhet är att när företaget satsar i hållbar riktning påverkas ofta hela affärsstrategin. Programmet ”Miljödriven affärsutveckling” har byggt vidare på dessa erfarenheter och arbetat med att stärka små och medelstora företags konkurrenskraft genom att stimulera verksamhets- och produktutveckling ur ett hållbarhetsperspektiv.

Inom insatsområdet ”Miljödriven näringslivsutveckling” har Nutek finansierat drygt 40 pilotprojekt för att driva utvecklingen framåt inom de strategipunkter som utvecklades i regeringsuppdraget 2003, samt förberett för SWENTECs strategiska arbete. Projekt har främst genomförts i samverkan med Statens energimyndighet, VINNOVA, Naturvårdsverket, Exportrådet, ALMI, ISA, branschorganisationer, universitet, industriforskningsinstitut, konsulter och regionala noder för miljödriven näringslivsutveckling.

Nutek planerar att fokusera särskilt på miljödriven produkt- och affärsutveckling samt förutsättningar på den nationella marknaden. Integrering av miljö- och hållbarhetsfrågor inom regional näringslivsutveckling är ett annat prioriterat område.

SWENTEC

SWENTEC är Sveriges nya miljöteknikråd som på uppdrag från regeringen ska stärka svenska företags affärsmöjligheter och konkurrenskraft inom miljöteknik, miljöanpassade varor, tillverkningsprocesser och tjänster på den svenska och internationella marknaden.

Det ska göras genom att:

- Stärka samordningen av statens insatser på området.
- Verka för att de samlade statliga insatserna bättre möter företagens behov.
- Främja samverkan mellan aktörer inom miljöteknik – skapa nätverk så att utvecklingen och marknadsföringen av svensk miljöteknik stärks.
- Identifiera och kommunicera Sveriges konkurrensfördelar inom området.
- Samla in, analysera och sprida väsentlig information och kunskap inom området.

Ett råd bestående av tio personer har utsetts av regeringen att leda SWENTECs arbete.

Naturvårdsverket

Naturvårdsverket är regeringens centrala miljömyndighet. Naturvårdsverkets huvudsakliga uppgifter är att:

- informera och se till att miljölagar efterföljs och tillhandahålla miljökunskap
- utarbeta underlag som regeringen behöver för miljöpolitiken
- vägleda andra centrala, regionala och lokala myndigheter i miljö- och tillsynsfrågor
- förklara hur lagar ska tolkas, ta fram föreskrifter, allmänna råd och handböcker
- driva mål och ärenden i domstolar och föreslå behövliga ändringar i lagstiftningen.

Naturvårdsverket finansierar också miljöforskning, till stöd för Naturvårdsverkets arbete, t.ex. om miljömålen, miljöbalken samt som underlag för internationellt förhandlingsarbete. Ett aktuellt program som berör miljöteknik är Förutsättningar för livscykelhänsyn i integrerad produktpolitik - FLIPP. Programmet ska visa hur lagar, skatter och miljömärkning påverkar olika grupper av människor. Forskarna ska också ta fram hållbara system för produktion och konsumtion av varor som gynnar både företag och miljön.

Andra verksamheter som på olika sätt har beröring med miljödriven teknikutveckling är arbetet med miljömålen, arbetet kring IPP (integrerad produktpolitik) samt administrationen av KLIMP (klimatinvesteringsprogrammet).

Vägverket

I Vägverket pågår ett arbete med att ta fram en strategisk plan för perioden 2007-2016. Som underlag till denna plan håller ett antal strategier för olika ”sakområden” på att utarbetas. Strategier som berör miljöområdet avser Klimat, Frisk luft, Mindre buller, Landskap – natur, kulturmiljö och gestaltning, samt Vatten och material.

Vägverket ansvarar för Emissionsforskningsprogrammet EMFO. Programmet tar upp luftföroreningar och buller som uppkommer i samband med att fordon trafikerar allmän väg samt emissioner från traktorer och större arbetsmaskiner. En viktig uppgift för programmet är att samordna aktiviteter inom programmet med såväl nationell som internationell forskning inom området. Programmet finansieras i ett samarbete mellan parterna i Programrådet för fordonsforskning, PFF där svensk fordonsindustri och myndigheter samarbetar. Deltagare är Saab Automobile AB, Scania CV AB, AB Volvo, Volvo Personvagnar AB, Fordons Komponent Gruppen AB (FKG), Energimyndigheten, Naturvårdsverket, VINNOVA och Vägverket.

Jordbruksverket

Jordbruksverket fördelar totalt ca 17 miljoner kronor årligen till projekt som ska ge tillämpad kunskap inom följande områden: minskade risker med bekämpningsmedel, växtnäringens miljöeffekter, ekologisk produktion och biologisk mångfald i odlingslandskapet. Pengarna används till försöksverksamhet med målsättningen att öka jordbruks- och trädgårdsproduktionens uthållighet både miljömässigt och ekonomiskt. Försöken omfattar huvudsakligen odlingsteknik och teknikutveckling. Ny kunskap ska kunna omsättas i praktiken inom en kort tidsperiod (ca 3-5 år). Medlen kompletterar därmed andra myndigheters och stiftelsers satsningar på forskning med längre tidsperspektiv.

Boverket

Boverket är den nationella myndigheten för frågor om samhällsplanering, stads- och bebyggelseutveckling, byggande och förvaltning och för bostadsfrågor.

Boverket arbetar med ett stort antal miljöfrågor, som grovt kan delas in i fyra områden:

1. miljökvalitetsmålet God bebyggd miljö
2. miljömålsfrågan Fysisk planering och hushållning med mark och vatten samt byggnader, inklusive projektet SAMS – planera med miljömål
3. byggsektorsansvar när det gäller ekologiskt hållbar utveckling
4. internt miljöarbete

Inom Boverket finns Hållbarhetsrådet med kansli i Umeå. Hållbarhetsrådet ska driva på det lokala och regionala arbetet för en hållbar utveckling.

Banverket

Banverket är den myndighet som ansvarar för järnvägen i Sverige. Det innebär att man följer och driver utvecklingen inom järnvägssektorn, bistår riksdag och regering i järnvägsfrågor, ansvarar för drift och förvaltning av statens spåranläggningar, samordnar den lokala, regionala och interregionala järnvägstrafiken samt ger stöd till forskning och utveckling inom järnvägsområdet.

Banverkets sektorsansvar innebär bland annat att de ska initiera, planera och stödja tillämpad samhällsmotiverad forskning inom järnvägsområdet. FoU-område 4 behandlar järnvägstransportsystemets säkerhet och miljöanpassning.

Skogsstyrelsen

Skogsstyrelsen är myndigheten för frågor som rör skog. De arbetar för att landets skogar ska vårdas och brukas så att skogen ger en uthålligt god avkastning samtidigt som biologisk mångfald bevaras. För skogsnäringens del innebär sektorsansvaret bland annat att den ska bidra till att målen om full sysselsättning, ekonomisk tillväxt, regional balans och balans i utrikesbetalningarna uppfylls (produktionsmålet), samtidigt som målen för miljö- och naturvårdspolitiken klaras (miljömålet).

Exportrådet

Exportrådet bildades 1972 och finansieras av staten och näringslivet gemensamt. Exportrådet underlättar för svenska företag att växa internationellt genom kostnadsfri information, strategisk rådgivning och hjälp på plats.

På den svenska regeringens uppdrag satsar Exportrådet genom branschprogrammet Svensk Miljöteknikexport på att genom samverkan öka förutsättningarna för export av svensk miljöteknik inom områdena: luft, vatten- och avloppsrening, avfallshantering, återvinning och förnybar energi.

Svensk Miljöteknikexport är ett nätverk av idag nära 700 företag. Genom gemensamma aktiviteter marknadsförs nätverksföretagens tjänster och

produkter internationellt. Nätverket är också ett forum för informations- och erfarenhetsutbyte mellan nätverkets företag samt mellan dessa och organisationer och myndigheter. Att delta i nätverket är kostnadsfritt.

SIDA

Sida, styrelsen för internationellt utvecklingssamarbete, är en statlig myndighet vars mål är att bidra till att skapa förutsättningar för fattiga människor att förbättra sina levnadsvillkor. Sidas avdelning för forskningssamarbete (SAREC) är Sidas ämnesavdelning för stöd till samarbetsländernas forskning och till forskning som har betydelse för deras utveckling. Detta sker genom stöd till forskningsråd, universitet och forskningsinstitutioner i länderna, till regionala forskningsnätverk samt genom stöd till internationella forskningsprogram. Avdelningen svarar även för stöd till svensk forskning av vikt för utvecklingsländerna. Aktuella områden inom miljöområdet är hållbar miljöteknik, förnybar energi vatten och sanitet, kemikalier samt uppbyggnad av miljöinstitutioner.

ALMI

ALMIs uppdrag är att främja utvecklingen av konkurrenskraftiga små och medelstora företag samt stimulera nyföretagandet i syfte att skapa tillväxt och förnyelse i svenskt näringsliv. Verksamheten täcker hela processen från idé till lönsamt företag. Målet är att fler innovativa idéer kommersialiseras framgångsrikt, att fler livskraftiga företag startas och utvecklas samt att företagens konkurrenskraft och lönsamhet ökar.

ALMI Företagspartner AB ägs av staten och är moderbolag i en koncern med 21 dotterbolag som ägs till 51 procent av moderbolaget. Övriga ägare är landstingen, regionala styrelseorgan och kommunala samverkansorgan.

Forskningsfinansiärer

Formas, forskningsrådet för miljö, areella näringar och samhällsbyggande

Forskningsrådet Formas stödjer grundforskning och behovsstyrd forskning inom områdena miljö, areella näringar och samhällsbyggande. Dessa tre huvudområden är indelade i mindre delområden. Formas främjar en ekologiskt hållbar tillväxt och utveckling i samhället, mång- och tvärvetenskaplig forskning samt internationellt forskningssamarbete. Formas ansvarar vidare för information om forskning och forskningsresultat. Inom Formas program Bebyggelse finns också möjlighet att finansiera utvecklingsarbete och experimentbyggande. Formas prioriterade områden är miljöforskning, jord- och trädgårdsbruk, fiske- och rennäring, skog och skogsbruk, bebyggelse och samhällsplanering. Formas

arbetar även med ämnesövergripande forskning mellan och inom huvudområdena.

Formas prioriteringar återspeglas både i forskningsstrategier och i forskningsprogram. Formas strategiska satsningar spänner ofta över flera FoU-områden och kännetecknas av en helhetssyn, hög relevans och aktualitet. Målet är att de inom en begränsad tidsperiod ska generera praktiskt tillämpbara resultat.

Det är nödvändigt att även samhällsvetenskaperna och humaniora deltar i forskningen för att belysa sambanden mellan ekosystemens funktion och tillstånd och en hållbar samhällsutveckling. Hållbarhetsbegreppet innehåller tre dimensioner - en ekologisk, en ekonomisk och en sociokulturell. Att få de tre dimensionerna att fungera tillsammans förutsätter systemtänkande och ämnesövergripande forskningsinsatser. Formas har som uppdrag att samordna den samhällsvetenskapliga miljöforskningen.

Inom samtliga Formas ansvarsområden är miljörelevansen stor, Koppling till miljötekniken är också betydande inom samtliga områden.

VINNOVA

VINNOVA är en statlig myndighet som ska bidra till hållbar tillväxt. VINNOVAs uppgift är att finansiera behovsmotiverad forskning och utveckling ur ett näringslivsperspektiv. Miljö- och hållbarhetsmotiv ingår bland andra motiv för många av de satsningar som genomförs inom VINNOVAs verksamhet.. Det gäller till exempel områdena:

- *Bioteknik*: Livsmedel
- *Tillverkning*: Effektiv produktframtagning, Trämanufaktur, samt Intelligenta och funktionella förpackningar
- *Material*: Lätta material och lättviktskonstruktioner, samt Gröna material från förnyelsebara råvaror
- *Transporter*: Innovativa fordon, farkoster och system, samt Innovativa logistiksystem och transporter

Hälsa och uthållighet ur ett socialt perspektiv finns också angivet för flera tillväxtområden, inom ämnesområdena Bioteknik samt Tillverkning.

Satsningarna inom Informations- och kommunikationsteknik (IKT) har andra huvudmotiv än miljöaspekter, men har betydelse som möjliggörande teknik av stor betydelse för all teknikutveckling och effektivisering inom samhälle och näringsliv. Tillväxtområdet IT i hemsjukvård handlar dock direkt om tjänster inom vård och hälsa.

VINNOVA satsar på några FoU-program som särskilt riktar sig mot små och medelsstora företag för att medverka till att företag får ett utökat utbud

av nya produkter/tjänster/processer och därmed stärkt konkurrenskraft, tillväxt och nya arbetstillfällen. Inom programmet Forska & Växa har exempelvis några företag erhållit stöd till utveckling av idéer med tydlig miljörelevans.

Energimyndigheten

Energimyndigheten arbetar inom flera områden för en effektiv och hållbar energianvändning och en kostnadseffektiv svensk energiförsörjning.

Inom Energimarknadsinspektionen hanteras bland annat lagtillsyn, el-, naturgas- och värmemarknadernas utveckling och härtill hörande konkurrens- och konsumentfrågor.

Inom Hållbar energianvändning har Energimyndigheten att uppdrag att driva på energieffektiviseringen i samhället.

Utveckling och hantering av styrmedel bidrar till omställningen i det svenska och europeiska energisystemet. Internationellt sker samarbete i flera forum, inte minst inom EU. Energipolitiskt motiverade klimatinsatser görs, bland annat genom samarbete i Baltikum och Ryssland.

Energimyndigheten har ett omfattande program för stöd till forskning och teknikutveckling bland annat för utveckling av förnybar el- och värmeproduktionsteknik samt utveckling av transportsystemet mot ökad hållbarhet.

Nyttiggörande och kommersialisering av resultat är prioriterade frågor för Energimyndigheten.

Stiftelsen för miljöstrategisk forskning, Mistra

Mistra är en stiftelse som har till ändamål ”att stödja forskning av strategisk betydelse för en god livsmiljö”.Mistra finansierar forskning som syftar till att lösa strategiska miljöproblem och för en miljöanpassad samhällsutveckling. Forskningen ska komma till praktisk användning i företag, myndigheter eller i olika organisationer.

Flera genomförda och pågående program avser på olika sätt forskning inom miljöteknik. Exempel på frågor och tekniker som berörts är bränslecellsteknik, metallåtervinning, miljövänliga båtbottenfärger, solcellsteknik, kretsloppsanpassat byggande, kretsloppsanpassad massafabrik och marksanering. Ett aktuellt initiativ är finansiering av ett nytt tvärvetenskapligt centrum för forskning och policydialog kring hållbar utveckling.

Andra forskningsfinansiärer

KK-stiftelsen har till uppgift är att stärka Sveriges konkurrenskraft, genom att stödja forskning och forskarutbildningar, kvalificerade utbildningar för näringslivet, samt skolutveckling och IT. KK-stiftelsen har inga angivna mål för miljö och uthållighet. I verksamheten finns dock projekt och program med inslag av miljöfrågor, till exempel vid högskolan i Kalmar samt Örebro universitet.

Svenska Byggbranschens Utvecklingsfond, *SBUF,* är byggbranschens egen organisation för forskning och utveckling med nära 5000 anslutna företag i Sverige. SBUF verkar för att utveckla byggprocessen så att det skapas bättre affärsmässiga förutsättningar för entreprenörer och installatörer att utnyttja forskning och driva utvecklingsarbete. Bakom SBUF står Sveriges Byggindustrier, VVS-Installatörerna, Ledarna, Svenska Byggnadsarbetareförbundet och SEKO. SBUF anger inte miljöaspekter bland de centrala kriterierna för stöd, frånsett arbetsmiljö.

Stiftelsen Lantbruksforskning, SLF, är lantbruksnäringens organ för finansiering av lantbruksanknuten forskning. Finansieringen kommer främst från lantbrukets producenter. Forskningen är främst inriktad mot de olika produktionsgrenarna, och har i många fall miljörelevans. Ett program med direkt miljöinriktning är ett nytt FUD-program Bioenergi, med Energimyndigheten som delfinansiär.

Stiftelsen för strategisk forskning, SSF, har till ändamål att stödja naturvetenskaplig, teknisk och medicinsk forskning. Stiftelsen ska enligt stadgarna främja utvecklingen av starka forskningsmiljöer av högsta internationella klass med betydelse för utvecklingen av Sveriges framtida konkurrenskraft. Det finns i stadgarna inga angivna mål för miljö och uthållighet inom den stödda forskningen.

Forskning och utbildning

Med strategins definition av miljöteknik berörs en stor del av svensk forskning och utbildning. Någon detaljerad översikt över forskningmiljöer och områden ges inte här, det skulle bli en omfattande katalog.

Forskning med en tydlig inriktning mot miljöfrågor och hållbar utveckling bedrivs vid flertalet universitet och högskolor, ofta med koppling till tillämpad teknikforskning. i en del fall också med inslag av samhällsvetenskaplig forskning. Miljöteknik ingår på olika sätt i en stor del av grundutbildningen och högre utbildning vid högskolor och universitet. Det finns också flera forskarskolor med tydlig miljöinriktning.

Många av industriforskningsinstituten bedriver forskning och annan verksamhet med miljöinriktning, flera av dem även i samverkan med och med stöd till små och medelstora företag.

Sammantaget finns det omfattande forskning och utbildning med direkt eller indirekt miljöinriktning kopplat till främst tekniska högskolor och naturvetenskapliga fakulteter eller motsvarande vid universitet. Samtidigt kan noteras att det finns förhållandevis få breda tvärgående ansatser med helhets- och livscykelperspektiv, med koppling till exempelvis användare och regelverk, och hur andra drivkrafter påverkar förutsättningarna.

Bilaga 2

Research strategies on environmental technology in Japan

A close-up study commissioned by Formas and VINNOVA

Åsa Andersson & Izumi Tanaka

itps SWEDISH INSTITUTE FOR GROWTH POLICY STUDIES

ITPS, Swedish Institute For Growth Policy Studies
Studentplan 3, SE-831 40 Östersund, Sweden
Telephone: +46 (0)63 16 66 00
Fax: +46 (0)63 16 66 01
E-mail info@itps.se
www.itps.se
ISSN 1652-0483
[Click here and type printer], [Click here and type place and year]

For further information, please contact Åsa Andersson and/or Izumi Tanaka
Telephone +81(0)3 5562 5030
E-mail asa.andersson@itps.se; izumi.tanaka@itps.se

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List of abbreviations

AIST	Institute of Advanced Industrial Science and Technology
ETAP	Environmental Technology Action Plan (EU)
GHG	Green House Gases
LCA	Life Cycle Analysis
MAFF	Ministry of Agriculture, Forestry and Fishery
METI	Ministry of Economy, Trade and Industry
MEXT	Ministry of Education, Culture, Sports, Science and Technology
MLIT	Ministry of Land, Infrastructure and Transport
MoE	Ministry of the Environment
NIES	National Institute for Environmental Studies
NIMS	National Institute for Materials Science
RITE	Research Institute of Innovative Technology for the Earth
R&D	Research and development
S&T	Science and technology

1 Summary

Environmental features provide a competitive edge

The environmental market in Japan has rapidly expanded since the second half of the 1990s, much due to the government's advancement of environmental laws, and a large number of environmentally-friendly products and services are currently being distributed in response to the increasing environmental awareness.

Continuous growth in market size and employment is expected in several sectors, but in particular for waste treatment services, resource recovery and recycling, consulting, photo-catalytic system and the fuel cell battery sector. Estimations calculate that the market size for so-called environmentally induced businesses by the year of 2025 would increase by 150% and the number of employment by 110%, compared to year 2000.

For a country renowned for producing energy efficient electrical appliances since the 1970's, it seems to be prevalent how environmental features can provide a competitive edge. Recent success stories for hybrid vehicles and solar cells confirm this ground. Consequently, Japan has adopted a broad definition of environment technology, naturally incorporating businesses in which environmentally conscious consumer behavior bring about demand for environmentally-friendly equipment and services, such as energy saving home appliances and low energy and fuel efficient vehicles. This broad definition of environmental technology is also widely adopted by different key actors in society, such as business leaders, government and academia.

Today, the broad definition of environmental technology seems to inspire an open mind to the importance of cutting-edge technologies. Of high importance to Japan is nanotechnology, seen as a key science and technology for solving various problems in biology, information, environment and energy. The field is also attractive as basic science that will bring unprecedented breakthroughs in nanometer-scale processing, synthetic materials and functions.

Asia perspective of increasing importance in Japanese strategy work

Japan wants to stress itself as "a nation of creative science and technology", and has a high acknowledgement of science and technology as an "investment for tomorrow". The S&T policy is considered one basic pillar for balancing environmental protection with economic growth, reflected in the third five-year phase of Japan's basic S&T plan, which began in April 2006. The plan addresses Japan's most pressing problems, and sets out a potential substantial increase of funding to the environmental field.

New visions in the third basic plan include a strengthened focus on biomass & 3R. Ministries and research institutes are currently working on how to mirror and realize the visions of the basic plan into their own strategies. The ministries are highlighting applications of cutting-edge technologies and the need for an Asian perspective. The research institutes to a large extent mirror biomass and the Asian focus.

The last year's policy focus has been on recycling, under the concept of 3R (Reduce, Reuse, Recycle), and climate change. These are also the two areas where a vast number of laws and voluntary agreements have been submitted. Our analysis of the visions in the newly revised basic Science & Technology Basic Plan, the ministries' strategies for environmental technology, and on where the research institutes put emphasis in their programs for the coming years, has shown that they to a large extent share the focus on 3R

and climate change. Hence, at least in theory, there seem to be a strong correlation between political and R&D goals.

Other key features of the strategies are the emphasis on relating current undertakings to long-term visions and the establishment of follow-up indicators, as done in e.g. the Ministry of Environment's Strategy on promotion of Environmental Research and Technology Development.

Traditionally, environmental research and technology development in Japan has been solution oriented, and the R&D was on need-basis to provide solutions to the existing environmental and/or pollution problems. Today, there seems to be a shift in the view upon the role of environmental R&D, since it is repeatedly being stressed that although R&D to meet the need to overcome current problems are still important, it is not sufficient, but need to be more future-oriented. Hence, environmental technology should play a role by not only tackling the current environmental problems, but to have mid and long term views to serve as pioneering knowledge forerunner in the society. At the same time the importance of environmental issues within Japan, particularly those related to the effects of the environment on the human body, is declining because of progress in improving the environment. Instead, it is becoming more and clearer how it is necessary to judge importance based on contribution to global environmental improvement.

Altogether, there is an increased shared awareness that the establishment of a sustainable society must come not from within Japan itself, but along with the neighbouring countries in the Asia-Pacific region. Asia is expected to play an increasingly important role in the world because of the rapid increase in population and remarkable economic expansion in the area. And, if the rest of Asia takes a path similar to the path taken by Japan in the post-war years, the environmental impact will affect not only the regional area but also the entire earth. Among other measures, interaction among researchers and human resource development in Asia is therefore emphasized, through not only ODA, but by providing measures promoting private and market-driven interactions.

Cluster initiatives as innovative measures for further environmental technology advancements

The Eco-Town concept, although a limited budget for the program, has proven an effective measure in Japan to promote local economic stimulation through fostering environmental businesses. The Eco Town Program can, to some extent, be compared to the Local Investment Programmes (LIP) and Climate Investment Programmes (KLIMP) in Sweden. As in LIP and KLIMP, local governments/ municipalities are working together with local companies and organisations. However, the Eco-Town program has had a much stronger focus on 3R-related activities (Reduce, Reuse, Recycle), compared to the Swedish programs mainly aiming at reducing the emissions of greenhouse gases. In addition to the EcoTown program, Japan targets environmental-related projects within industrial cluster as well as intellectual cluster programmes.

Another innovative policy measure Japan has applied is the environmental technology verification, in place as a pilot project since 2003 and planned as a full-fledged program from two years from now. The verification has already proven useful to e.g. obtain knowledge/know-how for providing guidance and information on procurement of environmental technologies. And, as developers were able to learn about features and improvements in technology, these were further stimulated, thanks to publicity from the program. Support for small and medium enterprises for verification is currently being considered for the full-fledge program. Other measures in Japan to support SMEs include training and subsidies provided to cover part of the cost of commercial R&D undertaken by SMEs, for technology contributing to rationalization of energy use. Especially

noteworthy, is also a new loan product from two major Japanese banks giving beneficial conditions and rates to eco-friendly small and medium enterprises.

Swedish measures in perspective of the Japanese efforts

The Japanese strategies provide several interesting cases in point to consider when forming the Swedish platforms for further development of environmental technology.

For strategy formation, the strong emphasis on follow- up on mid-term targets, e.g. to strive for a double of the number of domestic patents and international patents, seems sophisticated and could most likely be proven efficient also for the Swedish undertakings. In addition, the broad definition of environmental technology used in Japan has clearly opened up a wide ranging field of possibilities for cross applications; also being reflected in the main policy document. In the Swedish context, these potentials are still to be exploited, and the Japanese ideas of cross-nurturing can be utilized as good quality examples.

For general policy measures, the Japanese types of targeted programs for e.g. environmental cluster projects, seems to be rather unique from a Swedish standpoint. The cluster projects within e.g. new energy, ecology and recycling would most likely be useful to study more comprehensively, to gain detailed insight on success factors and what components of the program could prove awarding for Sweden to apply. The verification program and the support for SMEs are two other such areas.

Last but not least, Japan is currently strengthening its Asian connections, and ambition frequently repeated throughout this report when referring to their future research undertakings. Swedish measures targeting Asia can presumably gain from closely monitoring the Japanese actions in this regard, especially for the environmental technology development in connection to China. Also, since Japan is now so actively aspiring to take the lead, research collaboration in the environmental field with Japanese researchers is likely to prove key for future collaborations in the wider Asian region.

2 Introduction

The year of 2006 marks the 50th year since the government of Japan officially acknowledged Minamata disease, one of the so-called "four major pollution triggered diseases", erupted in 1950 to the 1960s. The attention paid by the general public to the environmental problems and health effects back then, constituted the starting point of a process towards the establishment of the first set or environmental regulations in Japan.

Manny of today's policy measures and trends for environmental technology and environmental business development are quite similar to those in Sweden and Europe. Some examples are the increased attention to stimulate sustainable production and consumption patterns by e.g. extended producer responsibility, green procurement, new legislation on waste management and recycling, as well as the enforcement of the Kyoto protocol. The driving forces behind Japanese policy measures can to a large extent be found in international agreements and a firm view on advanced environmental technology as a competitive factor of increasing importance. [1] Other factors stimulating the development even further, than compared to e.g. Sweden, are Japan's high population density and its strong dependence on imported energy sources.

Currently, Japan imports nearly 90 percent of its oil from the Middle East, making the need to create technologies for new energy to replace oil an urgent matter. Also, Japan's population is aging more rapidly than any other country's and began to shrink last year. With this trend, and an intensifying competition among Asian countries, economic productivity through the development of new technologies is often emphasized as essential to Japan's future competitiveness in the world market. One example is the World exhibition of 2005 in Aichi, Japan, where visitors were surrounded by technologies designed to improve the environment in different ways. In fact, the whole exposition was dedicated to the theme of "Nature's wisdom", with parts of the sight powered by the latest solar cells and shuttle buses used were equipped with fuel cells. (EXPO, 2005)

2.1 "Environmental revolution" representing a new growth model

After a prolonged period of stagnation and deflation, Japan's economy is currently undergoing a recovery. GDP growth has been climbing since 2002 and reached 2.8% last year (2005), with expectations of a similar rate for 2006. (Global Watch, 2006) At the same time, environmentally advanced products and technologies from Japanese companies are gaining attention as well as increased benefits from being highly competitive on the global market. Japanese companies have for example dominant positions in today's world market of e.g. hybrid cars and solar cells.

Furthermore, businesses related to the remediation of contaminated land sites in Japan have been growing rapidly since the passage of the new Soil Contamination Countermeasures Law in 2003. With more than 320,000 estimated number of contaminated site locations across Japan, this law is stimulating the market for land clean up. Significant growth is expected to be seen also in wastewater treatment, solid waste treatment, soil and groundwater remediation, recycled materials, renewable energy and

[1] *For a comprehensive examination of drivers for environmentally driven technology and business development in Japan, please refer to Ahlner & Tanaka, 2003.*

energy-saving technologies and facilities. The New Energies Use Law from 2003, stronger dioxin standards enforced in December of 2002 and a number of new recycling laws aimed at controlling e-waste, construction waste and industrial waste (effective from 1997-2001 and onwards) are further driving this market. (JETRO, 2006)

The Ministry of Environment has identified this development as crucial signs of the environmental revolution, representing the possibility of revolutionizing industrial activities through changes in our daily lives, and following the footsteps of the "Industrial Revolution" and the "IT Revolution". In their annual report on the environment of 2004 the first chapter is dedicated to life-enhancing environmental techniques. (MoE, 2004). The annual report from 2005 moves on from there, by demonstrating a growth model for Japan based on a virtuous circle for environment and economy, which will enable Japan to lead the world as an environmentally advanced nation. (MoE, 2005)

Figure 1(Koike, 2005)

2.2 Environmental R&D continuously strengthened

Japan wants to stress itself as "a nation of creative science and technology", and has a high acknowledgement of science and technology as an "investment for tomorrow". The S&T policy is also considered one basic pillar for balancing environmental protection with economic growth, reflected in the third five-year phase of Japan's basic S&T plan, which began in April 2006. The plan addresses Japan's most pressing problems, and sets out a potential substantial increase of funding to the environmental field. Ministries and research institutes are currently working on how to mirror and realize the visions of the basic plan into their own strategies. Altogether, this creates an appropriate timing to grasp the current research visions and efforts at different levels in Japan; laying out the ground for the environmental technology successes of the future.

2.3 Aim and purpose of this study

The overall aim is to gain an understanding of the current governmental efforts to promote environmental related R&D in Japan, by analyzing policy and research strategies from the viewpoint of gaining insight in both the underlying assessments as well as main aspirations for the future. The analysis is aimed to serve as an inspiration for future efforts relating to environmental technology in Sweden, in particular to Formas and Vinnova in their work

on a governmental assignment to propose a joint research strategy for environmental technology.

The following issues are to be highlighted:

1) The visions in the new 3rd basic plan for Science & Technology Basic; what are the areas of attention within the environmental field, including new changes of directions and how is environment approached in other priority areas?
2) What strategies do the ministries' set out for environmental technology, and how are these related to the S&T Basic Plan?
3) In what way do the strategies of the research institutes put emphasis on environmental technology and what are the recent changes of direction in this regard?

The purpose is to analyze Japan's new research strategies and experiences gained this far, both from a perspective of receiving important influences from a somewhat different system, as well as to map out Japan's current and future standings in the environmental research field. In order to gain a deeper understanding of the context of the analysis of research strategies, a brief overview of new policy trends and innovative promotion measures for environmental technology is also included.

2.4 Method & selection

The study is based on interviews with central actors in Japan within the subject area, foremost representatives from ministries and research institutes as well as academics with key influence on the environmental policy process. The interview material is complemented by a comprehensive study of new policy and strategy documents, both in English and Japanese, channeled out mainly through the interviewees.

Important to note is that Japan has applied a broad definition of environmental technology, and none of the governmental organizations have published strategies specifically dedicated to traditional environmental technology. Hence, the scope of this study as well as the selection of research institutes is not limited to the traditional environmental technology but instead quite wide; including energy technology and applications from other cross-cutting technologies such as nanotechnology.

The selection among the total number of Japanese national institutes conducting R&D relating to environmental technology was based on this broad spectrum, and made through guidance from key academics relating to the interests expressed from the Swedish side.

3 Recent policy measures & eco business market

3.1 Kyoto Protocol into force and the new target achievement plan

Under the Kyoto Protocol, Japan has committed to reduce greenhouse gas emissions in the first commitment period by 6% below 1990's base year level. The current state of Japan's emissions of greenhouse gases, show that emissions in 2004 stood at approximately 1.33 billion tons, a figure representing a 7.4% increase over base year level. (MoE, 2005) and the actual decrease mandated is therefore a total of approximately 13-14% compared with today's levels, see below.

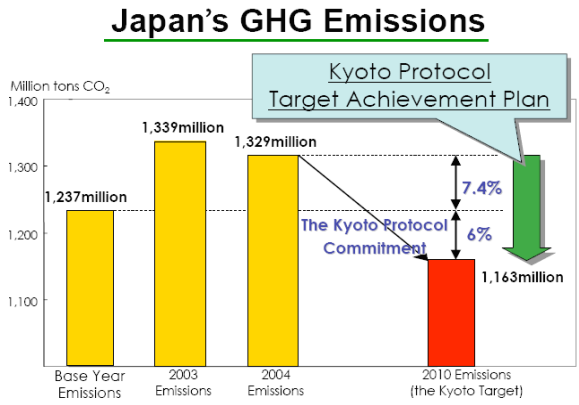


Figure 2 (Koike, 2005)

The Kyoto Protocol came into force in February 2005. Later in 2005, in order to implement policies and measures to achieve the Kyoto target, the Japanese government formulated the "Kyoto Protocol Target Achievement Plan", adopted by the parliament in April 2005.

According to Kyoto Protocol Target Achievement Plan, policies and measures are based on two major key points for ensuring the achievement of the reduction commitment. One is a national campaign to encourage every citizen and business entity to take part in the actions to combat global warming. Another is the dissemination of low emission technologies such as clean energy vehicles, photovoltaic power generations and light-emitting diodes (LED:s).

The basic concepts are of the plan are:

- Environment/economy: Win/Win approach
- Promotion of Technological Innovation
- Involvement of stake holders
- Policy mix
- Annual Review and evaluation

- International collaboration

Furthermore, the plan proposed an emission trading system (ETS) and environmental tax as economic instruments. There has been some experimental work conducted on the development of domestic ETS.

An environmental tax on fossil fuels has been discussed intensively the last two years, but has not been able to reach consensus in the government yet (as of October 2006). It is viewed as a key measure to achieve the Kyoto target by MoE and the Ministry of Agriculture, Forestry and Fisheries (MAFF), aiming at making Japan a fore-runner in the field of environmental technology by applying the revenues from the tax to the development of new technologies in areas such as energy conservation. The ministries have though faced strong opposition from industrial circles, which believe an environmental tax would cause a rise in prices and weaken the industries´ international competitiveness.

Japans new domestic, voluntary ETS is mentioned as a way to gain experience and knowledge about cost-effective emission reductions and trade. The plan states that the effects of ETS should be carefully studied, and also be compared with the efficiency of other methods when it comes to effects on industrial activities and the country's competitiveness. (Government of Japan, 2005)

3.2 Energy dependency a rising concern

As stated in the introduction, Japan relies almost completely on imports for its supply of fossil fuels; oil, coal and natural gas, and stands out as one of the few OECD members that possess almost no domestic primary energy resources. Moreover, the transportation of these imports brings about both high costs and instability of supply since Japan is not connected by land to its neighboring countries and quite distant from regions with abundant natural resources, e.g. the Middle East. Therefore, the question of how to acquire a cheap and stable supply of energy is the most critical challenge that Japan faces in the formulation of its national energy strategies.

The recent increase in energy prices and the development at the international energy markets, has spurred the government to set out a new, national energy strategy. The new strategy shifts focus from deregulation, highlighted in the strategy from the 1990s, to national security. Moreover, the new strategy highlights solutions on energy related environmental concerns and how Japan can contribute to increased international collaboration on energy issues.

Five specific goals to be achieved in 2030:

1. Reduce oil dependence (from 50% to 40%)
2. Reduce oil dependence in the transport sector (from 98% to 80%)
3. Larger share of nuclear power (from 29% to 30 - 40%)
4. Improved energy efficiency by 30%
5. Larger share of oil produced by Japanese corporations (from 15% to 40% of the import)

Japan has so far been late coming in implementation of bio-fuels. Nevertheless, an important part of the strategy consists of measures within the transport sector, and the strategy sets out a goal on increasing the maximum portion of bio ethanol in gas from 3% to 10% and the government is planning to enact a new law within a few years to mandate all newly produced cars to be able to run on a mixture of 10% bio ethanol. Today's level for new cars is a mixture of 3%, but the supply is still very limited. (METI, 2006c) An important part of the energy policy is the actions to promote new energy technology.

3.3 Eco-business market

The "environmental industry" suffers on a global scale from a lack of clear identity and poor representation as a sector of its own right. Japan has, along with e.g. Canada and the U.S. adopted broad definitions of the environment industry. (ITF, 2001)

According to the OECD classification, environmental businesses include waste treatment, development of equipment for preventing air pollution, development of equipment for preventing air pollution, and provision for education, training as well as information services. Environmental Technology Action Plan (ETAP) include all technologies whose use is less environmentally harmful than relevant alternatives - and encompass technologies and processes to manage pollution (e.g. air pollution control, waste management), less polluting and less resource-intensive products and services and ways to manage resources more efficiently (e.g. water supply, energy-saving technologies). (ETAP, 2004)

The Ministry of the Environment in Japan has recognized that the environment-related businesses continuously have increased in recent years, and among these businesses in which environmentally conscious consumer behavior bring about demand for environmentally-friendly equipment and services- covering a broad range of businesses, including the environmentally businesses classified by the OECD. The ministry has named these businesses "*environmentally-induced businesses"* and predicted their market size and employment potential, see figure 3 below. (MoE, 2004)

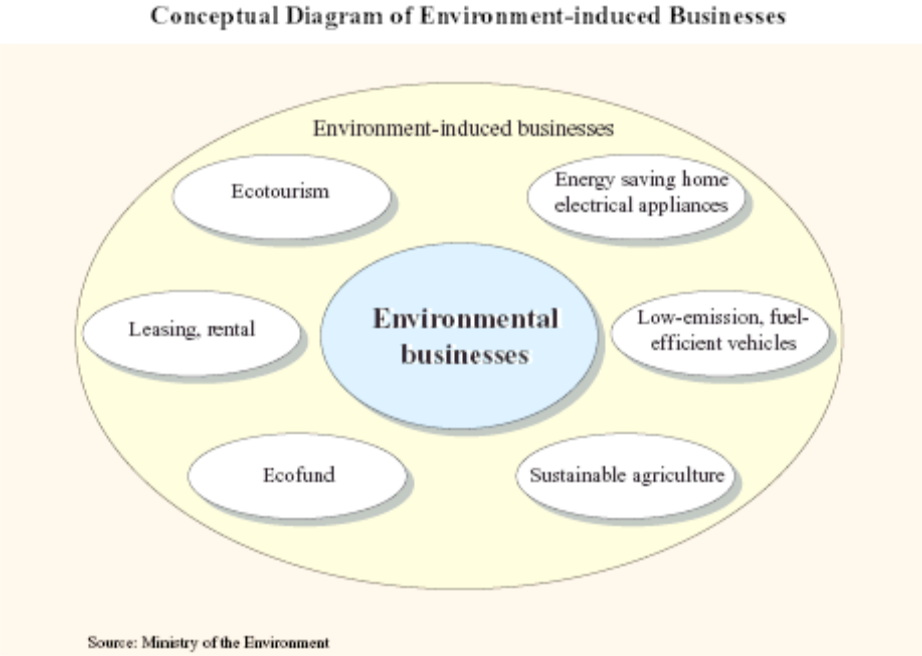


Figure 3 (MoE, 2004)

Though lacking from an absent of clear definition, the structure of the environmental industry is continuously growing and changing. The current market is today dominated by developed countries in North America, Western Europe and Japan. Emerging markets in Asia and Latin America are also growing steadfastly as environmental protection climbs higher on the priority lists. Developing countries are demanding environmental goods and services, and aid agencies are placing a bigger emphasis on environmental performance in their funding support programs, including the Japanese JICA. (ITF, 2001)

In a report, released by MoE in 2003, the market size based on the OECD classifications was approximately 30 trillion yen in year 2000 (approximately 2 trillion SEK[2]), and the expected expansion was estimated to approximately 47 trillion yen (3.1 trillion SEK) in year 2010 and approximately 58 trillion yen (3.9 trillion SEK) in year 2020. In this calculation, the environmental business market was defined as the provision of products and services that measure, prevent, reduce, minimize or improve negative impacts on the environment including water, air, soil and problems related to waste, noise and ecosystems. (MoE, 2003 in JETRO, 2006b) The large-scale sales were stated in the areas of:

- Waste treatment services and the manufacture/construction of waste treatment facilities
- Resource recovery and recycling.

[2] *Please observe: This and the following calculations are made with the exchange rate 1 SEK= 15 yen*

Other sectors predicted to enjoy sizable growth in market size and employment is the consulting sector, the photo-catalytic system sector and the fuel cell battery sector. These and the following sectors are also expected to experience market growth (JETRO, 2006):

- Manufacturing of air pollution control equipment and pollution preventing resources (photo-catalytic system, catalysts, emissions treatment devices etc.)
- Education, training, information supply (environmental reporting, auditing, consulting for obtaining ISO 14000 etc.)
- Environmental burden reducing and energy saving technology and processes
- Energy saving and energy management (fuel cell cars, new energy etc)

Another forecast of the "*environmentally-induced businesses*", including environmental businesses, by MoE show that the market size would increase from approximately 41 trillion yen (2.7 trillion SEK) in 2000 to 103 trillion yen (6.9 trillion SEK) in 2025 and the size of employment would increase from approximately 1.06 million people in 2000 to 2.22 million people in 2025. (MoE, 2004)

	Market Size (trillion SEK)		Workforce (people)	
	2000	2025	2000	2025
Environmentally-Induced Business	2.7	6.9	1060000	2220000

Figure 4 Estimates of the current and future market size and employment potential of environmentally-induced businesses (MoE, 2005)

4 Governmental R&D in the environmental field

The R&D intensity in Japan is the third highest in the OECD area, and in 2005/06, total R&D spending in Japan (industry and public sector) was ¥21 trillion, with a R&D/gross domestic product (GDP) ratio at 3.1% (OECD, 2006). Government R&D investments account for approximately a fifth of total national investments, with Japanese industry accounting for most of the remainder.

The Governmental R&D-funding excluding institutional funds to universities and some competitive funds in environmental field for FY 2005 was 149.3 billion yen (9.95 billion SEK), representing a share of 7,5% of the total budget. Compared to fiscal year 2001, the budget increased by 63%, an exceptional increase also compared to the other so-called primary prioritized areas, as illustrated in figures 5 and 6 below.

Council for Science & Technology (CSTP) was established in the beginning of the new century established in the cabinet office, and has since then been serving as the control tower responsible for co-ordinating S&T policy from a government-wide perspective. Still, the actual financial contribution within the environmental field (as for others) stems from several ministries, whom continue to draw up own strategies and roadmaps as guide lines and for input to CSTP.

The main purpose of this chapter is to grasp the central changes of directions set out in the government's plans, both the central on from CSTP, as well as to analyze the content and implementation of the strategies from ministries and key research institutes related to

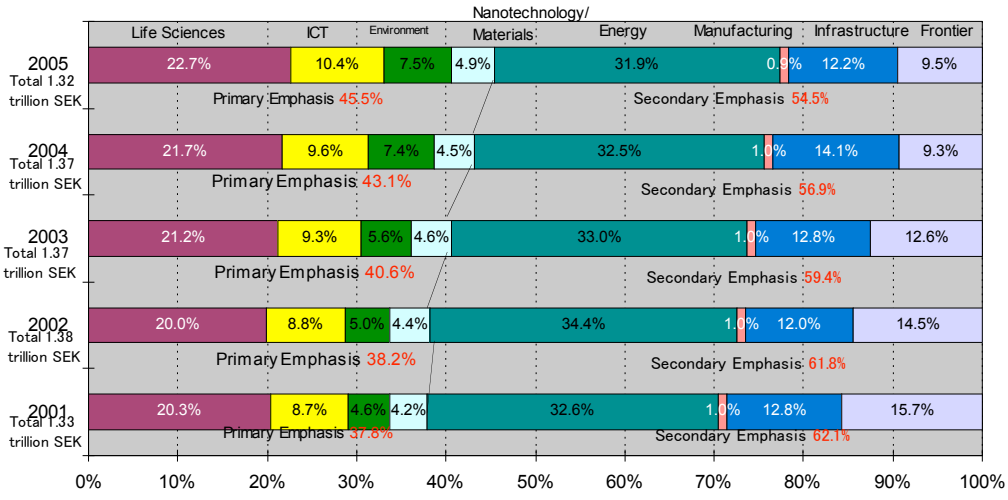


Figure 5 (CSTP, 2006)

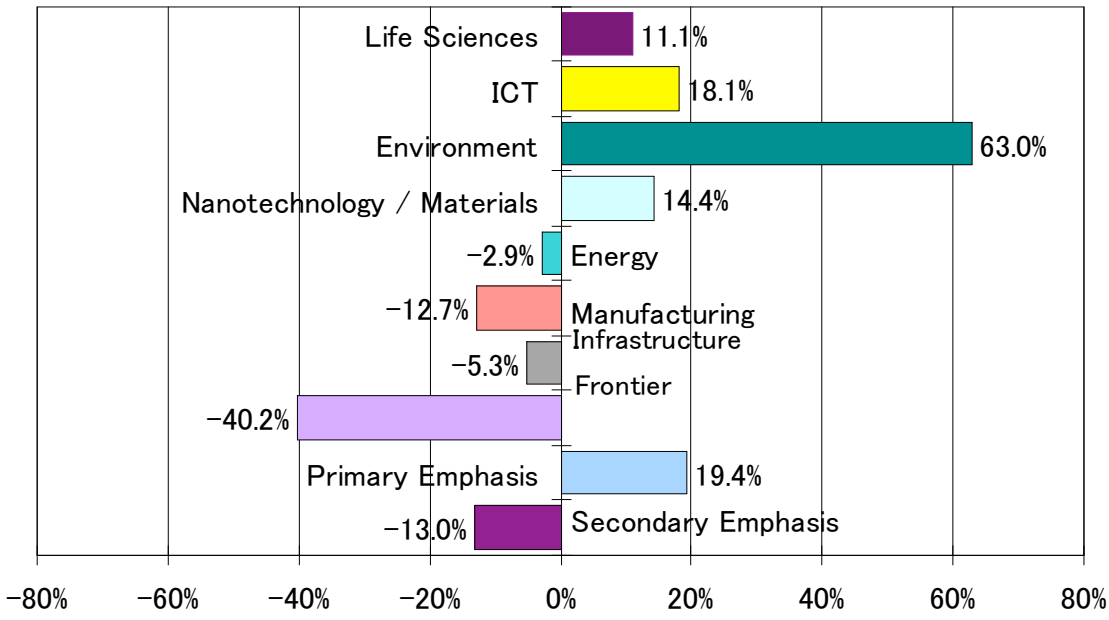


Figure 6 Budget Figures for CSTP (CSTP, 2006)

4.1 Research funding system

As in Sweden, the financial contribution to research in the environmental field comes from a number of different governmental sources. In Japan, the main ministries involved are MoE, MEXT, METI, MAFF and MLIT.

MEXT and other ministries promote research and development related to their missions through their national institutes, through institutional funds and grants to universities and contracts with private corporations. The national R&D institutes, attached to the different ministries, are representing a much larger component of research financed by the government compared to research institutes in Sweden.

There are also several independent organizations which are fully funded by several ministries, from where researchers can apply for funds directly. For example, both the Japan Society for the Promotion of Science (JSPS) and the Japan Science and Technology Corporation (JST), funded by MEXT, have significant grant programs. Likewise, the New Energy and Industrial Technology Development Organization (NEDO), which is fully funded by the Ministry of Economy, Trade and Industry (METI), provide grants for research related to energy and new technologies.

The largest share of the government budget for science and technology goes to the Ministry of Education (MEXT), accounting for 63.7% of the total budget, followed by that of the Ministry of Economy, Trade and Industry (METI), which accounts for 17%. The majority of MEXT's budget is spent on institutional fund for national universities. Primary awardees of funding from the Japan Science and Technology organization (JST), the funding agency under MEXT, continue to be universities and governmental institutions. (OECD, 2006b) [3]

[3] *For a comprehensive overview and in depth analysis of the research funding system in Japan, please refer to Stenberg, L. (2004) Government Research and Innovation Policies in Japan, ITPS A2004:001*

4.2 New administrative structure

In January 2001, there was a major reorganization of the core ministries and agencies. The changes included the establishment of the new "Council for Science and Technology Policy (CSTP)" and the "Council for Economic and Fiscal Policy (CEFP)" in the Cabinet office, as well as a merger of the Ministry of Education, Science, Sports and Culture and the Science and Technology Agency of Japan (STA) to form the Ministry of Education, Culture, Sports, Science and Technology (MEXT), with the aim to unify the responsibilities for science and technology and for promotion of academic activities.

Moreover, 68 national research institutes were reorganized into independent administrative institutions in April 2001 and national universities into corporations in April 2004, and the research institutes then became able to conduct more flexible research management. Compared to their legal status before, the research institutes are now less dependent on the ministries on personal matters and for financial resources.

Since five years back, CSTP conducts planning, drafts, and undertakes comprehensive adjustments of basic science and its fiscal policy. In the annual budget formulation process, the various ministries prepare their annual budget requests with advice and guidance from their external advisory committees, and in consultation with the CSTP and the Ministry of Finance. After these budgets are submitted to the Ministry of Finance, the CSTP may suggest further modifications. Hence, CSTP provides comprehensive coordination of S&T-related policies from a government-wide perspective, giving advice on prioritizing truly important policy areas and striving to eliminate sectionalism among ministries. (CSTP, 2005) Since September 2006, the former Minister of Science and Technology Policy and one of the central players in the formulation of the Science and Technology Plan, Koji Omi, has become the Minister of Finance. This may indicate a bright outlook for science and technology funding the future. (Stenberg, 2006)

4.3 New basic plan for Science &Technology 2006-2010

The basic law for S&T was adopted in 1995 and the following year, the first Science and Technology Basic Plan was launched by the Japanese government, covering the period 1996-2000. A second plan was adopted in 2001, and placed particular priority to four broad fields during the years 2001-2005: Life Science, IT, Environmental Science & technology and Nanotechnology/materials.

The third basic plan for fiscal year [4]2006-2010, was adopted in December 2005, and gives continued priority of the four fields stated above, including environment.

According to the third plan, government R&D investment should be 1% of GDP between fiscal year 2006 and fiscal year 2010, in total about 25 trillion yen (approximately 1.7 trillion SEK), one trillion more than the actual target for the second plan and 6 trillion more compared with the first plan adopted in 1996.

[4] *Fiscal year in Japan runs from April-March the succeeding year*

4.3.1 Core standpoints of the 3rd basic plan

The plan includes important system reforms, and shifts emphasis to investing highlighting human resources and exemplifying the principles from "hard" to "soft", as well as greater significance of individuals at institutions. One important difference in the new plan compared with the second, is the chapter on public confidence and engagement promoting public understanding of S&T. (Takemura, 2006)

Reforms will e.g. introduce schemes to encourage young researchers, increase opportunities for female researchers, to attract outstanding researchers from abroad and provide opportunities for excellent senior researchers. It also sets out that the research environments must be made more competitive, by e.g. increasing general competitive research funds. (Yakushiji, 2006)

Another prominent feature of the plan is to implement a system reform towards world-class excellence in S&T. In order to strengthen development in the sciences and constant innovation, a high priority is to work for further reform of the university system and stronger competitiveness in higher education by setting the goal of creating about 30 world-class centers of excellence. Furthermore, as a base of industry-academia-government collaboration, "advanced research centers on integrated fields for innovation" will be created and supported to provide continuity of assistance from basic research to applied research in the effort of stimulating innovation. One more prominent feature of the 3rd basic plan is to make effort to further develop international co-operation in S&T. In specific terms, this means promoting an early commencement of ministerial meetings among Asian countries to tackle common themes through policy-related information exchange and concrete S&T cooperation. (Matsuda, 2006)

CSTP has declared three key ideas and six central goals, reflecting the plans basic stances. Among them there is one a goal for "sustainable development- economic growth & environmental protection".

4.3.2 Environmental science continued primary prioritized field

The four prioritized fields, laid out in the second basic plan and still emphasized, are given continuous status as "primary prioritized areas", see below:

<u>The "primary prioritized areas":</u>

- Life science
- Information & Communication technology
- Environmental sciences
- Nanotechnology and materials

The "secondary prioritized areas":

- Energy
- Technological craftsmanship (Monodzukuri technologies)
- Infrastructure
- Frontier (outer space and ocean).

In the other primary prioritized areas, apart from environmental science- life science, information & communication technology and nanotechnology and materials, - issues pertaining to and application targeted towards the environment are highlighted. Development of technology in the other fields also are anticipated to contribute to the environmental applications, see below.

Life Science

- Increase in knowledge of metabolism for knowledge of functionality of and increased production of plants
- Environmental technology utilizing biological functions (bio-mimicry)

ICT

- Energy device technology and system such as electrical device with low ultralow voltage and low-power consumption
- Traceability

Nanotechnology and materials

- Nanodevice
- Nanodevice to lower energy consumption
- Use in sensor technology for environmental monitoring
- Innovative material to realize high efficient energy- as material for power generation, magnetic material for efficient generators and motors, photovoltaics etc.
- Non-toxic material and technology to detect and remove toxic material
- Alternative material to rare-earth such as indium and precious metals
- New material with low environmental impact for such applications as, high efficient environmental catalyst and bio-degradable plastics. (CSTP, 2006)

To further strengthen the strategic priorities, the 3rd basic plan also makes added efforts in the selection and concentration process within each of the various fields, both in the primary and the secondary prioritized areas. Close investigation in each of the prioritized areas are therefore made to designate "*strategically focused research field",* to where budget allocation will be emphasized for the next five years. This work, called the **"**field-specific promotion strategy", was finished in the end of March this year (2006).

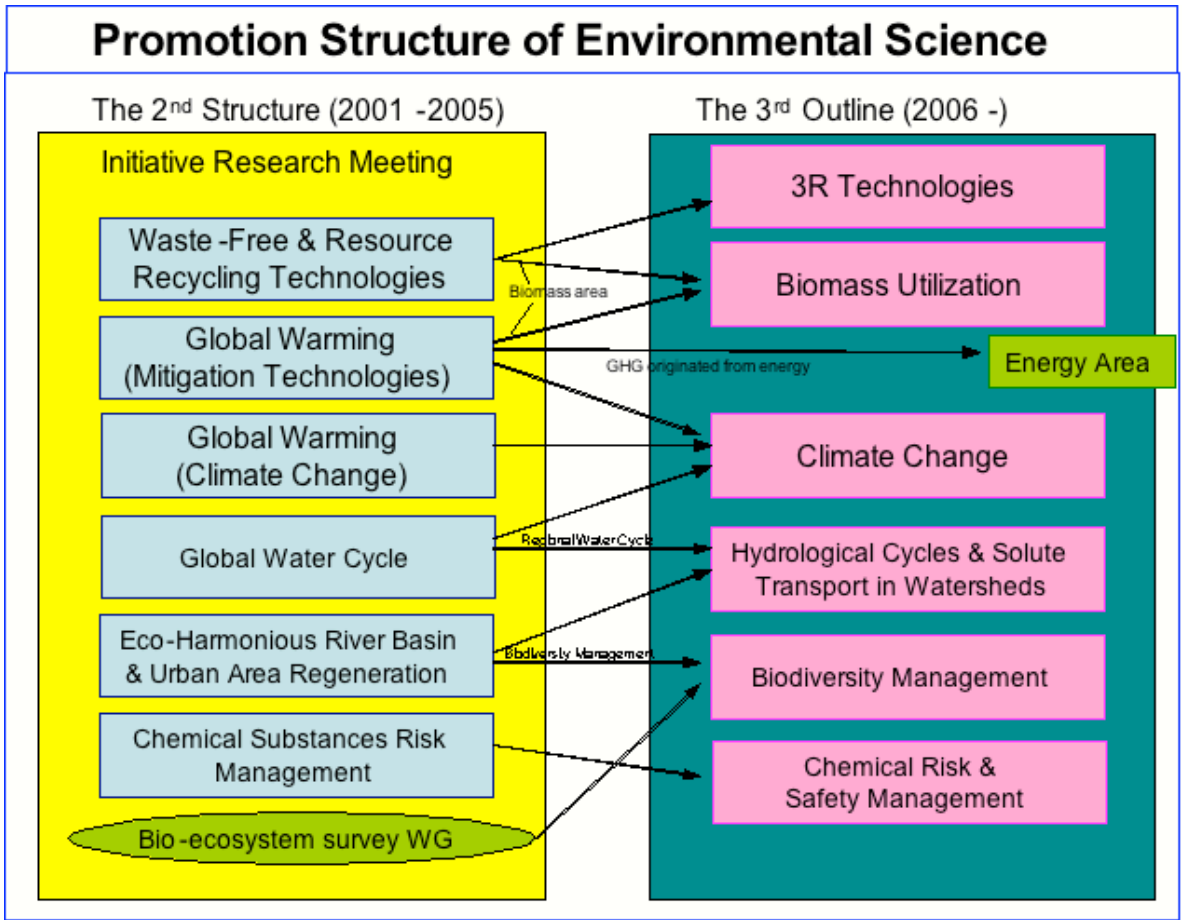


Figure 7 (CSTP, 2006)

The promotion strategies for the prioritized area of environmental science include 58 essential R&D issues and 14 strategically focused S&T, see figure above.

<u>The 14 strategically focused S&T for environmental science:</u>

Climate Change research

- Satellite observation of greenhouse gases and earth surface environment
- Climate change prediction for the 21st century by global climate modeling
- Forecast and management of climate change risk with designing carbon free social system in the future

Hydrological Cycles & Solute Transport in Watersheds research

- Basin scale environment observation and building up information infrastructure
- Social scenario design to establish eco-harmonious river basin and city area

Biodiversity Management research

- Multi-scale observation, analysis and evaluation of biodiversity
- Management of ecological service from landscape

Chemical Risk and Safety Management research

- Anticipative approach to assessment and management of new chemical substance
- Chemical risk management technologies to address international cooperation
- Human and social science for chemical risk management

3R (Reduce, Reuse and Recycle) Technology Research

- System analysis, estimation and design technologies for 3R
- Useful material and harmful substance control technologies for international 3R

Biomass Utilization research

- Utilization technologies of grass and wood biomass energies
- Biomass system technologies for a sound material-cycle society

(Yakushiji, 2006)

4.4 Ministry of Environment (MoE)

In response to environmental field being selected as one of the priority areas set in the 3rd S&T Basic Plan, Ministry of Environment is now taking initiatives to further promote environmental science and technology by increasing competitive funds for environmental research, by conducting "Environmental Technology Verification Model Project" (see section 5.2) and preparing a strategic plan of environmental S&T. (Shinsuke, 2005) In the following section, the main outline of the new strategy for funding from MoE, the "Strategy on Promotion of Environmental Research and Technology Development", is presented.

4.4.1 Strategy on promotion of Environmental Research and Technology Development

This promotion strategy, is the strategic document mainly for National Institute for Environmental Studies, a national research institute with affiliation to MoE, and for research funding conducted by the MoE, i.e. the "Global Environment Research Fund", "Environmental Technology Research and Development Fund," "Waste Management Research Fund," and "Environmental Protection Evaluation Fund."

A similar report on measures for promotion of environmental research and technology development was published based on the "1st Basic S&T (1996-2000)" and the "2nd Basic Plan on S&T (2001-2005)" and the "Basic Environmental Plan." The report based on the first two plans for S&T were structured based on the society at that time being in economic-recession, hence emphasized the need for innovation and supported close-to-implementation researches, believed to stimulate economic growth.

This current strategic document is formulated based on the 3rd S&T Plan and the renewed Basic Environmental Plan in Fiscal Year 2005 (March 2006). The characteristic of this document differing from the previous two documents are that it promotes both nurturing of the existing researches and at the same time, cultivation of new "seeds."

The strategy is intended to serve as guideline for researchers seeking for research funding, including the social and economic aspects, and set out to cover the next five years, with the next 20-30 years in mind. In the report, "sustainable society" is identified as one of the future visions. Understandably, "sustainable society" includes perspectives other than environment, notably energy supply, food supply and demand, human equality and peace etc. However, in this report, only the environmental aspect was highlighted. (MoE, 2006)

The following six areas of emphasis were previously identified by MoE in 2002, based on the 2nd S&T Plan:

- Global warming research
- Environmental risk evaluation and management of chemical substances
- Clean-up of negative environmental legacy of the last century
- Formulation of resource-circulating (recycling-oriented) society
- Development of technology supporting resource-circulating (recycling-oriented) society
- Basin existing in harmony with nature and renewal of urban areas

In the process of reviewing accomplishment of each above-mentioned areas, areas 2. and 3, as well as, areas 4 and 5 were combined. In the new MoE strategy the areas of emphasis are categorized as follows:

1. Society with no global warming

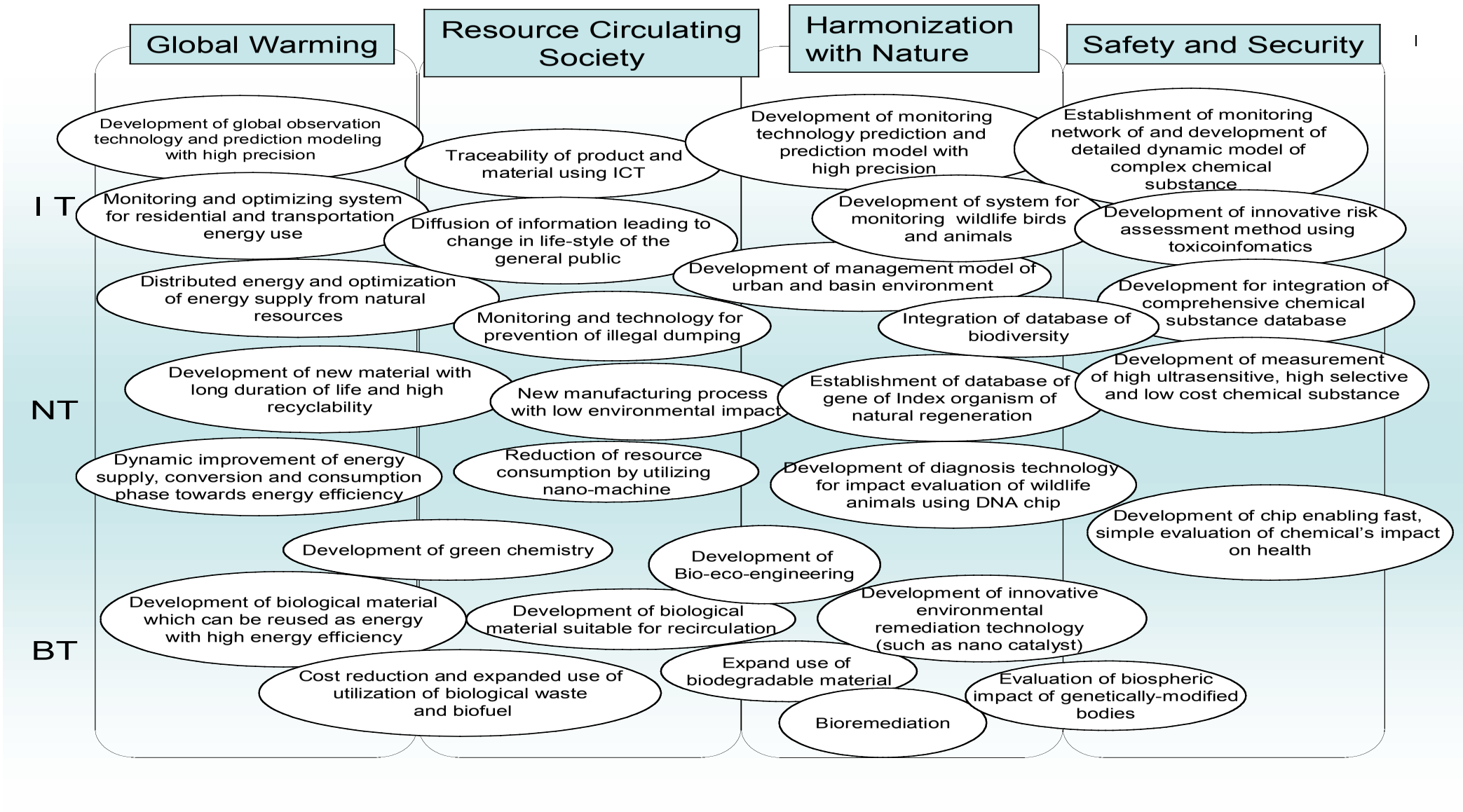
2. Resource-circulating (recycling-oriented) society

3. Society existing in harmony with nature

4. Safe and secured society with high quality of life

For each of the four areas of emphasis, mid to long term "Policy Objectives" and "Research Issues of Emphasis" and "Issues to emphasize investment" for the next five years have been identified. (See appendix 1 for an example of the first area of emphasis)

Per each area of emphasis, targets are determined. Among suggested mid-term targets are e.g. to strive for a double of the number of domestic patents and international patents in environmental area from fiscal year 2006, and to increase the domestic market size of environmental related technology (environmental industry) (yen per year) a 50% increase of predicted size in 2010. Figure 8 below presents the cutting-edge technologies identified by MoEs strategy group to contribute to the area of emphasis.


Global Warming
Resource Circulating Society
Harmonization with Nature
Safety and Security
I T
NT
BT
Development of global observation technology and prediction modeling with high precision
Traceability of product and material using ICT
Development of monitoring technology prediction and prediction model with high precision
Establishment of monitoring network of and development of detailed dynamic model of complex chemical substance
Monitoring and optimizing system for residential and transportation energy use
Diffusion of information leading to change in life-style of the general public
Development of system for monitoring wildlife birds and animals
Development of innovative risk assessment method using toxicoinfomatics
Development of management model of urban and basin environment
Distributed energy and optimization of energy supply from natural resources
Monitoring and technology for prevention of illegal dumping
Integration of database of biodiversity
Development for integration of comprehensive chemical substance database
Development of new material with long duration of life and high recyclability
New manufacturing process with low environmental impact
Establishment of database of gene of Index organism of natural regeneration
Development of measurement of high ultrasensitive, high selective and low cost chemical substance
Dynamic improvement of energy supply, conversion and consumption phase towards energy efficiency
Reduction of resource consumption by utilizing nano-machine
Development of diagnosis technology for impact evaluation of wildlife animals using DNA chip
Development of chip enabling fast, simple evaluation of chemical's impact on health
Development of green chemistry
Development of Bio-eco-engineering
Development of biological material which can be reused as energy with high energy efficiency
Development of biological material suitable for recirculation
Development of innovative environmental remediation technology (such as nano catalyst)
Expand use of biodegradable material
Cost reduction and expanded use of utilization of biological waste and biofuel
Evaluation of biospheric impact of genetically-modified bodies
Bioremediation

4.5 Ministry of Economy, Trade and Industry (METI)

METI has developed a governance system through visions and roadmaps for the technology covered by their field of responsibility, foresight exercises that coordinate various actors and sets out common goals for the future.

To realize the visions set out in the New Industrial Structure Report (N Report) published in 2004, METI has formulated Strategic Technology Roadmap (hereafter referred to as STR) in 2005 and revised it in 2006. The aim of STR is to be used as a communications tool between those involved in the projects mentioned in STR and those involved the operation of R&D. (METI, 2005) Additionally, in the New Economic Growth Strategy published in June 2006, the follow-up of the progress and policy to stimulate both demand and supply for nurturing of technology and the market for the seven strategic field, fuel cells, digital consumer electronics, robots, content, health and welfare devices and services, environment and energy device and services, and business support services, is stressed. (METI, 2006a)

4.5.1 Strategic Technology Road Map

The METIs STR is established for the following areas:

- Information and Communication
- Life Science
- Environment and Energy
- Manufacturing

For each area of STR, i) Scenario for Introduction, ii) Technology Overview, and iii) Roadmap is formulated, see below.

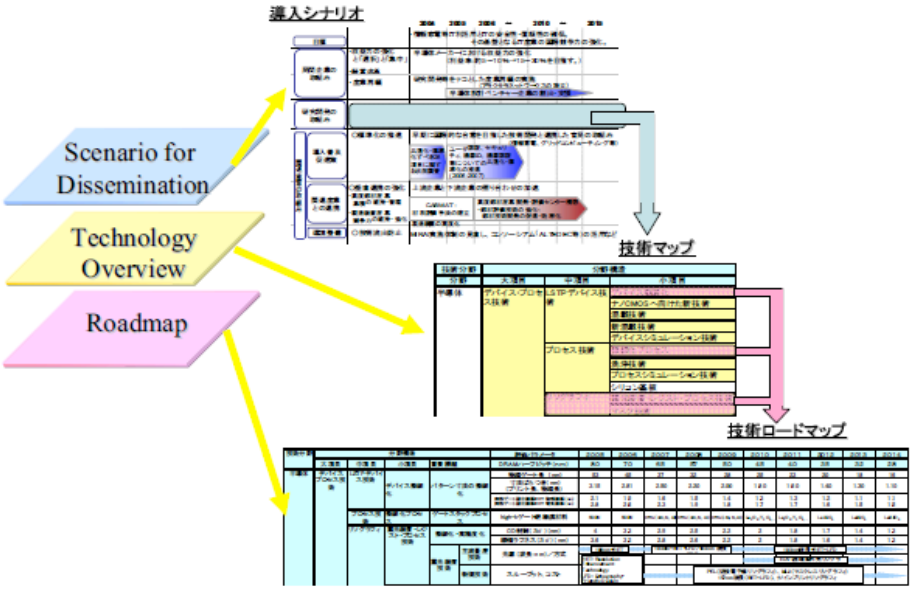


Figure 9 Structure of STR (METI, 2005)

For the process to establish the STR, task forces were established for each field by New Energy and Industrial Technology Development Organization (NEDO) and by RITE (Research Institute of Innovative Technology for the Earth) for the field of carbon dioxide capture and storage. The task forces consisted of representatives from academia, private enterprises, METI, NEDO, and National Institute of Advanced Industrial Science and Technology (AIST) in order to reflect the expertise of industry, academia, and public institutions. (METI, 2005)

For environment and energy, STR is formulated only for those fields which METI has research and development investment in, namely, carbon dioxide capture and storage, reduction of CFCs / development of CFC substitutes, comprehensive management of chemical substances, the 3Rs (Reduce, Reuse and Recycle), and energy. (METI, 2006b) (Korenaga, 2006)

The STR is comprised of three pillars in the environment and energy area, namely, energy technology, global warming prevention and environmental technology. The technologies mentioned in the STR have objectives of 1) stabilization of energy supply, 2) reduction of carbon dioxide or 3) the realization of environmentally-sound society, which is in line with the area of responsibility of METI. In particular, technologies such as resource development (methane-hydrate), fuel-cell (DME, GTL), clean coal technologies, new energy (fuel cell, biomass, photo voltaic), fluorine substitution and etc. are noted.

4.6 Center for Research and Development Strategy - affiliated with the Japan Science and Technology Agency under MEXT

MEXT-affiliated Japan Science and Technology Agency (JST) is implementing a broad range of activities in line with the objectives of the Science and Technology Basic Law and Basic Plan. In FY 2003, JST established the Center for Research and Development Strategy (CRDS) in order to strengthen their strategic planning capabilities. The CRDS group core mission is to design effective research and development (R&D) strategies and recommend them to the Government. One, out of in total 4 groups, cover the field of

environmental and energy science (Inoue group, named after its principal fellow). (CRDS, 2006)

CRDS makes bird's-eye view maps to survey all the R&D areas in each field, revised every year. They also systematically prioritize among these areas and select the most important R&D areas which are then categorized as "strategic initiative", "strategic program" or "strategic project", results recommended to MEXT. (Yokomizo, 2006) (CRDS, 2006)

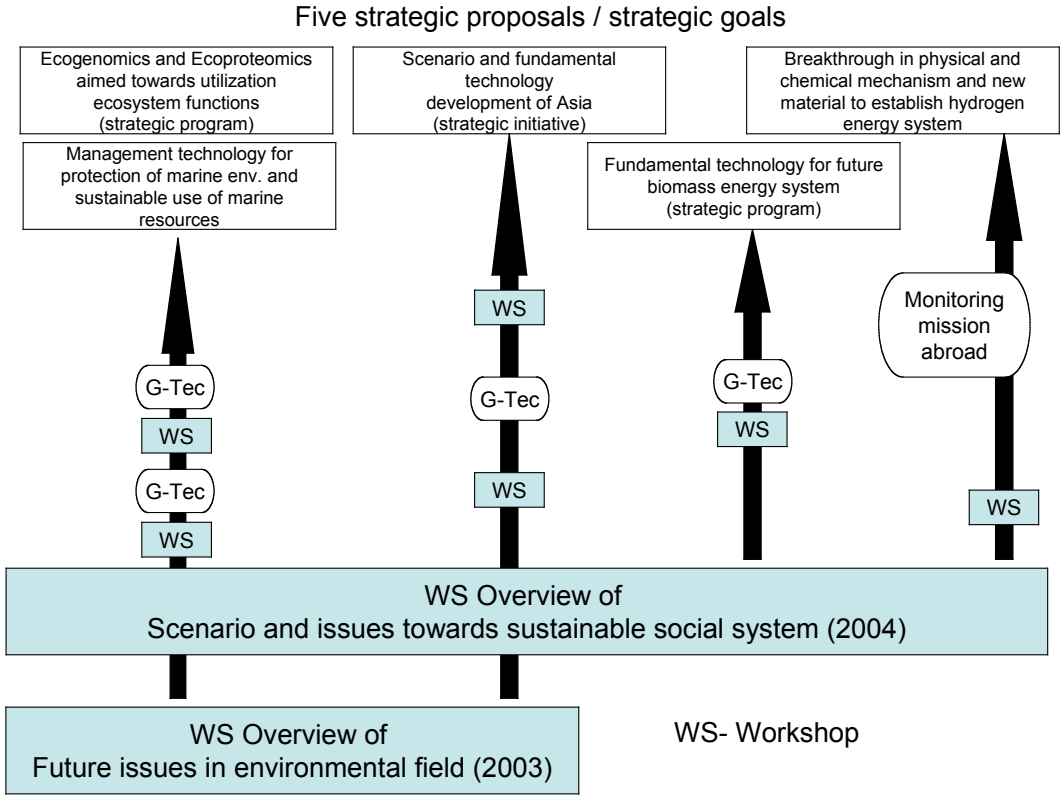


Figure 10 Flowchart of activities of environment/energy group

Derived from presentation made by Inoue, Kotaro (Inoue, 2006)

In the process of selecting important R&D areas, CRDS carry out G-TeC (Global Technology Comparison) investigations, through which they compare Japan's R&D activity level in the selected areas with that of other major countries. (CRDS, 2006) Four G-Tec reports have been published. The following are some examples of research issues highlighted as future issues for Japan in the G-Tec reports. (Inoue, 2006)

Title of G-Tec (published)	Future research issues for Japan
Japan-EU-US comparison of third generation biomass technology (May 2005)	- preprocessing and saccharization of hard biomass - parallel production of liquid fuel and material
International research and development on sustainable exploitation and management of marine bio-resources and ecosystem services (February 2006)	- observation and modeling food chain - bio-resource management based models and modeling - ecosystem based management

	- marine biotechnology
Japan-Asia research institutes/organizations overviews on development of environmental and energy technology for sustainable development in Asia (January 2006)	- monitoring, prediction, impact evaluation and observation of environmental pollution at global and local ("glocal") level - water and waste management based on cycles and fluctuation estimates in mega-cities
Japan-US comparisons and overviews on terrestrial biodiversity-ecosystem researches (May 2005)	- establishment of research program to challenge complexity and uncertainty in ecosystem - integration of data collected by different entities and utilization in models

The strategic proposals landed in a priority of 13 items, suggested to MEXT. The 5 most important according to CRDS were:

- Ecosystem,
- Renewable energy,
- Hydrogen and Fuel cell,
- Environmental assessment, maintenance & environment in Asia,
- Developing scenarios for Asia

Other items identified were: Global Warming- observation and prediction, Global Warming- Impact Analysis**,** Water cycle observation, prediction and management, Urban environment, Human impacts/toxicology, 3R, Environmentally friendly energy system, and Energy utilization with low emission

5 Key research institutes' strategies on environmental technology

In the environmental and energy fields the majority of R&D is carried out at research institutes and directed R&D projects, and only a smaller share goes into institutional funds at the universities.

The key national R&D institutes for environmental technology, covered in this study, are:

- Institute of Advanced Science and Technology (AIST)
- Research Institute of Innovative Technology for the Earth (RITE)
- National Institute for Materials Science (NIMS)
- National Institute for Environmental Studies (NIES)

5.1 Institute of Advanced Industrial Science and Technology (AIST)

National Institute of Advanced Industrial Science and Technology (AIST), formerly a national research institute affiliated with (now) Ministry of Economy, Trade and Industry (METI), since 2001 is an Administratively Independent Agency. However, a large portion of their funding comes from METI.

AIST conducts researches towards advancement of industrial technology with missions to contribute to a sustainable society, industrial competitiveness, local industrial development and industrial technology policies. (AIST, 2006a).

Research units at AIST are categorized into *research centers*, *research institutes* and *research initiatives*. Research centers are of limited-term (typically seven years) organization with clear goals and enjoy a priority to the budget and personals resources.

Research institutes aim to keep continuity of operation to implement mid- and long-term strategies of AIST. Research institutes are also expected to maintain technical potential of AIST and to develop new fields of technology.

Research initiatives are rather small units of limited-term. The purposes of research initiatives are to promote specific research projects, especially those of cross-fields. Some research initiatives also aim to meet immediate governmental needs. Researches at AIST are conducted using the "Full Research" method which covers from basic research to product realization. (AIST,2006b)

5.1.1 Research Strategy for Second Mid-term Goal Period

In AIST's Research Strategy for Second Mid-term Goal Period, (five years starting fiscal year 2005) the seven future visions and six research fields are established, see below.

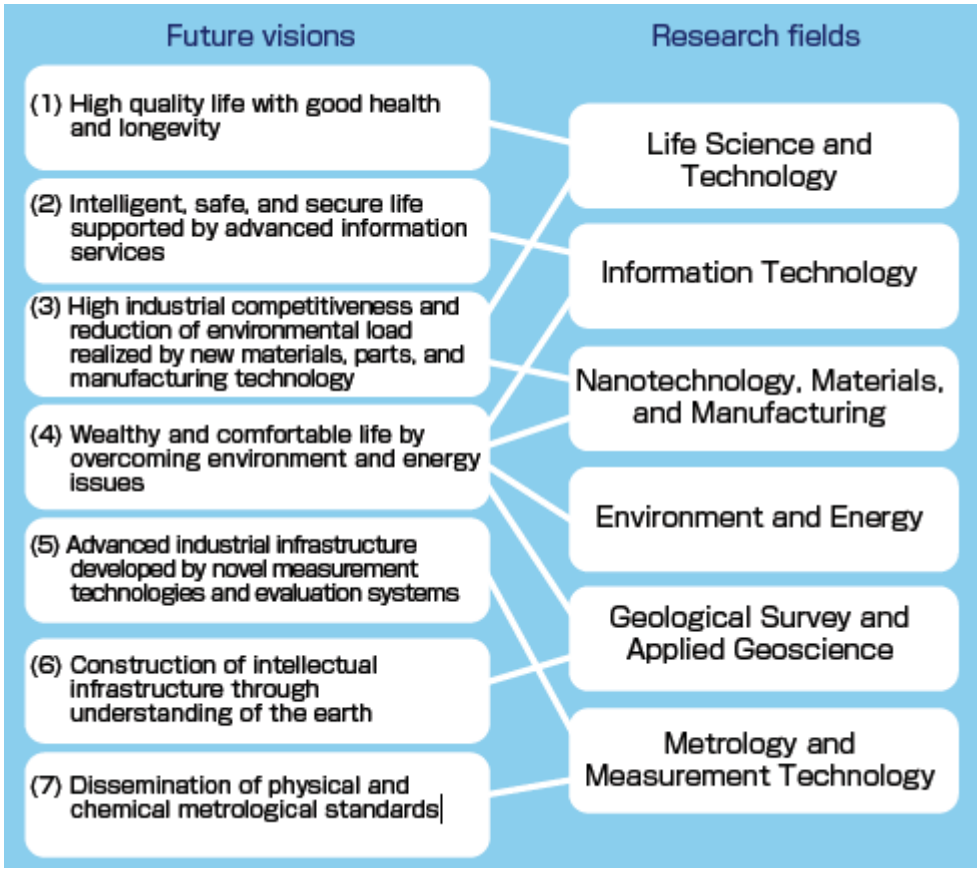


Figure 11 Future Visions and Research Fields (AIST,2006b)

For each research field, a multi-layered structure is established to fulfill the corresponding future visions. For each strategic goal, strategic research subjects are determined. Both strategic goals and strategic research subjects are identified based on social, industrial and governmental needs and overall vision of AIST; they are determined by top-down process. On the other hand, focal research subjects, which are determined for strategic research subject, are established by the potential of the research units, thus by a bottom-up process.

In the field of environment and energy, 14 Research Centers, Research Institutes and Research Laboratories are operated. 32% of total budget and 24% of researchers are allocated to the field of environment and energy. (AIST,2006b)

Research strategy in environment and energy

The strategic goals, which are determined, based on the social, industrial and governmental needs and overall vision of AIST, for the research field of environment and energy are as follows:

1. Providing optimal solution for environmental and safety matters through integration of environmental diagnosis, assessment and measurement technologies
2. Establishment of clean chemical industry with high international competitiveness through development of chemical technology with maximal eco-efficiency

3. Development of distributed energy network for carbon dioxide reduction and improvement on self-sufficiency of energy supply
4. Biomass energy to contribute to prevention of global warming

Portfolio analysis is conducted to determine the focal research subject as follows, see figure 12 below.

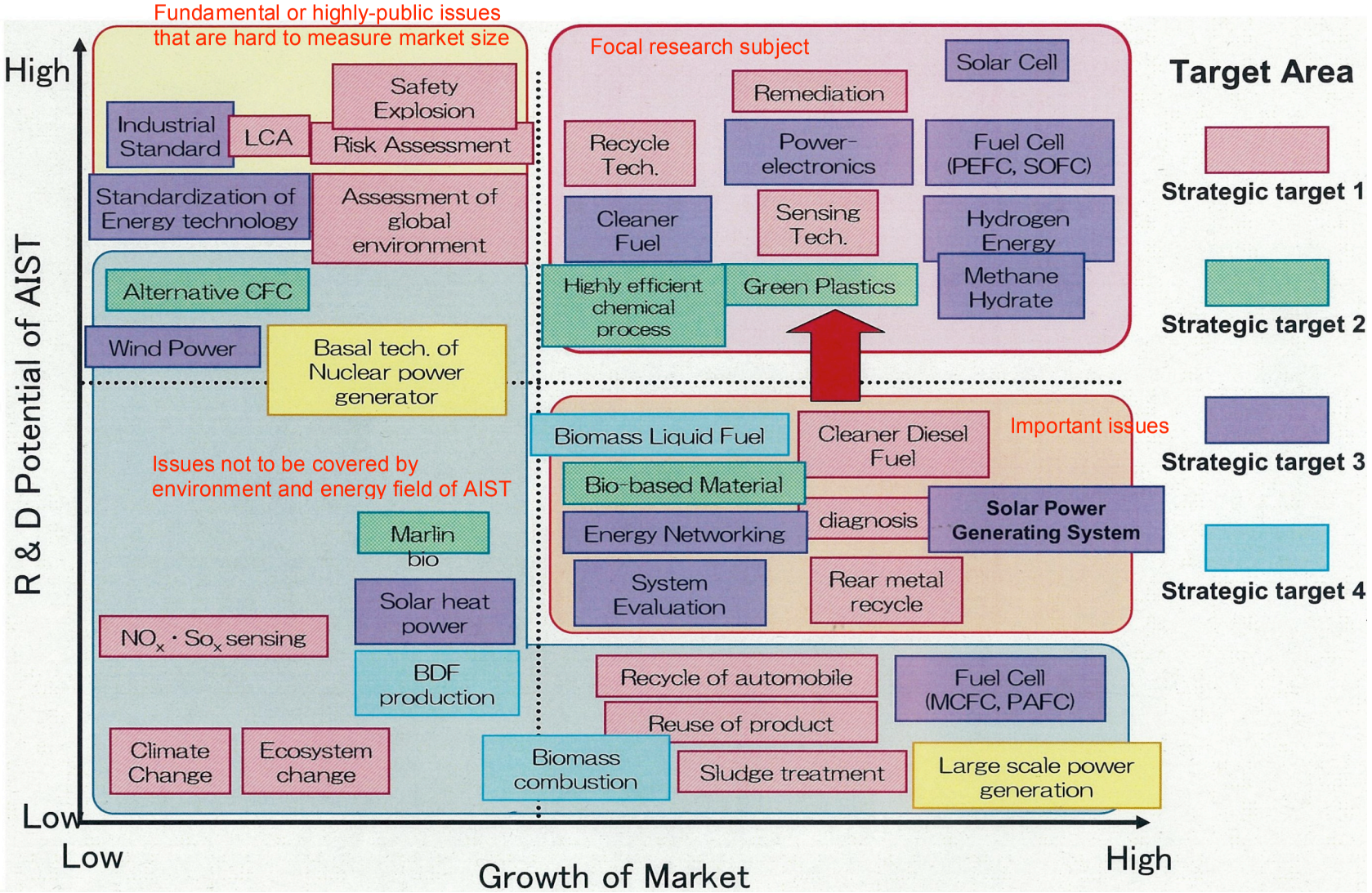


Figure 12 Portfolio Analysis

The technology strategy of AIST in the environment and energy area is established independent from the Technology Roadmap announced by METI. However, researchers from AIST are involved in the process of determining the Technology Roadmap as experts. Technology areas highlight at AIST in the strategy and those mentioned in Technology Roadmap corresponds well. (AIST, 2006c)

5.2 The Research Institute of Innovative Technology for the Earth (RITE)

The Research Institute of Innovative Technology for the Earth (RITE) is a research institute/ research funding institute under METI, established in 1990 to perform R&D and investigate industrial technologies that contribute to the conservation of the global environment and the progress of the world economy. RITE promotes development of innovative environmental technologies and expansion of CO2 sinks and CSS (Carbon Sequestration and Storage). The focus is on R&D projects that are not economic feasible to perform within the private sector, e.g. technology development of CO_2 recovery and storage.

RITE is deeply involved in drawing up the technology overview and the Strategic Technology Roadmap, METI´s navigating tool for strategic planning and implementation of R&D. One of the targeted fields is "Environment & Energy", e.g. carbon dioxide capture and storage, and a task force was set up in RITE to prepare drafts for METI. In the technology overview, RITE/ METI declares three fields of technologies whose introduction for implementation should be prepared because both of reduction potential and future cost are promising: Geological storage (aquifer, coal seam, EOR and depleted gas field), Ocean Storage (dissolution and dilution and deep sea storage) and Terrestrial storage by large scale afforestation (forest management, vegetation expansion and innovative biomass utilization). According to the Roadmap, the implementation of CSS on a world wide scale will be occurring in 2015 for both the chemical absorption and the geological storage. For ocean storage, application of the technology is expected to occur after 2020. (Takagi, 2006)

The current total cost of capture and storage in Japan is estimated to be 5,000- 10,000 yen (approximately 350- 700 SEK) /t-CO2, and 3000 yen/ t-CO" avoided is adopted as a target cost of CSS out of consideration of marginal mitigation cost in 2010. (Takagi, 2006)

The fundamental research groups at RITE are:

- System Analysis Group (proposing short- and long term strategies for global warming mitigation),
- Plant Physiology Research Group (applying the results of post-genomic research to trees),
- Microbiology Research Group (novel bioprocessing using RITE bacterium)
- Chemical Research Group (offering a route to reducing co2 emissions by a chemical approach) and

- CO2 Sequestration Research Group (reduction of atmospheric CO2 emission by geological and ocean sequestration). (RITE, 2006)

The CSS is considered a bridging technology, meaning that RITE believe that this technology is not that in decarbonized age but a technology bridging from today and future decarbonized age. Another important example of RITE studies is to find and breed trees which grow rapidly under severe condition of water supply and sunshine, i.e. those with high CO_2 absorption capacity. This may be, according to the general director of RITE, one of important study targets for RITE from now on in the institute. RITE also plans to explore new technology areas such as innovative ways of utilizing natural energy sources. (Kaya, 2006) Other important steps in the future will most likely be R&D on hydrogen and biomass. (Miyagawa, 2006)

5.3 National Institute for Materials Science (NIMS)

National Institute for Materials Science (NIMS) is a result of a merger between National Research Institute for Metals and the National Institute for Research in Inorganic Materials, since 2001 transformed into an independent administrative institution.

The 3rd basic plan promotes Nanotechnology and materials as a primary priority field. The promotion strategy set up for the primary priority field of nanotechnology, has energy/environmental related goals: e.g. materials to deal with toxic substances, materials for environmental improvement and conservation, and advanced materials for highly efficient energy use. Accordingly, NIMS's basic strategy follows the CSTP:s basic plan and has set it's Second Mind-Term Program (2006-2010) with the two main research domains:

1) Nanotechnology-driven advanced material research
2) Advanced material research for social needs

The research field "Materials research for the environment and energy" relates to the second domain, and includes the following projects:

- High Temperature Materials
- Superconductor Materials
- Fuel-Cell Materials
- Novel Photo-Catalysis
- Structural Materials

Among the projects/centers mentioned above, Fuel-Cell Materials Center and the Photo-Catalytic Materials Centers are the ones currently being most promoted, while the other fields are facing stagnating or decreasing budgets. In general, there is a greater focus on nanotechnology and functional materials, reflecting the political will of MEXT, and today approximately 80% of NIMS activities are nano-related.

According to NIMS, the first domain is increasing rapidly, mainly driven by the desires from MEXT, and the second domain which includes more conventional science and engineering is decreasing. (Takemura, 2006)

5.3.1 National Institute for Environmental Studies (NIES)

National Institute for Environmental Studies (NIES) was established in 1974, and the institute has since then been playing a major role in environmental research in Japan.

According to NIES, a variety of responses are needed to solve environmental problems and therefore a broad range of research is essential for the development of the technologies for these responses. NIES is e.g. conducting research on pollution cleaning technologies that utilize biotechnology, and on environmental technologies that can be readily adapted for use in developing countries. To combat emissions of greenhouse gases, NIES is also conducting research to develop electric vehicles, better transportation systems, and technologies to limit greenhouse gas generation from wastewater and sludge treatment, as well as research relating to social structures and systems.

In the beginning of fiscal year 2006, NIES summed up their research activities and it's findings; and made up a second 5-year program. The new program aims to include not only the ways of solving or mitigating environmental problems, but also the ways of achieving coexistence of affluent natural environment and comfortable and convenient life in cooperation with the citizens outside of the NIES. (NIES, 2006)

Special Priority Research Projects in the first 5 year program:

- Climate Change Research Project
- Ozone Layer Research Project
- Endocrine Disrupters and Dioxin Research Project
- Biodiversity Conservation Research Project
- Watershed Environments and Management Research Project
- Particulate matter (PM2.5) & diesel exhaust particles (DEP) Research Project

The Special Priority Research Projects in NIES´s second 5-year program are (*tentative translations):*

- Climate change research program
- Waste Management and Sustainable Material Cycles research program
- Environmental Risk research program
- Harmonization with Nature in Asia research program

6 Examples of measures to promote environmental business

6.1 Cluster programs – lessons to learn

Based on recognition that the eco-industrial approach is one important way forward to realize sustainable development, Japanese leaders have launched various types of eco-industrial projects around the country. (Morikawa, 2000) Within the industrial clusters, companies and other entities are organized into multi-sector collaborative "networks."

In Japan, where venture capital is limited compared with the situation in e.g. the U.S., these cluster programs can provide opportunities for critical financial support in high-risk projects. In general, they have played an important role in the promotion of eco-businesses, whom have expanded their domestic and international markets.

Among the cluster initiatives in Japan, two programs can be sorted out as of high importance for environmental business development and for gaining experiences from a Swedish perspective; METI's industrial cluster program and METI/MoE:s Eco Town-program.

6.1.1 Industrial cluster program

METI has concentrated its efforts on the recovery of economy and industrial revitalization and from this perspective played a role in the promotion of eco-businesses. Aiming at strengthening Japan's international competitiveness and revitalizing regional economies, METI has promoted the Industrial Cluster Project since FY 2001, to create "industrial clusters" that encourage new industries and businesses to be formed at the regional level. A sum of 29.4 billion yen (1.96 billion SEK) was initially allocated to industrial cluster development measures, increased year by year to a current budget level of approximately 80 billion yen (5.3 billion SEK). (METI, 2006)

Today, there are a total of 19 projects within the industrial cluster project nationwide. Targeted industries are mainly biotechnology, ICT, electronics, neo manufacturing, new energy, ecology and recycling reflecting the region's own backgrounds. (Mitsui, 2003) Among these projects, about 30% have an environmental/energy profile, involving approximately 1000 companies and 90 universities in total.

The city of Kitakyushu (described below) represents one of these industrial cluster projects in the environmental field, the Kyushu Recycle and Environmental Industry Plaza. (Nakagawa, 2004) Kitakyushu is also a part of MEXT Knowledge Cluster Initiative, established in 2003 to create innovative and internationally competitive regional bases that integrate research institutions, R&D industries or universities. In total, 10 regions have been selected, emphasizing partnership between universities and industry. The knowledge

cluster initiatives are mainly within the IT and life science field, and Kitakyushu is one of three initiatives within this particular program that focus on environment. (MEXT, 2006)

6.1.2 Eco-Town program

The main objective of the Eco-Town initiative, a policy program for the promotion of eco-industrial development in Japan, is to promote local economic stimulation through fostering environmental businesses that utilize the strengths of local industries. Local governments play a central role in activities under this program, linking local citizens and local industries in order to achieve innovative approaches to urban development that are environmentally friendly. (METI, 2006) The bottom line is that each area develops its plan in the context of region specific characteristics and advantages. For instance, the three cities of Akita, Omuta and Uguisuzawa, are developing areas abandoned after the closing of mines and are now utilizing the technologies in pollution prevention and resource extraction for the development of eco projects as an injection to the local economy. (Morikawa, 2000)

The Eco-Towns originated through a subsidy system established by METI and MoE in 1997. The national government established Eco-Towns to solve garbage problems and assist companies in declining industries such as steel and cement. Kawasaki City, Iida City, Kani City and Kitakyushu City, were approved eco-towns in the first year. Since then 25 cities have been approved eco-towns (by June 2005) and received subsidies.

The national government supports Eco-Towns by establishing the legislative system, and by designing the subsidy system. The local governments initially create an "Eco-Town plan", taking advantage of the region's local characteristics. Then, if the basic concept and concrete projects incorporated into the plan are judged by METI and MoE as meeting a certain standard of originality and innovativeness, the two ministries jointly approve the plan. Financial support is then provided for projects to be implemented by the local governments and private organizations to improve physical recycling facilities, and to implement "soft" (institutional/organizational) projects that can contribute to the realization of a sound material-cycle society. (GEC, 2005)

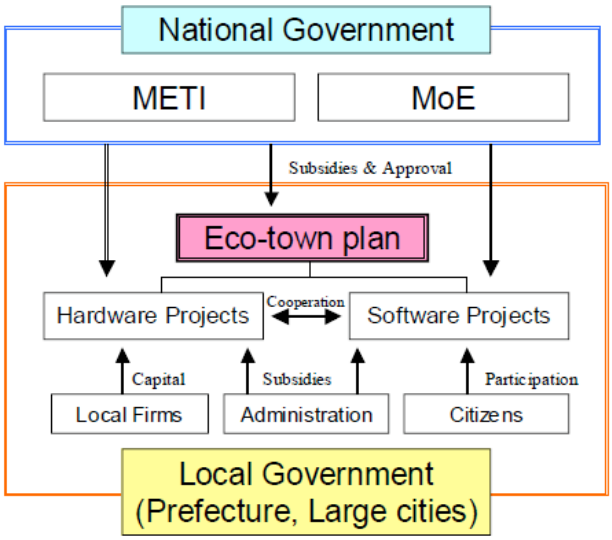


Figure 13 Eco Town Support structure overview (GEC, 2005)

There are two types of subsidy schemes of Eco-Towns: hardware projects subsidy and software projects subsidy. Hardware project subsidies are applied for effective and stable recycle or reuse projects in Eco-Towns and one third of the total cost (half of the cost when a project is particularly innovative) is subsidized. Subsidy amount for a project: 300-500 million yen (20-33 million SEK) and the total amount for hardware projects was 1.43 billion yen (0.1 billion SEK) (2004) and 2.61 billion yen (0.17 billion SEK) (2003). Software projects include Eco-Town planning, regional information projects etc. and the subsidies cover less than half of the total cost. The total amount for software projects was 110 million yen (7.3 million SEK) (2004) and 70 million yen (4.7 million SEK) (2003). The total budget for Eco Town-projects amounted to 1.54 billion yen in 2004 (0.1 billion SEK) (GEC, 2005)

The Eco-Town concept include recycling facilities, and more and more so related to 3R (Reduce, Reuse and Recycle), the building of an economy based on the life cycle-approach. In addition to 3R, the concept of eco-towns also include green procurement, green consumerism, industrial ecology, extended producer responsibility, socially responsible investment, integrated waste management, green labeling, global reporting initiative, corporate social responsibility, EMS and ISO 14001. The eco-town concept, which originally focused on the individual systems related to 3R, has now expanded and become part of the Eco-City concept- to focus on overall urban planning and urban ecosystems, civil society and greening of cities.

Main experiences and key advantages for Eco-Town stakeholders

A number of lessons have been learnt in the setting up of eco-towns in Japan, and not limited to the specified areas but to the cities as a whole where they are located. Eco-

Towns are laboratories where various different eco-concepts can be developed and implemented, and a number of developmental objectives have been simultaneously achieved: eco-towns have helped to dispose waste in an environmentally sound manner and to protect air and water resources, as well as stimulated the local economy and secured employment.

National government Eco-Town Projects have been effective in creating a concrete picture of a sound material-cycle society to the citizens in the late 1990´s, eco-town projects have played an important role in the promotion of eco-businesses, whom also have expanded their domestic and international markets, and for demonstrating Eco-Towns as models of sustainable production and consumption.

Local governments Revitalization of local economy when tax revenue has increased and new employment have been created. Environmental improvements. Administrative capability enhancement- a "one-stop-service" based on coordination among different local government divisions, which substantially decreases the burden on private companies. Image improvement.

Business The business risk has been reduced by positioning Eco-Town projects as a political measure, Accessibility to information on environmentally-friendly businesses, including CSR.

Citizens Promotion of environmental education, Increasing the transparency and openness.

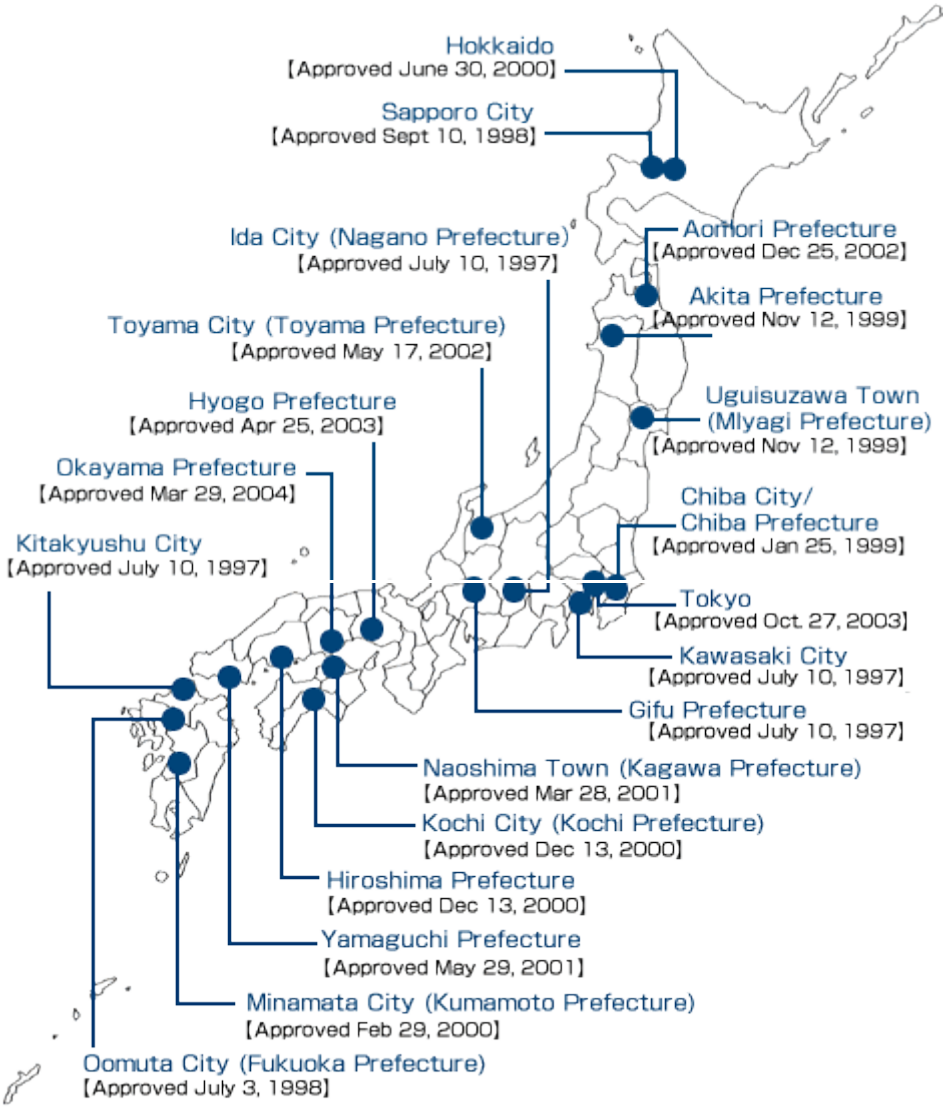


Figure 14 EcoTown, 20 zones as of April 2004 (METI, 2006)

Kitakyushu Eco-Town

Kitakyushu Eco-Town was the first to be approved in 1997 and today it aims to be "Asia's International Resource-Recycling and Environmental Industry Base City". The city has also promoted development of a special Recycling Area to locate small- and medium sized companies**.** The city leases land in the area to local SME´s for a long period of time in order to support expansion of SME´s business into the environmental field.

The main driving forces for the establishment and development of Kitakyushu Eco-Town were, according to a study conducted by the Global Environment Centre Foundation,

administrative and political leadership, survival strategies in heavy industries, and cooperation with research institutes. Private companies in heavy industry apparently played a key role in forming Eco-Town, emerging from stringent circumstances with deteriorating competitiveness and by seeing the situation as a chance to rejuvenate their operations and taking risks to invest in the new industries at that time. (GEC, 2005)

6.2 Verification of environmental technology information – a new initiative

The Ministry of Environment in Japan has recognized how advanced environmental technologies, even though they are commercial-ready and seem to be useful, have not necessarily been pervasive widely since the users such as local governments, companies and citizens, cannot make selection of those technologies because of the lack in objective assessments, concerning the performance in environmental conservation.

In fiscal year 2003, MoE, therefore launched the Pilot Project of the Environmental Technology Verification (ETV) as a trial implementation of ETV, to verify objectively the performance of the advanced environmental technologies by third parties. (MoE, 2006) The program is for advanced environmental technologies for which no objective performance data exist. However, it is not a certification program, since the technologies under the J-ETV program are not judged according to a specific standard and the evaluation of data is left up to the users.

The expectations through this project are to increase dissemination of the technologies verified, achieve environmental conservation, stimulate economic activity, and to establish a suitable method and system of ETV. The pilot period for establishing a verification system is from 2003 to 2007. Verification will initially be conducted on a trial basis in representative technological categories. This will lead to Phase 2, at which time vendors will be expected to pay for verification services. Starting in FY08, the technology categories will be expanded, and the verification program will enter into full operation.

During the pilot period, representative environmental technology categories will be selected for: (1) technologies related to major environmental challenges in Japan, and for which the need exists to find ways to encourage the diffusion of those technologies; and (2) technologies for which many companies are requesting verification.

At present, this program does *not* cover the following areas, which are covered under other programs: (1) technologies related to global warming countermeasures, (2) equipment to reduce vehicle emissions, (3) technologies related to waste countermeasures, and (4) installation of greenery on walls and roofs.

Eight technology categories have been selected related to: (1) water quality and chemical substances, and (2) the atmosphere and energy. The five technology categories under water quality and chemical substances are: (1) organic wastewater treatment for small establishments, (2) toilets for mountain areas, (3) simplified monitoring of chemical substances, (4) wastewater treatment technologies for nonmetallic elements (e.g., boron), and (5) water quality improvement of lakes/reservoirs. The three technology categories under the atmosphere and energy area are: (1) ethylene oxide treatment, (2) mitigation of

the urban heat-island effect, and (3) volatile organic compounds (VOC) treatment. (Kamita, 2005)

The next step for JETV is to enhance the benefits of verification. A verification logo will be introduced, and use of the logo will be permitted for verified technologies under conditions similar to those used in the United States (i.e., the logo does not imply certification or approval; and unauthorized use is prohibited). After completion of the verification process, the verification results will be published on their program Web sites. In FY06, symposiums will be held to raise awareness of the verification program. For each technology category, other ways, such as using verification data in government procurements, will be sought to stimulate demand for utilization of verified technologies.

The five-year pilot period will end in FY08, followed by full program implementation. After the pilot period, technology categories that have established verification methodologies will shift to a vendor-pay, fee-based system. In principle, fees will cover the actual costs of verification testing. The cost of equipment installation and removal will be covered by the applicant. In some cases, the cost may be too high for small and medium enterprises and some support for small and medium enterprises is therefore being considered. Additional technology categories will be added in FY06. (Kamita, 2005)

6.3 Targeted support for small- and medium sized enterprises

Major banks and large-sized companies were the main players of the Japanese economy during the periods of the bubble economy and the subsequent "lost decade". Needless to say, however, the Japanese economy does not consist only of major banks and large companies. On the contrary, some 70% of Japanese workers are employed by small and medium-sized companies. (Uesugi, 2006)

The main central agencies providing support for SME in different ways are the Small and medium enterprise agency, the Organization for Small and Medium Enterprises and Regional Innovation (SMRJ) and Japan Finance Corporation for Small and Medium Enterprise (JASME). Various support are given for promotion of technological development of SMEs; e.g. support for reducing and exempting SMEs from patent fees and related charges, providing special loans and exemptions from credit guarantee requirements.

As for the IT area, the governments of Japan have actively been promoting an information technology (IT) training program that would benefit employers and employees in small businesses and provide support for introduction of IT into SMEs. As for today, a similar program for environmental technology does not exist. The environmental technology related support activities are instead conducted to some extent through e.g. the eco town program (described in section 4.1.2). However, the main bulk of support within the environmental field to SMEs goes to activities related to environmental management.

Environmental technology-related, governments of Japan have offered assistance to SMEs, e.g. by promoting relocation to Eco Towns where SMEs have access to shared pollution control and waste treatment facilities. (IGES, 2006) Furthermore, in order to promote start-

ups and new ventures created through the commercialization of outstanding technology "seeds" of SMEs contributing to the rationalization of energy use, subsidies are provided to cover part of the cost of commercial R&D undertaken by SMEs and other businesses, evaluation of technologies required for commercialization activities, and acquisition of intellectual property. (JSBRI, 2005) For SMEs that are faced with environmental issues such as compliance with the Containers and Packaging Recycling Law and the Household Appliance Recycling Law, the state can also arrange for special staff at JASME to provide the companies with consulting services, and offer information on environmental issues that SMEs need by dispatching lecturers to seminars.

Environmental management-related, one of the most recent initiatives by governments is the Eco Action 21, an environmental performance assessment programme for SMEs which is less complicated and costly than ISO 14001, is promoted in many ways. Municipalities are holding seminars to disseminate the Eco Action 21 agenda, producing brochures with worksheets, and providing financial assistance for the registration of participants. (IGES, 2006)

Recently, two major Japanese financial firms, Mizuho Bank, Ltd. and Orient Corporation, launched a new lending scheme to promote and support corporate social responsibility (CSR) activities of small and medium sized enterprises (SMEs). The new scheme, started in December 2005, allows environment-conscious SMEs to obtain loans at about one percent instead of the average interest rates of 2 to 3 percent by using a jointly-developed loan product called the "Mizuho Long Partner," which provides unsecured loans and long-term support to SMEs. Some of the criteria considered when selecting eco-friendly enterprises are (1) acquisition of ISO 14001 certification or the Ministry of the Environment's Eco Action 21 certification, (2) publication of an environmental report or other similar non-financial report, (3) engagement of environmental consulting services with Mizuho Financial Group companies, and (4) a rank of A or better in the Tokyo Metropolitan Government's program to combat global warming. (JFS, 2006b)

Furthermore, Japan External Trade Organization, JETRO, (Japanese equivalent to Exportrådet and/or ISA), give special assistance to Japanese small and medium-sized enterprises that boast superior products and technologies but have difficulties entering overseas markets.

7 Main conclusions

Japan wants to stress itself as "a nation of creative science and technology", and has a high acknowledgement of science and technology as an "investment for tomorrow". The S&T policy is considered one basic pillar for balancing environmental protection with economic growth, reflected in the third five-year phase of Japan's basic S&T plan, which began in April 2006. The plan addresses Japan's most pressing problems, and sets out a potential substantial increase of funding to the environmental field.

New visions in the third basic plan include a strengthened focus on biomass & 3R. Ministries and research institutes are currently working on how to mirror and realize the visions of the basic plan into their own strategies. The ministries are highlighting applications of cutting-edge technologies and the need for an Asian perspective. The research institutes to a large extent mirror biomass and the Asian focus.

7.1 What are the areas of attention within the environmental field in the new 3rd Basic Plan for Science & Technology?

As initially mentioned, the governmental R&D-funding within the environmental field for FY 2005 saw a substantial budget increase of 63% compared to FY 2001, excluding institutional funds to universities and some competitive funds. The priority of environment as a primary prioritized field from the second plan is also confirmed in the new third plan. Thus, continued strengthened research efforts can be expected, especially since the total budget for S&T for the coming period 2006-2010 is set to increase.

The new promotion structure of environmental science in the third basic S&T plan provides a bird-eye view on how the strategic priorities within each of the various fields should be further strengthened. Notable changes of direction in the latest plan within the environmental field is the new focus on Biomass Utilization, a stronger notification on Biodiversity Management and a stronger priority on 3R technologies.

The priorities on 3R and biomass with an up-lifting of utilization technologies of grass and wood biomass energies, as well as biomass system technologies for a sound material-cycle society, is of special interest from an environmental technology perspective. Another interesting feature in the new promotion structure is the concentration of efforts towards combating climate change under one common frame of "climate change", hereby integrating efforts from three former fields of Global warming and mitigations technologies, Global warming and climate change, and Global water cycle. The amendments mark a change towards a more comprehensive outlook on climate issues. It also marks a step towards clearly targeting climate change issues in other fields, as the research area relating to GHG originating from energy is being regrouped from the environmental to the energy field of the plan's structure.

Energy is one of the basic plan's secondary prioritized areas, and a field that has experienced a small decrease in funding the last period, though energy still stands out as it is representing the by far largest share of the total funding, in FY2005 almost 32%. Among

the energy priorities, the most relevant themes with environmental technology links among the strategically focused area are, for example, energy saving technologies for urban systems, energy saving technologies for housing and architecture, clean energy vehicle technologies, high performance and low cost photovoltaic technologies, and fuel cell systems and hydrogen storage/transportation technologies. The most prominent field within the energy area is nuclear.

7.2 What strategies do the ministries' set out for environmental technology, and how are these related to the S&T Basic Plan?

MoE' s new strategy has restructured it's areas of emphasis, building on the new basic plan and set out a targets and suggested indicators for the areas chosen. Of special interest is the included list of cutting-edge technologies identified by the committee to contribute to the areas, stating important applications of cutting-edge technologies seen in areas such as nanotechnology, biotechnology, and ICT in environmental technologies.

For example, in nanotechnology, the prospective for use in environmental monitoring, impact on health and prevention of pollution are strongly stressed. Nano-biotechnology is expected to provide new opportunities for development of sensor which pin-pointed can recognize the hazardous material in the environment. ICT may contribute in many ways, but most prominently for high-precision climate prediction models, on-line monitoring system at global scale, GIS, as well as for traceability of product and material. At the same time, there is an increasing concern of ethical, legal and social issues (ELSI) surrounding the cutting-edge technologies. Research on ELSI, along with the environmental impact of those technologies, is therefore stated as essential.

MEXT strategy work is mainly conducted by JST/CRDS, whose latest strategy proposal for the environmental field highlighted biomass utilization, ecosystem and the Asian perspective. The line of reasoning for a higher priority of biomass is that Japan is currently lagging behind the Kyoto undertakings, in special spotlight since the ratification of the protocol last year. At the same time, solar should be prioritized for stationary use and bio-ethanol and bio-diesel for transport, and co-operation with more resource-endowed Asian neighbours is stressed as vital.

Based on the strategies analyzed in this report, the echoing of CSTP's priorities seems to be of different importance for different ministries. For example, MoE's new strategy has a direct reference to CSTP's 3rd basic plan as the basis for policy, while METI's roadmap does not include any such reference. Also, the research institutes seems to relate in various extents, e.g. RITE makes main connections to METI' s roadmap, NIMS relates clearly to CSTP and NIES clearly to Moe's and CSTP' s plans.

7.3 In what way do the strategies of the research institutes put emphasis on environmental technology and what are the recent changes of direction in this regard?

NIES special priorities mirror the MoE strategy closely, since they also narrow down six areas to four, with somewhat different titles but apparently a correlating content. Noticeable are a lower priority given to ozone layer research, a continued focus on climate, and a new Asian focus.

RITE institute currently has a strong focus on CSS, Carbon Sequestration and Storage. Important study targets for RITE in the future will be breed trees as well as R&D on hydrogen and biomass. NIMS activities has, as CSTP has identified nanotechnology and materials as a primary prioritized field, turned more and more focused towards nanotechnology-driven advanced, including functional materials research.

The future visions and research fields of AIST's new research strategy are interesting from foremost two angles. First, the future visions that incorporate environmental aspirations (number 3 and 4) have clearly laid out connections to the other research fields in addition to environment and energy: life science, nanotechnology, and geological survey. Secondly, the selection of focal research subjects is based on a portfolio analysis of both growth of market and the R&D potential of AIST. The result shows us that the fields with the highest potential, made out of these two aspects, are e.g. fuel and solar cells, remediation and green plastics.

Biomass combustion and biomass liquid fuel are also stressed as fields of importance for AIST, even though their current standings have a relatively low rating both for market growth and for the institutes own potential, as compared with the other focal research subjects.

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APPENDIX 1

Example of identification - Society with no global warming

Policy Goals

- Meet the First Commitment Period (2012) reduction target [short term goal]
- Establish and meet the post- First Commitment Period reduction target [mid term goal]
- Stabilization of green house gases [long term]

* note the definition of short, mid and long term differs for this area from the other.

Short- approximately five years, Mid- 20-30 years, Long- approximately 100 years

Research Issues of Emphasis

- Establishment of comprehensive green house gas monitoring system*
- Establishment of climate change monitoring and evaluation network of Asia- Pacific region*
- Increasing precision of the climate model and climate change impact prediction and management of risk from climate change*
- Research on design and policy evaluation model for society without global warming *
- Technology development of renewable energy and research on structure to promote diffusion of *
- Technology development and diffusion of new social system such as hydrogen and fuel cell*
- Research on implementation method of low CO2 emission in Asian countries through CDM and technology transfer
- Development, diffusion and evaluation of green house gas reduction technology (such as free-halogen substance) etc.

APPENDIX 2

List of Technologies

1. Development of global observation technology and prediction modeling with high precision
2. Monitoring and optimizing system for residential and transportation energy use
3. Distributed energy and optimization of energy supply from natural resources
4. Dynamic improvement of energy supply, conversion and consumption phase towards energy efficiency
5. Development of biological material which can be reused as energy with high energy efficiency
6. Traceability of product and material using ICT
7. Diffusion of information leading to change in life-style of the general public
8. Development of new material with long duration of life and high recyclability
9. Development of green chemistry
10. Cost reduction and expanded use of utilization of biological waste and biofuel
11. Monitoring and technology for prevention of illegal dumping
12. New manufacturing process with low environmental impact
13. Reduction of resource consumption by utilizing nano-machine
14. Development of biological material suitable for recirculation
15. Development of monitoring technology prediction and prediction model with high precision
16. Development of system for monitoring wildlife birds and animals
17. Development of management model of urban and basin environment
18. Integration of database of biodiversity
19. Establishment of database of gene of index organism of natural regeration
20. Development of diagnosis technology for impact evaluation of wildlife animals using DNA chip
21. Development of Bio-eco-engineering
22. Expand use of biodegradable material
23. Bioremediation
24. Establishment of monitoring network of and development of detailed dynamic model of complex chemical substance
25. Development of innovative risk assessment method using toxicoinfomatics
26. Development for integration of comprehensive chemical substance database

27. Development of measurement of high ultrasensitive, high selective and low cost chemical substance
28. Development of chip enabling fast, simple evaluation of chemical's impact on health
29. Development of innovative environmental remediation technology (such as nano catalyst)
30. Evaluation of biospheric impact of genetically-modified bodies

Bilaga 3

Research, Development and Demonstration Strategies on Environmental Technology – Suggested foundations for a Formas-VINNOVA policy

Authors:
Pontus Cerin
PhD, IVL Swedish Environmental Research Institute
Ulrik Axelsson
Manager, IVL Swedish Environmental Research Institute
Östen Ekengren
Vice President, IVL Swedish Environmental Research Institute

Executive Summary

The aim of this report is to provide information for Formas and VINNOVA to utilise in their development of a common strategy for their forthcoming environmentally adopted collaborative program. The structure of this report follows the assignment given by Formas and VINNOVA to explore how three different aspects can and should influence the design of their forthcoming program. The three parts of the study, that each could constitute a report of its own, are: *Definitions of environmental technology*, *Development trends in the world's vast latecoming economies* and *Comparative study on environmental policy-making processes for environmentally adopted solutions and technology transformation*.

The conclusions from the first part of the study are that there exists numerous definitions on environmental technology and on the concept often used in association to it: sustainable development. The wide definitions used in statistics make the picture of the importance of environmental technology erroneous since it is too inclusive, but for the purpose of the Formas-VINNOVA research program a wide definition should be applied, merely focusing on whether the suggested technology will improve environmental performance compared to alternatives. Formas-VINNOVA should not engage in developing a new definition on environmental technology of its own.

The conclusions from the second part of the study are that the need in the world's large latecoming economies for environmental technology is – by far – to solve the obstacles that arise from A) the huge internal migrations from rural areas to urban areas where some of the largest cities in the world will be created. Access to infrastructures like running water and sewage, waste disposal system, electricity, communications and transport systems will be of outmost importance. Also the rural population needs access to e.g. water and energy which can be solved by stand alone systems where the costs are to high for constructing entire networks. The other important problem that needs to be solved is that B) the resource scarcities will become even more severe when the buying power increases in the most populous nations of the world which will require product and service solutions that are considerably more resource efficient that currently today, in some cases radical innovations will be required.

The conclusions from the third part of the study are Swedish policy processes have not always provided Swedish industry with competitive advantage. In the case studies included in the third part of this study, on the contrary, the Swedish policy process has been rather lax. The interesting comparison is made to the policy processes in Japan and their culture of collaborating between government and industry through industry associations that play a central role in the process. Seemingly the Japanese proactiveness in establishing environmental policies has been followed by Japanese firms making use of their competitive advantage on other world markets. Another finding from the study is that when trying to learn from the policy processes from other nations it is vital that an understanding about the environmental conditions and constraints (resource availability), the size and power relations between the involved actors as well as understanding society structures in which government and industry interact. Japan could e.g. be characterised by East Asian corporatism while small open economies in Europe are neo-corporativistic countries. Without such awareness the risk of making simplistic and faulty conclusions when learning from other policy measures will be higher. The third part of the study has, moreover, detected that a prerequisite for the international trade in the very nearby future may be the environmental requirements, standards and technical legislation implemented in China and India, as with the fargoing Chinese RoHS legislation to enter into force during 2007.

When considering the size of the coming Formas-VINNOVA programme for environmental technology the recommendation is to make the programme focused on e.g. technology development or demonstration projects. To gain greatest leverage it is vital to figure out how the programme can fit into the landscape of programs that support environmental technology in Sweden and thereby fill the gaps in support that Swedish environmental technology actors are experiencing today.

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A. Introduction

Environmental technology has increasingly become a core interest in political, economic and scientific discourses during the early years of this millennium. The reasons are obvious: in a period when people in the already industrialised countries are facing challenges as regards resource depletion and environmental pollution, growth processes are taking off in several, primarily Asian, countries thus speeding up the environmental degradation processes. At the same time the obvious need for enormous efforts as regards environmental conservation creates opportunities for new industries and technologies that can contribute to solving the anthropogenic environmental problems now reaching heights never seen before on a global scale. There is, thus, a hope that the old countries (industrialisation wise) – drawing on the experiences of environmental conservation policies and strong environmental quality demands – may have a well-built position in this structural change towards sustainability which is ahead globally. In short, that is the background for many recent policy related activities in Sweden and other OECD and EU countries within the environmental technology area (cf. e.g. Swedish Trade Council, 2005; EC, 2002; EC, 2003; EC, 2004; NUTEK, 2003 and VINNOVA, 2003).

A.1. The assignment to Formas and Mistra

The aim of the programme assigned to Formas and VINNOVA by the Swedish government is to create a jointly financed research program on environmental technology in collaboration with Swedish industry and other affected actors. There are two documents that set the foundation for the program design. The first document is a proposition made by the government Mach 2005 on how to create improved life through research – *Forskning för bättre liv* (Regeringen, 2005a). The other document is the decision from the Swedish Government, Ministry of Industry, Employment and Communications, to VINNOVA providing directives for the budget year 2006 (Regeringen, 2005b), concretising the outlines drawn in the government proposition made in early 2005.

The directive states that Formas and VINNOVA shall together develop a research strategy on environmental technology in collaboration with industry and other

affected actors. The research program shall be co-financed by the government and industry and other prerequisites for research shall be illuminated by Formas and VINNOVA as well as how to make the participation of small and mid sized enterprises easier. The strategy shall consider the priorities made within ETAP as well as the potentials for collaboration with SWENTCH and Nutek's program for environmentally driven business development. The research strategy is to be presented November 1st, 2006.

A.2. The assignment by Formas and Mistra – essence and structure

As described above in this report the task of this study is to provide information for Formas and VINNOVA to develop a common strategy on their forthcoming environmentally adopted collaborative program. The work description by Formas and Mistra is divided into three distinct segments which each can be viewed as a project of its own. Even though the three parts of the assignment can be framed as separate stand alone studies and could constitute the foundation for making three individual reports some of the results retrieved will, when combined, provide knowledge areas where the findings of the three studies can reinforce each other in the suggestions made to Formas and VINNOVA as well as providing a more holistic picture of the outcomes of the individual sub-projects.

The report has consequently been divided into three main sections, dealing with one task each in accordance with the assignment from Formas and VINNOVA. The three parts of the Formas and VINNOVA are:

Part I – Definitions of environmental technology: The first part of the project is to study the definitions of environmental technology, both wide and narrow, that is applied by actors for different purposes. The chose scope of environmental technology in e.g. a policy instrument, statistics or funding program will influence their outcomes. Definitions of special concern in this sub-project are those made by ETAP and Nutek.

Part II – Development trends in the world's vast latecoming economies: The second part of the project is to forecast future societal conditions especially in the vast rapidly

transforming latecoming economies. By applying the perspective one to a few decades from present an economic, social and environmental forecast of these markets shall be carried out. What is the demand for goods and services in these markets and how large is the purchasing power behind these demands compared to the OECD countries? The social and environmental severities of these countries will affect their legislation. Will the regulations develop in sync with corresponding OECD legislation or even ahead to address environmental problems that are more severe? Will there also be elements of impeding foreign competition in the environmental policies of these markets? No matter which, there will be implications on Swedish and European environmental policymaking. Countries of special concern in this sub-project are Brazil, China and India.

Part III – Comparative study on environmental policy-making processes for environmentally adopted solutions and technology transformation: The third and last part of the project is to compare the environmental policy processes in Sweden to competitors that are seen as being on the frontier within the OECD in creating beneficial policies for its industry that may provide respective industries with competitive advantages in the domestic and global markets. Which actors are e.g. included in the national policy processes? Countries of special concern in this sub-project are Germany, Japan and Sweden.

On request by Formas and VINNOVA this report, suggests the basic strategies for Formas and VINNOVA and positions as regards research and research funding on environmental technology. The report does not provide a full national perspective; the aim is as limited as the Formas-VINNOVA programme which hopefully will benefit from the policy recommendations made in this study.

A.3. Report content

The core structure of the report follows the structure described in the assignment by Formas and VINNOVA, also describe in the section above. The report consists of three major parts, individual studies, and the results from each and one of them will be discussed in the concluding part of the report.

The report is, thus, structured as follows. The first section of the report contains the introduction where the assignment to Formas and VINNOVA from the government is described, followed by the description of the assignment that Formas and VINNOVA have made for the creation of this report and the introduction section ends with this outlining of report content. Part I of the report deals with environmental technology definitions and relates it to the concept of sustainable development and discusses whether it is suitable to apply a definition to this program. Following Part II of the report describes the status and development trends of the three latecoming economies Brazil, China and India that increasingly will constitute the world lead players in tomorrow's global economy. What conditions are people, environment and industry experiences today as well as tomorrow and how will this change affect global resources, environment and the need for infrastructures as well as adopted products? In the last subsequent Part III of the report is the policy processes of especially Japan, but also Germany and Sweden investigated. Which actors take an active role in the policy context and in which government-industry networks do collaborative atmospheres take place? The report is, thereafter, concluded in the synthesis and recommendations section that provides condensed information of the finding that ought to be taken into account in the development of the strategy for the Formas and VINNOVA program for environmental technology.

Part I:
Definitions of environmental technology

PI. Definitions of environmental technology

Although the expression environmental technology *a prima vista* seems easy to grasp that is far from the case. To illustrate that we may mention the fact that much of our recent economic history has consisted of making resource utilization more efficient, that is using less inputs for a given output - but including all those efforts may contribute to a too broad and loose definition. In addition the meaning of "environmental" as well as how to evaluate the utilisation of non renewable resources in various technologies may be argued. Limiting the concept environmental technology to the technology of cleaning up what others pollute is e.g. a reactive rather than pro-active approach, obviously lacking long run visions of transforming society into sustainability. In order not to end up too narrow the discussion below is commenced from a more broad perspective, i.e. with the sustainability concept (sub section 2.1) which has become the "dominant concept" of this discourse. Arguing in that sub section for a new focus on the ecological dimension of the sustainability concept we then proceed by analysing the concept of environmental technology (sub section 2.2) which is in focus for the Formas-VINNOVA task but nevertheless far from clearly defined. That analysis is followed by some short reflections (in sub section 2.4) on what could be a reasonable policy from Formas-VINNOVA as regards their R&D support to environmental technology as asked for in the recent R&D bill from the government.

PI.1. The concept of sustainability and its implications

The need for environmental technology has long been interrelated with the concept of sustainable development by many actors in society ranging from local NGO' to municipalities, governments and on the global level by UN. The concept of sustainble development has also been embraced by the business community, both internationally and nationally by larger domestic companies. The term sustainable development, for which environmental technological solutions are one prerequisite, along side with social wellbeing and stability, is however seen upon very differently by different actors. This diverging and incoherent view on sustainable development may affect the

view on environmental technologies. Therefore, is a thorough discussion on the matter taking place in Appendix 1.

The sustainable development agenda is not entirely a concept for global development used by the developed nations and the transnational corporations based there, even though it might appear so at times. China's GDP as of 2006 is exceeding US$ 1,200 and is expected to reach US$ 1,700 per capita by 2010 (and US$ 3,200 per capita by 2020) according to senior researcher at the State Council Development Research Centre Zhang Xiaoji (China Daily, 2006). When the Chinese Premier Wen Jiabao explained the 11th Five-Year Plan (FYP) proposal for the Central committee of the Communist Party of China in October 8th 2005 he also stated that the country will experience an enormous GDP per capita growth from 2006 to 20010 and during the same time cut energy costs per unit GDP by 20 percent. These two goals, according to Wen, *"...reflects the requirements for the building of an energy-saving and environmental friendly society and sustainable development,..."* (Chinese Government's Official Web Portal, 2006). This is, according to Chinese predictions, partly achieved by putting 562 coal-fired plants into operation – corresponding to nearly half the world's total at present. The Premier Wen, however, warns that the Chinese economic development excessively rides on increasing material output and sees a huge need for more efficient growth patterns that moves away from dichotomising economic development and the environment that can no longer continue. In short, the FYP may be interpreted as illustrating the strong contradictory forces between demands on increasing material wealth, on the one hand, and social inequalities and preserving the eco system, on the other hand, for avoiding social unrests and well as ensuring resources for human survival in the long term. The FYP aims, thus, for a more robust society where social inequalities are decreased and employment, education, healthcare, infrastructures as well as environmental protection are given high priority. The denomination for this goal is *the harmonious society* and it is supported by the concept of development.

Like China, India has also indicated a concern for the economic growth being first, supported by environmental and social matters. E.g. the Indian critique on the draft Programme of Implementation at the *World Summit on Sustainable Development* Johannesburg, South Africa 2002 (UN, 2006): *"Because we focus on sustainable*

development, we underplay the fact that the real problem is unsustainable consumption and the pressure it generates on the earth's finite resources. It is this attachment to unsustainable consumption patterns, and a determination to preserve and raise levels of prosperity at any cost, that breeds resistance to any meaningful reform in the financial and economic structures that underpin global society today, and results in the neglect of the development agenda. The poor are not the biggest consumers of the world's resources; the rich are. The concept of sustainable development puts an unequal burden on developing countries as their developmental aspirations are considered potentially threatening to the prosperity of the developing countries and come under close scrutiny."

The notion of sustainable development has, as illustrated above, opened up for new discourses in analysis, politics and business related to our environment in a broad sense. Although the conceptual process is far from clearly defined it allows for other alternatives to environmental degradation – i.e. pollution and resource depletion – than economic stagnation and continued social inequalities.

Actors may perceive the notion of sustainable development differently and there exist actually more than 70 definitions on sustainability (Holmberg and Sandbrook, 1992). The definitions that evolve may, however, be troublesome in another way as Welford (2000) puts it: "*There exists a strange and fruitless search for a single definition of sustainable development among people who do not fully understand that we are really talking here of a process rather than a tangible outcome.*" Welford's statement goes inline with the sustainable development strategy of Sweden (Swedish Ministry of Sustainable Development, 2002): "*Sustainable development is not a clearly defined objective, the important thing is the process of change.*".

Kofi Annan's, UN Secretary General, is quite concerned with the fact that so many people in the world live in non-sustainable environments of which far too many under sever conditions: "*Our biggest challenge in this new century is to take an idea that seems abstract – Sustainable Development – and turn it into a reality for all the world's people.*" (UNEP, 2006). But also here, even though not stressed, is the process an underlying force. Another way of looking at Sustainable development is to point at factors that are restraining its process. *Our Common Future* (1987) has

extracted the essentials as being relative limitations on the environment that relate to human organisation and technological advances: *"The concept of sustainable development does imply limits - not absolute limits but limitations imposed by the present state of technology and social organization on environmental resources..."*

The sustainability concept is, thus, far from clear, but it is not obvious that a clear and unambiguous definition is needed or wanted. "Sustainability" may, at best, serve as a tool for mobilising actors towards complex (policy) strategies containing goal conflicts; e.g. between employment and pollution. The problem, however, is whether this loosely defined and partly contradictory sustainability concept in many, most or all policy situations should be allowed to invade the individual pillars of the sustainability concept.

The position of this report is that this should not be the case. Even if sustainability is a useful concept for high-level declarations it is - on some levels at least - necessary to restore the individual ecological pillar or dimension in concrete policy situations. The technological choices have an imperative impact on the stress that humanity is posing on its life-supporting milieu. Following this argument, UNEP (2004) uses Trindale's (1991) wordings when explaining the imperative need to adopt well-informed choices in and transfer of technologies, techniques, know-how and institutions for facilitating a more sustainable development:

> *"To a large extent, the state of the environment today is the result of technological choices of yesterday. The state of the environment in the 21st century will be determined largely by the technologies we choose today."*
>
> (Trindale, 1991)

In short we argue that in an R&D programme as this Formas-VINNOVA case the ecological dimension only should be in focus. This is a stronger position than it superficially seems to be and we will come back to it below in this section. It is possible to stick to a reasonably clear understanding of the ecological dimension even within the framework of a vague sustainability umbrella. In fact this may be necessary in order not to end up including every phenomenon as environmentally important. What we mean here is e.g. that the ranking of technologies – or artefacts – according

their potential in solving ecological problems should not be influenced by their potential as employment providers. But, and that is the topic of the sub section below, also the more narrow ecological – or environmental dimension – has to be identified properly.

PI.2. The Environmental Technology concept

Environmental technology is supposed to serve, as one of several approaches, for sustainable development which is reflected in the name given to the European Commission report on environmental technology: *"Environmental technology for sustainable development"* (European Commission, 2002). There exists, however, more than one definition of environmental technology and the concept is used by organisations for different purposes and their applicability continues to be a topic for further discussions (cf. NIC, 2006). There is also, as we will se, some confusion as regards how the concept "technology" is related to concepts like "firm", "industry" etc; a phenomenon to which we will return later in this sub section.

In 1995 OECD and Eurostat retained an informal working group (OECD, 1996) that agreed on an interim definition of environmental goods and services industry which goes as follows:

> *"The environmental goods and services industry consists of activities which produce goods and services to measure, prevent, limit, minimise or correct environmental damage to water, air and soil, as well as problems related to waste, noise and eco-systems. This includes cleaner technologies, products and services that reduce environmental risk and minimise pollution and resource use."*
>
> (OECD, 1996; OECD, 2005)

The working group added that: *"For cleaner technologies, products and services, despite their importance, there is currently no agreed methodology which allows their contribution to be measured in a satisfactory way."* The European Commission also stated in their Communication that statistics on environmental technology is not available, but there is for the European ecoindustry (European Commission, 2002)

and in a Communication from the Commission the following year European Commission, 2003) they wrote that the data they *"have only captures a narrow range of environmental technologies, and includes only those that are driven purely by environmental requirements."* Also, environmental products and services are not defined satisfactory and this poses an important challenge (OECD, 2005a). The European Commission (2002) has, however, stated the purpose of environmental technology is to serve, as one of several approaches, for a more sustainable development which is also reflected in the name given to the report on environmental technology: *"Environmental technology for sustainable development."*

There is - in this policy world – not always a clear border line drawn between "technology", "industry", "good" etc. As now, when WTO ministers failed to agree on a common term, countries have created their own lists of what they regard being environmental goods. These lists usually contain goods that manage environmental pollution and or harvest renewable energy while lists from some nations also contain environmentally preferable products for consumption – i.e. bicycles and natural biodegradable materials. Also the definition of environmental services has created problems.

In short, and leaving the detailed analysis to others, it may be argued that the process of identifying environmental technologies, products, services and industries as well as relating them to an overall sustainability umbrella is highly influenced by the perceived advantages and disadvantages various countries face in the WTO negotiations. Inclusion/exclusion may impact trade conditions since environmental products are to be treated differently for tariff purposes, according to OECD (2005b). Products that are related to processes, production methods and life-cycle impacts may not be addressed and, thus, omitted in lists from these countries (i.e. the APEC list) although included in the OECD list which is based on the wide interim definition by OECD and Eurostat 1995 (OECD, 2005b). The wider environmental goods and services classification of OECD/Eurostat has only received support from Canada, EU, Japan and US. These countries regard current GATS classification being narrow and given their competitive advantage in environmental services they have interests in broadening the scope of the environmental services definition (Chaytor, 2002).

Based on the definition work by the OECD/Eurostat informal working group and in the absence of any internationally agreed product list of environmental goods OECD created a list for the purposes of studying trade and trade barriers (OECD, 1999). The list of environmental goods was divided into three main categories; A) *Pollution Management*, B) *Cleaner Technologies and Products* and C) *Resources Management*. A fourth group, D) *Environmentally Preferred Products*, was added from the United Nations Conference on Trade and Development – UNCTAD (OECD, 2005a). However, the OECD report of 2005 (OECD, 2005b) states clearly that its *"list was only meant to be illustrative rather than definite, and particularly for use in analysing levels of tariff protection."*

It is also difficult to retrieve a clear definition paragraph on environmental technology within the web portal of the European commission's Environmental Technology Action Plan that states something like: *"ETAP's definition of environmental technology:"* that is followed by a clearly distinct definition (cf. ETAP, 2006). What can be read on ETAP's Technologies page, however, is this:

> *Environmental Technologies are all around us: wind turbines and solar panels, cleaner cars, biofuels and certain washing powders, recycling systems for waste or water, etc. These are basically any technology that are designed to prevent of*[1] *reduce the environmental impacts, at any stage of the life cycle of the products and activities.*
>
> (ETAP, 2006)

Condensed, by extracting the examples, the resulting ETAP definition of environmental technology would be: "*Environmental Technologies are basically any technology that are designed to prevent or reduce the environmental impacts, at any stage of the life cycle of the products and activities."* which is a very broad description that could encompass a wide variety of products and services that may not be appropriate for defining environmental goods in national or EU statistics. In Sweden we have the example with the water pumps and fluid handling technology of ITT Flygt that all are counted for as environmental technology products in Swedish statistics which results in an erroneous picture of the size of Swedish environmental

[1] Probably a misspelling or typing error by ETAP at the European Commission. It should, most likely, be an "or" there instead of the "of".

technology sector (cf. Bråsjö & Blomkvist, 2006). It would likewise be misguiding if the Swedish statistics accounted all Volvo trucks that are equipped with Euro4 and Euro5 engines instead of Euro3 (current legal minimum requirements) as environmental technology products.

The report from the European commission 2002 on *"Environmental technology for sustainable development"* states, furthermore, very clearly – in italics – that it *"takes a broad view of environmental technology, to include all technologies whose use is less environmentally harmful than relevant alternatives."* (European Commission, 2002). Both integrated technologies that prevent pollutions from being generated in production processes as well as end-of-pipe solutions that reduce the emissions of pollutions that are created are exemplified as environmental technologies. The report also positions new materials, energy and resource-efficient production processes and know-how, and new ways of working as being environmental technologies. Environmental technology, furthermore, includes both low and high-tech applications and the commission report addresses the importance of high-tech since: *"that in a knowledge-based economy,* ***technology is increasingly about our skills and know-how*** *rather than the simple presence of industrial processes or high capital spending per employee."* (European Commission, 2002). These strong beliefs in high-tech solutions are in the Communication from the Commission in 2003 on *"Developing an action plan for environmental technology"* given some less emphasis where the report states that the concept of environmental technology *"...includes both low and high-tech applications as well as skills and know-how. For instance, relatively modest adaptations in industrial processes by means of piping, screens, filters, tanks etc, can be just as important – and more accessible - as high-tech applications."* (European Commission, 2003)

This *Report from the Commission* 2002 constitutes the foundation for the *Communication from the Commission* 2003 which has set out the broad mandate in e.g. choice of environmental issues and stakeholders when developing its action plan for environmental technologies. The high-tech focus is, however, seen as a bridge between the European Council strategy of Lisbon (2000) to make the European Union *"the most competitive and dynamic knowledge-based economy in the world."* and the

environmental dimension of European strategy of Gothenburg (2001) to create a sustainable society (European Commission, 2002; 2003; 2004).

Although different appellations of environmental technology have been applied in the European Commission documents, one in 2002 and 2003 documents and another one in the 2004 document[2], their inward sense is similar. Both apply a wide scope on environmental technology that embraces all technologies that are less environmentally harmful than alternatives, in a cost effective manner. The appellations, hence, work better as concepts for creating a common worldview where the introduced have a more or less coherent holistic picture than as definitions for scientific or statistical work and follow-up and steering in detail.

Also at the *"Workshop on Nordic Environmental Technology – Innovation and Export"*, arranged by the Nordic Innovation Centre (residing under the Nordic Council of Ministers) March 2006, it was agreed not to create another definition of environmental technology but to advocate a holistic view that comprises both hardware technology as well as software such as education, know-how and competence. The workshop came to the decision to recommend the application of the definitions used by ETAP or OECD or both (cf. Nordic Innovation Centre, 2006).

[2] In the *Communication to the Council and the EU Parliament* 2004 on how to stimulate sustainable development through the EU Environment Technologies Action Plan the Commission leans towards the documents described above from 2002 and 2003, but applies the definition on technologies dealing with environmental matters from UN Agenda 21. The tree first clauses of chapter 34 – dealing with the transfer of environmentally sound technology, cooperation and capacity-building – are quoted in the Communication from the European Commission (2004).
The three clauses quoted from UN Agenda in the European Commission (2004) for defining Environmentally Sound Technologies are:

34.1 Environmentally sound technologies protect the environment, are less polluting, use all resources in a more sustainable manner, recycle more of their wastes and products, and handle residual wastes in a more acceptable manner than the technologies for which they were substitutes.

34.2 Environmentally sound technologies in the context of pollution are "process and product technologies" that generate low or no waste, for the prevention of pollution. They also cover "end of the pipe" technologies for treatment of pollution after it has been generated.

34.3 Environmentally sound technologies are not just individual technologies, but total systems which include know-how, procedures, goods and services, and equipment as well as organizational and managerial procedures.

The entire UN Agenda 21 definition on Environmentally Sound Technologies is available in the Agenda 21 web portal (UN Agenda 21, 2006)
The Agenda definition refers to *sound* environmental technologies whereas the concepts of the two European Commission (2002; 2003) documents referred to above deals with the shorter phrase environmental technologies. UNEP's division of Technology, Industry and Economics use the Agenda 21 definition when linking sustainable development to one enabler, namely, environmentally sound technologies which have the potential to significantly improve the relative environmental performance of other technologies (UNEP, 2004).

NUTEK – the Swedish Agency for Economic and Regional Growth – has, based on the European Commission's (2002) definition on environmental technology (for sustainable development), created the term *environmentally adopted products and services*. This term to define the market of environmentally adopted products and services has received vast impact in Sweden. NUTEK has divided the term *environmentally adopted products and services* into three categories:

1 *Pure environmental technology*

   Goods, services and systems aimed for dealing with discharges, pollutions and wastes. Central application areas are water and wastewater treatment, abatement solutions for air, recycling, handling residual wastes, energy technology, emission monitoring and analysis services.

2 *Environmentally efficient products and services*

   Technologies, systems and methods that reduce the risks for the creation of environmental burdens such as through minimized resource consumption, minimised waste generation, increased use of environmentally adopted substances and materials in processes as well as products that incorporate environmentally improving characteristics (SOU, 1998:118:p. 22). Goods and services with an energy efficiency and energy economising alignment as well as gradual improvements of environmental efficiency of goods and services.

3 *Innovative environmental solutions*

   Major changeovers and system swifts that involve several stages in the value chain or markets (cf. system innovations in VINNOVA, 2003). Innovations breaking free from the prevailing path-dependence are a prerequisite which often requires a collaboration of actors and often distinguished by a technology leap. Such examples are renewable energy systems, functional sales as well as dematerialisation.

Also this definition, with the ambition to gasp over all forms of reducing environmental degradation and resource depletion, however has the problem of identifying technologies with products (and, in the extension, with industries). This may, in many everyday occasions, be a small problem. For analysts it makes sense, however, to identify the distinction. Technologies may be more or less generic and, thus, more or less applied in different industries. Environmental technologies may

well be applied in firms not classified into environmental industries. And there may well be industries which are ecologically sound although they use very little "environmental technologies". Therefore, our position is that Formas-VINNOVA in their allocating of money should avoid mistakes related to this blurring of concepts.

In a recent study Bråsjö & Blomkvist (2006) have organized firms in the environmental primary and secondary sectors following Statistics Sweden (2005) according to the business logic model (Giertz, 1999) instead of the traditional industry classification. This undertaking reveals a somewhat modified picture on the character of the environmental industry. 57% of total turnover relates to infrastructure services, e.g. solid waste management, waste water management, renewable energy production etc. These infrastructures are in this report referred to as environmental infrastructures. In short the lion part of these services is related to the municipal sector and extremely important but not necessarily related to frontier technologies. In fact to a large extent they may be labelled mature and well-known among those who use them. The gap to bridge for these actors may for many be the internationalisation step. Increasing the international activities and transferring the technologies of these firms may, however, well be an institutional problem beyond the R&D focus of the present Formas-VINNOVA programme (cf. Regeringen, 2005b:10).

PI.3. Summing up Part I

- There exist several definitions on environmental technology and environmentally sound technology. Some definitions have a narrow focus on recycling of products and processes and handling of residual wastes. Others apply a wider scope that also includes technologies that generate low wastes and pollution. Environmental technologies may also be seen as innovative solutions that takes technology leaps and changes entire systems.
- One common definition on environmental technology is ETAPs (European Commission's wide definitions. Another definition on environmental technologies that is useful is the three scope developed by NUTEK pure environmental technology, environmentally efficient products and services and innovative environmental solutions.

- Wide definitions on environmental technologies may have the problematic implication that whole industries and companies become in national statistics accounted for as environmental technology, such as water pumps, which results in erroneous statistics.
- For this Formas-VINNOVA program, however, the wide definition on environmental technology is suitable. Technologies that qualify into the program should be those where potentials exist for environmental, health and ecological improvements.
- A new definition on environmental technologies should not, within the scope of the Formas-VINNOVA program, be developed.

Part II:
Development trends in the world's vast latecoming economies

PII. Development trends in the world's vast latecoming economies

There are two major aspects that will determine humanity's impact on the environment and due to the reciprocity – since humans are dependent on the environment – these two areas where humanity impacts the environment may in turn backfire by affecting the health of humans in return. Impacts on the environment and human health are related to the demographic and economic developments, especially in the vast latecoming economies. The two most important demographic issues regards population growth and migrations, often intranational flows, from rural areas to urban densely populated areas. This huge reallocation of people requires enormous investments i.e. infrastructures in piped water and sewage water and waste treatment systems as well as investments in electricity, transport and telecommunication infrastructures. The economic development of the populous countries will increase the need for resources worldwide. This will have impacts on products and services (that can) produced for all markets in the world. There will, hence, also be a huge need for more resource efficient products as well as possible alternative services, that have the ability to replace the current resource consuming alternatives.

PII.1. Population Trends

Population estimates for the work within United Nations is carried out by the UN Population Division of Economic and Social Affairs. They have for the firs time, in their *"2002 Revision"* (UNPD, 2003), projected future fertility levels in the majority of developing countries to fall below 2.1 children per woman by 2050. In other words: 3 out of 4 less developed countries will in the mid-twenty-first century face fertility rates that are below the replacement fertility level (2.1). However, currently the global population is increasing by almost 80 million people annually. Six countries accounts for half of that annual increment. India and China belongs to this group and constitute 21 and 12 per cent of world annual population increase respectively. The only developed country in this group, USA, accounts for 4 per cent of global population increase. The developing country China has, however, already reached below its replacement levels today.

PII.1.1. Urbanisation puts huge demands on new infrastructure

The world population is increasingly living in *Urbania* and huge migrations from rural areas feed the urban areas with new inhabitants, that seek for better living conditions. These new citizens of *Urbania*, however, due to their numbers put a lot of pressure to improve and expand the city infrastructures such as transports, piped drinking water and sewage and waste handling, just to mention a few. According to UNPD (2005) 30 percent of the global population lived in urban areas as of 1950. By 2007 it is estimated that half of the world's population will be urban-dwellers and in 2030 the urban population is projected to constitute a good 60 percent of the global population.

	World		Brazil		China		India	
	Urban population		Urban population		Urban population		Urban population	
	Thousands	% of Tot	Thousands	% of Tot	Thousands	% of Tot	Thousands	% of Tot
2005	3,150,451	48.7	157,010	84.2	531,817	40.4	316,942	28.7
2030	4,912,553	59.9	214,603	91.1	872,671	60.3	589,957	40.7

Table 1: Urbanisation trends globally, in Brazil, in China and in India (Data Source: UNPD, 2006).

As seen in table 1 there is a strong urbanisation trend in the world currently, making the urban populations of Brazil, China and India outgrow their respective rural populations. The most remarkable growth-differences between urban and rural areas can be found in China. The rural population has already started to decrease as of 1990-1995, but the urban population will growth by more than 340 million inhabitants as of 2005-2030, that is a 20 percent-unit increase of the share that urban area inhabitants constitute of China's total population. The urban population in India will increase by 273 million people and despite the general population increase in India will the urban population increase its share of the total population by 12 percent-units. Brazil is compared to the other two a much urbanised country where almost half the population lives in urban areas. There is also here an ongoing flow of migrants into the cities and the share of urban population will increase by some 7 percent-units until

2030. Between 1990 and 2025, the number of people living in urban areas around the world is, thus, projected to double to more than 5 billion, see figure 1.

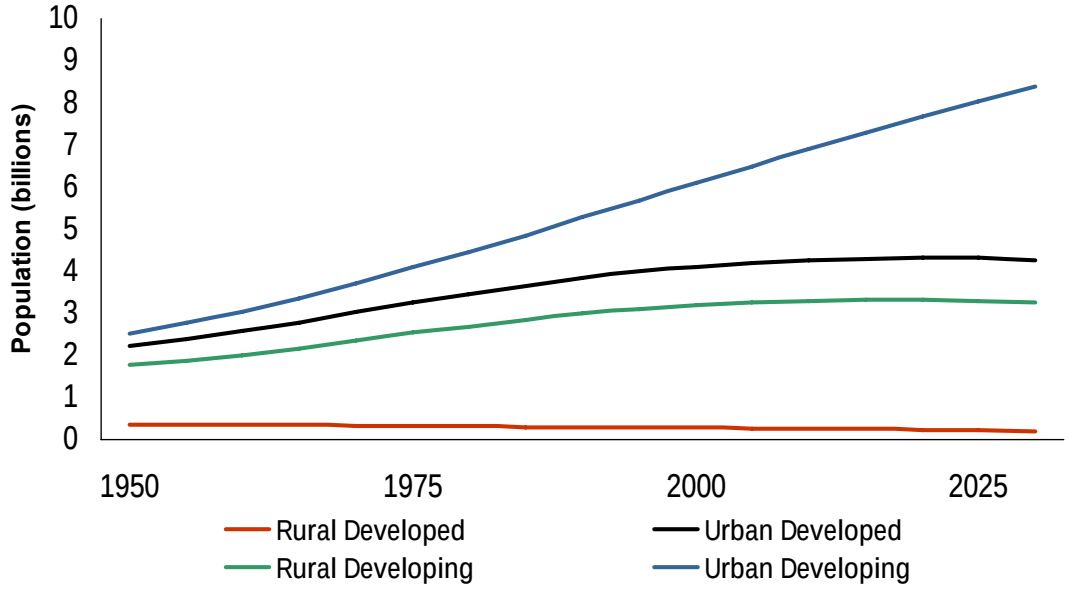

Figure 1: Urban population growth outgrowths rural growth as of 1950-2025 (Sources: WRI et al., 2002; and UNDP.

The mega-cities with populations exceeding 10 million inhabitants will in Brazil, China and India increase their populations between 2005 and 2015 by 3,5 million, 15,2 million and 9,9 million in Brazil, China and India respectively – see appendix 2. Not only do these people need new infrastructures such as transports, water, sewage and waste – but all these people and the infrastructures aiding them may cause even worse environmental and health problems to the inhabitants of the mega-cities. Other infrastructures in combination with increased purchasing power and the following increase of vehicles will give rise to escalating traffic problems that are likely to pose severe problems in the largest cities. In India e.g. by 2016 urban transports are estimated tot increase by 2.6 times in large and mid sized cities and the increase of two- and three-wheelers is seen as truly troublesome (Nagdeve, 2002).

One very important demographic factor in both China and India are the huge internal movements of labour from rural areas to the rapidly growing major cities. The mamothian intranational migrations will create some of the largest megacities – i.e.

populous cities having more than 10 million inhabitants each – in the world. The largest city is predicted encompass a population on about 27 million inhabitants by 2015 (National Intelligence Council, 2000). This will pose immense demand on constructing new "environmental infrastructures" for traffic, electricity and telecommunications but also for infrastructures that include treatment of water and wastewater as well as the treatment of household and industrial wastes. According to the National Intelligence Council (2004) the internal number of migrators in China is currently 100 millions which is a low estimate compared to some other estimates done.

All these people are going to need access to piped drinking water and sewage. The Chinese Ministry of Construction has accounted that the domestic cities that in total lack sewage systems and sewage treatment plants to as many as 278 cities **CHECK!**. In China as of 2006-2010 alone the Ministry of Construction and the 11th FYP have set aside US$41.3 billion for constructing and extending the access to sewage treatment and recycling facilities. By 2010, the aim is that 70 percent of the urban population shall have access to sewage disposal (WRI, 2006).

PII.1.2. Population severities that influence population trends, stability and economic development

There exists, moreover, huge challenges of social and demographic character that can alter the predictions of the development in foremost China and India illustrated above. That is the huge surplus of men that evolves in China and India as a consequence of the practice of favouring male children. The male surplus may lead to civil unrest in these countries among other negative side effects and then there is the issue of HIV/AIDS infections in Asia and Latin America that may impact coming population figures – compare with those illustrated in appendix 3.

PII.1.3. The growing middle class in latecoming economies

Not only will the number of people moving into the cities increase the need for these infrastructures and the need for managing environmental waste but also the rapid economic development with the consumption patterns that follow. The Chinese

middle class is expected to by 2020 constitute 40 percent of the country's total population. The middleclass is, consequently, currently a good 250 million people in China and India's middleclass is estimated to be 300 million people. The GDP per capita for these persons are not as high as in the west, but good enough for spurring car purchases for the middleclass households (National Intelligence Council, 2004).

The GDP of China has according to some calculations already surpassed the UK GDP and the Chinese economy is projected to be the second largest in the world by 2020 after the USA (Goldman Sachs, 2003). India's and Brazil's GDP development's are close behind with India at echelon with the major countries of Europe and Brazil right beneath the GDP of the largest European economies as of 2020.

PII.2. Consumption Trends

The great increase in economic wealth currently taking place in the world's vast and populous nations – of foremost concern are the economic development trends in China and India – that rapidly turns into increased consumption of goods demanding increased resource use of energy and materials. Food consumption increases and the transport and energy content per produced food as well. The consumption patterns will also profoundly turn towards home appliances, electronic goods, apparel, furniture and automobiles. As described above, the middle class in China and India currently number 250 and 300 million people, respectively, and as estimated below the number of cars in China and India by 2030 will together account 540 million vehicles which is close to the total number of vehicles (630 million) on the earth today. This huge increase in car usage and car replacement (when buying new cars) will put some immense pressure on global resources in terms of availability (available high quality ores to mine) and extraction capacity. Oil, aluminium, plastics and platinum-group metals are some resources that will be considerably affected by the increased vehicle usage in the world as of 2030. These severities will have to be met by some radical innovations in the transport sector. The impact on resources, other industries (i.e. electronic goods), recycling practices and radical innovation system innovations by future vehicle fleet is discussed in the case study below.

PII.2.1. CASE: The arising Automotive Economies and the Decreasing Resource Availability

According to the WRI et al. (2002) the number of vehicles – cars, busses and trucks – in the world as of 1995 was 630 million. If we assume that for most nations the number of cars per 1,000 inhabitants at the same national GDP per capita level[3] would be somewhat similar and that the current number of cars in South Korea is 250/1,000 inhabitants[4] (OECD, 2006c; STEPS, 2005) we will get a rough estimate of the size of the car park in tomorrow's China. By 2030 China's per capita income will be as large as Korea's is today (Goldman Sachs, 2003) and the number of inhabitants in China exceeding 1.44 billion. Applying the car rate in Korea as shown above is 250/1,000 inhabitants then the number of cars in China would be some 360 million cars by 2030 when the Chinese population exceeds 1.44 billion inhabitants (se appendix 2).

STEPS (2005) shows that the car ownership rate versus GDP per capita is currently similar between China and India. The estimates on future rate of ownerships is, however, according to STEPS (2005) very diverting between the studies e.g. made by IEA/WEO, WEC and EU. Taking the average ratios between China and India for 2020 in the STEPS reports the car ownership rate in India by 2030 will be about 50% (47.9%) of that in China[5]. By 2030 both countries are estimated to each have populations exceeding 1.44 billion inhabitants. The number of cars in India would, then, approximately be 180 millions as of 2030 and in China about 360 million cars. Together these two countries will encompass some 540 million cars. Then we have an increased car usage in many other regions of the world, especially in countries i.e. Brazil, Indonesia, Iran among many others. So, by 2030 the number of cars in the world would if these estimates are not too erroneous be far more than doubled compared to 1995[6]. This enormous expansion in vehicle ownership has already begun in China where during 2002 three vehicle groups – busses, trucks and cars – all reached and passed 1 million units sold each and the number of cars sold during 2015

[3] As shown by STEPS (2005).
[4] In Japan with a higher GDP/capita the corresponding car ownership rate vs. GDP per capita number is above 550 vehicles per 1,000 inhabitants.
[5] In comparison: STEPS (2005) estimates that the car park of India will be half the size of China's by 2050 mainly due to two facts: *one* the economy of India will not be as large as China's and *two* the railway networks measured in number of passengers is much higher in India which can serve as a route for decreasing the need for high-way solutions.
[6] For example STEPS (2005) have estimated, by using OECD data, that motor vehicle kilometres travelled by 2020 will increase by 86% worldwide and 40% in the OECD compared to 1995 figures.

will be almost 6 million cars and the annual vehicle sales is estimated to have reached 9 million units (KPMG, 2003).

How will a global car park – as of 2030 – twice as large as current global numbers impact the resource demand of some core means of modern society i.e. iron, aluminum, plastics and special metals? As stated above the global auto numbers will by 2030 count somewhere around 1.2 billion, low estimation, and the current figure 630 million cars (WRI, 2003). If applying an fictive usage phase of ten years[7] we get an replacement rate on one tenth a year for the global car stock which for 2030 will be correspond to a production of 120 million vehicles. Assuming that the vehicles (compact class) have a weight on a metric ton a piece and that the steel content is approximately 70 weight percent (Schmidt *et al.*, 2004) then the total demand for steel from the auto industry as of 2030 will be 84 million ton/year. The production of autos during 2005 has been estimated to 54.5 million vehicles (Autoparts Report, 2001) which corresponds to a steel demand on 38 million ton/year. The aluminum content of standard cars is currently 3 percent, but some brands like Audi and Mercedes have cars in the product portfolio with considerably higher aluminum shares and lesser content of steel. Light weight cars of tomorrow are assumed to have aluminum content somewhere in the range of 11 to 49 percent. There is, thus, two scenarios for aluminum demand from the auto sector as of 2030. A) 120 million vehicles times 1 ton/car times 3 percent aluminum content equals 3.6 million ton/year and B) 120 million vehicles times estimated 0.75 ton/car times (e.g.) 40 percent aluminum content equals 36 million tons. The plastic content is assumed to as much as double in light cars but in current cars the plastics content is approximately 19 percent (Daimler-Chrysler, 2006). That would make the demand for plastics in the auto sector to 22.8 tons/year. If each car is assumed to be equipped with some kind of catalytic converter by 2030 with an average platinum-group metal[8] weight on 1.5 gram (USGS, 1998) the demand from the auto sector will then be 180.000 tons on a yearly bases as of 2030. These figures that are dealt with in this paragraph on the auto industry

[7] On average, according to Eurostat figures, the average age of passenger cars in Europe was 7.3 years as of 1998, which is an increase by one year since 1990 (STEPS, 2005).
[8] The platinum-group metals consist of platinum, palladium, rhodium, ruthenium, iridium and osmium and they tend to have similar physical and chemical characteristics. Converters contain several different he metals, although having different efficiencies, in catalytic converters are sometimes substituted for each other (USGS, 2006).

demand for resources, current and by 2030, as well as current annual production is shown in table 2, below.

Resource (Data in million tons)	**Current Annual Production**	**Current Annual Auto Sector Demand**	**Auto Sector Demand as of 2030**	**Auto Sector Demand Increase to Current Production**
Steel	1090	38	84	4.2 %
Aluminum (low estimate)	31	1.6	3.6	6.5 %
Aluminum (high estimate)	31	1.6	36	111 %
Plastics	155	10.3	22.8	8.1 %
Platinum-Group Metals	0.43	0.06*	0.18	28 %

* A rough estimation is made here, assuming that 75 percent of global vehicle production is currently equipped with catalytic converters.

Grayish shaded areas represent current annual resource production that currently is close to/facing global yearend capacity.

Yellowish shaded area concerns the resource extraction of PGMs. The mining of these metals is currently expanding due to the vanishing availability of higher grade ores.

Table 2: The estimated increase in global auto sector resource demand as of today and 2030 to current resource production figures. (Sources: Autoparts Report, 2001; Schmidt, 2004; Daimler-Chrysler, 2006; Plastics New Zealand, 2006; STEPS, 2005; Swedish Recycling Industries' Association, 2006; USGS, 1998; 2004; 2006a; 2006b; 2006c).

As seen in table 2 above the future demand increase on resources from the auto industry is considerable compared to current global production/extraction of resources. The increases in aluminium and plastics demand for the vehicle industry are, furthermore, faced with the severity of already having reached annual production capacity today (cf. Swedish Recycling Industries' Association, 2006; cf. 2006a). A study by the US Department of Energy (Wall *et al.*, 2006) assessed two alternatives for steel, concerning weight and recyclability, in the Toyota Prius, one aluminium and one composite alternative. The composite body alternatives will solve the worst case aluminium scenario above with an increase in auto industry demand surpassing current annual production, but since composites are made of carbon fibers and a mix containing a wide range of various plastics today's global production capacity has also to be expanded considerably. There is, consequently, room for and, importantly, an enormous need for innovation in creating lightweight vehicles for the very nearby future to solve the resource and recycling issues facing the world economy due to the rapidly increasing middle class in the latecoming economies.

Lightweight vehicles are also a prerequisite for solving the auto fuel problem. Another technology for dealing with finite fossil fuels in transports is the development of fuel cell automobiles that will require considerable amounts of Platinum, constituting the catalyst in the fuel cell engine that converts hydrogen and oxygen to electricity. Palladium is, also used in the actual fuel cells (USGS, 2006c). The demand for Platinum-Group Metals will increase considerably if the use of fuel cell technology becomes widespread and there will be a great need for recycling. Recycling of these PGMs is a rather easy task to solve, since they are so precious already today (increasingly valuable cf. Harler, 2005), but all anthropogenic substances going into the economy can never be one hundred recycled, fractions end up in the environment or even into the biosphere[9]. There is, thus, even here regarding engine technologies a vast need for innovation solutions that are not only solving the fossil fuel problem, but also importantly solving the problematic aspect of the increasing demand for precious metals resources.

According to the calculations of McKillop (2005) the oil need for the future car fleets are immense. When China and India reaches OECD levels in car rate ownerships these two countries alone will together consume some 10 billion barrels of oil per annum and this is equal to the yearly production of oil of the entire OPEC countries and more than a third of total oil production worldwide as of 2003 (EIA, 2006). The struggle for produced oil is, hence, going to be much more severe that it has been to date where the current oil demand for road traffic from China and India has without exaggeration been very moderate, especially if considering the fact that the car owner rate is in China is just above 5 cars per 1,000 inhabitants (WRI *et al.*, 2002; KPMG, 2004; STEPS, 2005). Some 25-30 years from now these vehicle markets will by far outnumber the big markets in the old OECD region and have a competitive buying power to retain resources for transports. If returning back to McKillop, the vastly increased demand for oil and the limited resources and production capabilities may, except for environmental degradation, be a source for international instability.

[9] Currently three-way catalytic converters disperse PGM in the environment, especially close to high-ways, but only Pt is taken up by plants. The abundance – relatively speaking to their economic value – of PGM on road shoulders and nearby areas has made it economically viable to recover these metals lying along the European and North American roadsides (Ely *et al.*, 2001).

As one possible solution to the oil dependency that China increasingly experiences is to explore the abundance of coal that China is in possession of. The Chinese coal reserves will last another 200 years which in comparison with the oil alternative may be perceived as an intermediate solution in the transition towards renewable energy sources. A council chaired by the Chinese Premier, Wen Jiabao, has developed coal gasification strategies for the Chinese government that will enable increased efficiency in electricity generation, decreased environmental costs (both SO_2 and carbon emissions are reduced) and more application areas compared to the traditional coal combustion (technology) plants. Interestingly, the syngas from the gasification process is the basis for synthesizing high quality liquid fuels i.e. methanol and DME (among other outputs) that can be used for transportation and agriculture. According to Farinelli's (2003) predictions the coal gasification production in 2050 could be as large as or larger than the total primary energy supply of China as of 2005.

PII.2. Brazil

In many aspects Brazil cannot be classified as a poor country if considering the fact that two thirds of the worlds nations and 77 percent of the world population has a per capita income that is lower than Brazil's on US$ 3,580 as of 2002. But if considering that one third of its population – i.e. more than 50 million people – are living below the poverty line in Brazil which is far worse than the case in comparable GDP per capita countries where the below poverty line share of the population is only 10%. Poverty has been persistent in the country for some decades but the extreme poverty was reduced by 5 percent during the 1990s down to just above 14% of the population (OVE, 2004).

PII.2.1. In Brief

The Federative Republic of Brazil is the fifth largest country in the world both area and population wise. The country also constitutes half of South Amerca's area and population. Brazil is a federation of 26 states and the federal district of Brasilia is its capitol. Being a former Portuguese colony the language is Portuguese, the strong cultural legacy is Roman Catholic and the legal system is based on Roman Law. The executive power of the state is held by the government lead by the president and the legislative power is held by the bicameral National Congress, one proportional representation – Chamber of Deputies and one house of Federal Senate. The President may veto and the Supreme Court tests laws against the constitution.

The individual states have significant autonomy and have jurisdiction over considerable law making, social and environmental issues and taxation. Each Brazilian state is headed by a Governor and a legislative assembly. The states are in their turn divided into municipalities headed by a Mayor and a legislative body. The municipalities' autonomy is large and the organisation of them varies. This organisational divide may influence and affect the success of e.g. ambitious federal environmental policies.

Brazil's economy is advanced and the country's industry is well advanced encompassing aircrafts, automobiles, computers, consumer durables, medicines,

petrochemicals and steel. The country is also blessed with enormous assets of resources that has contributed to a successful agriculture, forest and mining sectors. The country has also a huge resource of labour. Tourism is also an important sector to the nation's economy. These factors combined make the Brazilian economy strong and less vulnerable to changes in industry sectors. Brazil is now considered to be a stable democracy with controlled inflation (the estimated figures for 2006 are less than 4) but a GDP growth a good two percent which is low for an emerging economy.

The International Monetary Foundation (IMF) has considered Brazil to have the world's ninth largest economy considering its purchasing power. The challenges for Brazil to face are, however, serious. The country is suffering from poor infrastructure, asymmetric income distribution – between population groups and regions – low quality public services, corruption and social unrest. The public debt is, moreover considerable and GDP growth is lower than the growth of comparable Latin American economics and of China and India.

Health and environmental problems are that water and sewage pipes coverage is low and rivers and bays receive toxic residuals and legal and illegal logging endager much of Amazonas. The President of Brazil since 2002, Luiz Inácio Lula da Silva, has put considerable efforts into decreasing the social inequalities and improving the living standards of the poorest by terminate hunger, provide schooling incentives to families and to provide households with infrastructure commodities like piped drinkable water, electricity. These, projects are long-term that takes time to accomplish.

PII.2.2. Poverty and inequalities

The inequalities in Brazil have, however, remained constant and the country is one of the world's most unequal nations and the Gini coefficient has remained at above 0.57 since the beginning of the 1990's. As a consequence, the group under extreme poverty is more sensitive to income distribution than growth in GDP, according to simulations. For the extreme poverty a ten percent decrease in poverty would be similar to 25 years of 3 percent annual growth. Wealth is also asymmetrically distributed among the regions, states and municipalities. In the wealthier Southeast 18 percent of the population is living with half the minimum wage or less while the

corresponding figure in the poorer Northeast is 51 percent. Another asymmetric distribution of wealth is along race, which create impediments of exclusion among groups. These inequalities in wealth and exclusion of individuals from the society are potential risks for social unrest, but already today Brazil's larger cities are *"known"* for their problems with violence. According the Inter-American Development Bank (OVE, 2004) considerable amount of money is spent on social sectors and Brazil "is certainly a country with an active social policy." So, according to the report the amount the country is spending is more than needed for satisfying the basic needs of the poor the challenge is not to mobilising resources but to improve the targeting, tracking and monitoring of the programs. A too large share of the population belongs to the informal economy with no contribution to the tax system and this population receives little securities made by the government in return. Overcoming the inequalities is, hence, still an imperative task for Brazilian policy makers and the President da Silva. The success in doing so, however, is a prerequisite for being able to solve the environmental problems of Brazil.

PII.2.3. Natural resources and environmental issues

Brazil has a troublesome historic burden of pollution from the second half of the last century, starting with almost unrestricted industrial pollution and untreated household waste that came with the industrialisation and urbanisation in the 1950s and 1960s. Major clean-up efforts started in the 1980s and 1990s, but much of the decontamination is still to be carried out. Toxic residues cover some important rivers and bays, like the bay of Rio de Janeiro and during the 1990s the eutrophication and biochemical oxygen was not reduced either. Vital rivers through densely populated areas still carry significant amounts of pollutants and phosphorus, nitrogen and heavy metals will be released into the water for many years to come (OVE, 2004).

PII.2.3. Water and wastewater

Also the access to potable water varies greatly in Brazil between regions, by income and along population density. As of 2001 more than 90 percent of the country's urban population was covered by the drinking water supply, but the sanitation coverage was much lower. For the lowest decile 70 percent in urban areas had access to piped water

while the lowest decile in rural areas only 8 percent had access to piped water. The progress in rural pipe water coverage is, according to OVE (2004) incremental. The coverage to sewage pipes is less developed than to fresh water. As of 2001 45 percent of the lowest decile in urban areas hade sanitation coverage and virtually no progress had been made in rural sanitation coverage since the early 1980s. Several projects have been undertaken since the turn of the millennium to address the shortage in access to piped water and sewage pipes in poor urban homes as a response to federal government directives aiming for coverage for all.

PII.2.4. Sustainable development

Brazil faces immense challenges in making the individual goals of economic development, poverty reduction – on the hand – compatible with preservation of the environment – on the other. There exists, conflicting aims in the huge needs for land of the vast mega-cities in the Southeast and preserving costal areas. Other conflicting resource usages are harvesting forests for fuel, wood, cattle ranching and soybean fields (such as in the Amazon region), exploiting the lands of indigenous people by establishing road networks into their dominions, human activities that intensify desertification and draughts, and activities that causes contamination of soils and waters.

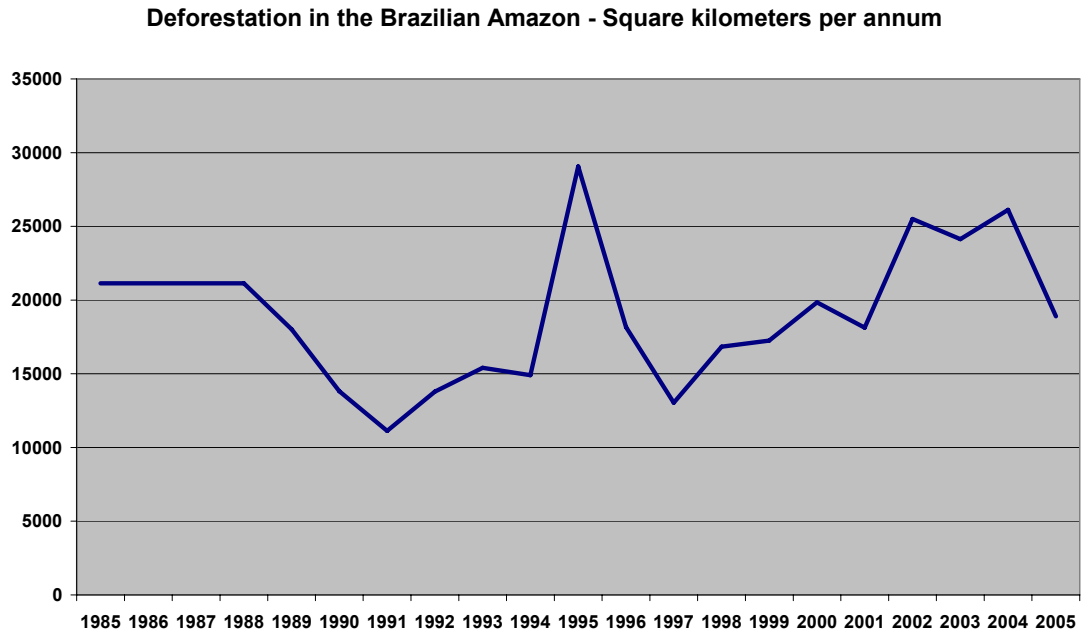

Figure 2: Annual Deforestation in the Brazilian Amazon, 1988-96 (Sources: INPE, 1998; WRI, 2003; Timber Hunt, 2006; Mongabay, 2006).

Only during the 1990s did an area corresponding to twice the size of Portugal become deforested (CIFOR, 2004) and between 2000-2005 a jungle area larger than Greece disappeared for the benefit of soybean fields and cattle pastures and, thus, the Amazon jungle will be completely vanished by 2050 if the rapid pace of deforestation does not decline. The CIFOR article stresses that one of the major contributors to this deforestation is the beef exports. As shown in figure 2 the rate of deforestation did not decline during the 1990s but rather increase and according to WWF (World Wildlife Fund)(WWF, 2006) is now 10-12% of the Amazon forever gone and according to WWF some of the consequences may be modified global climate, droughts in Brazil's agricultural region and of course loss of biodiversity and habitats in the Amazon region. The Brazilians that will be most severely struck are the poorest and the indigenous peoples still living in the Amazon jungles.

As the CIFOR and WWF references above indicate; also the GIS (Geographical Information System) study by Laurance *et al.* (2002) points out large-scale cattle ranching and slash-and-burn farming to be the greatest threats to the rainforest and this in the Eastern basin which are most easily reached by the large population areas.

The OVE (2004) report claims – unlike the findings of Laurance *et al.* (2002) – that at federal levels, however, "Brazil has been a leader and innovator" in integrating environmental aspects and development issues, but the obstacles lie in the limited institutional capacity to handle environmental issues at the state and local level authorities, especially when weighting them to economic and employment aspects. Since, Brazil is a federation the implementation of responsibilities such as environmental do often come into the dominion of the individual state. The challenge of the federal government is to support the environmental agenda (among others) in the face of very heterogeneous needs of the different Brazilian regions. This institutional battlefield is also a field of multidisciplinary research to reveal – describing the potential salients and reverse salients.

Financial support is an institution that is imperative for change. As an indication of the importance of financial aid the Inter-American Development Bank has invested in many projects for improving the environmental conditions in bays and rivers in urban areas covered by toxic sludge. By decontaminating the bays and rivers local living conditions can be improved. But the success requires the execution of civil works in a coordinated manner which in the described case by OVE (2004) did not happen despite the finance of treatment plants, household connections and water meters, solid waste collection and municipal waste information system among other financed initiatives in the program.

PII.2.5. Transports

After the oil crises in 1973 Brazil, lead by its military junta, developed the nation-wide alcohol program for exchanging imported petrol to own generated ethanol sugarcanes, which at the time experienced low market prices. The sugar cane is an efficient source of fermentable carbohydrates that rather easily can be processed to ethanol fuel. The sugar canes also yields sugar and alcoholic beverages but is also used for generating electricity. Sugar cane farming requires little labour and the huge offsets for the product has made sugar cane the main crop in Brazil today. Today, gasoline fuel is replaced in 40% of the transports and ethanol is being exported to other markets.

The positive environmental side from ethanol is the improved air qualities in the cities resulting from the lesser use of gasoline. One of the negative sides of ethanol fuel for Brazil is that vast plantations with monoculture fields of sugar canes have taken over small farms with varied production. The need for new sugar cane fields has also lead to deforestation of forests, leading to decreased biodiversity.

Other crops grown for industrial purposes are eucalyptuses and pines. These are successfully grown in plantations and the cycle from sowing to harvesting is seven years. The Brazilian eucalyptuses and pines works fine and are internationally very competitive for pulp and paper production. These monocultures of species alien to Brazil may pose further pressure on the remaining domestic forests.

PII.2.6. Summing up on Brazil

- Agriculture is in need of improvements concerning the droughts, especially in the Northeast, and the erosion of soil is another severity of Brazilian farming.
- The hunt for new land for agriculture is one of the main causes of deforestation in the Amazonas. Rainforests have to give away for pastures for beef cattle, soybeans and sugarcanes that is used for producing ethanol formerly primarily for the domestic market, but exports to other markets, like Europe, are increasing fast.
- Rivers and bays, especially in densely populated areas have received considerable amounts of toxic sludge, disposal residues and eutrophication. Emissions causing these severities in rural area do still occur.
- A large part of the lowest decile of the urban population lacks access to piped drinkable and sewage water that is contaminating.
- The country is one of the most unequal countries in the world with an Gini coefficient exceeding 0.5.

PII.3. China

China experiences a rapid economic development that reshapes the entire global trade environment. As of 2005 China's trade surplus with the rest of the world reached new record $ 104 billion which is a tripling of Chinese surplus figures from 2004. In total the Chinese export reached $762 billion and total foreign trade topped $ 1.4 trillion making China the third largest trade nation in the world, beaten only by the USA and Germany **CHECK – NOT JAPAN?** (Morrison, 2006; People's Daily Online, 2006a). China is currently 4th largest economy when sorting countries according to nominal GDP and 2nd largest economy if sorted by purchase power (IMF, 2006).

PII.3.1. In Brief

Since the Chinese Civil War succeeding WWII China may be interpreted as a region divided into two separate states: the People's Republic of China (PRC) and the Republic of China (ROF) of which the former governs the mainland China and the latter Taiwan. Both states are claiming to be the sole ruler of all China. Since the 1970's, however, the PRC has gained increasing international recognition and is the only of these two that have representation in the United Nations. The China referred to in this report is the PRC in control of mainland China as well as Hong Kong and Macau. The PRC will in the report often be referred to as just China.

The People's Republic of Chinas is the fourth largest country in the world by area but without comparison the largest country in the world population wise, encompassing some 1.3 billion inhabitants. China is a one party-state led by the Communist Party of China (CPC). The country's economy has been partly privatised since the 1980's which have resulted in an economic upswing, bringing down poverty rates from 33 percent to 12 percent of the population and the country is now the third largest economy in the world. China is the second largest country in the world if seen to purchasing power, only beaten by the USA, but the GDP per capita is only a sixth of the corresponding US figures. This economic development is, however, also associated with some asymmetries in wealth distributions and rate of employment between e.g. rural and urban China.

The economic expansion and the increased military spending have influenced the power relations in the area. China has currently territorial disputes with India, Japan and the Republic of China that is in control of the Island Taiwan. The People's Republic of China regards the government of ROC (Taiwan) as being illegitimate and strives for a reunified one single China under its one-China policy.

The economic reforms, in combination with loosened authority controls of private lives started in 1982. By giving peasants a stake in the land incentives for improved agricultural production was provided and during the 1990's, in the post-Tiananmen China, the economic growth has been exceptional that have pulled out some 150 million peasants form severe poverty and enabled the unprecedented growth on an 11.2 percent in annual GDP growth per year (People's Daily Online, 2000).

Politically China is regarded as being a communist state of strict authoritarian character closely related to the strong centralised monarchies that have played a central role in Chine for most of the preceding 2,000 years. The economic system is, however, increasingly characterised by capitalistic decentralised decision-making among the economic actors in society. The communistic central planning in detail has been loosened up, but restrictions of thought are still significant in media, internet and the right to demonstrate.

The single Communist Party of China is divided into sub-parties, so-called democratic parties. It is claimed that there are some political freedom in the elections for local village governance, but in higher levels the CPC holds total control since there are no contested national elections carried out. Other attempts to keep the opposition in place is by oppressive force on those engaged in alternative views (to the CPC) and to improve the economy and, thus, the living conditions of people.

The People's Republic of China is divided into 22 provinces that it governs, but the regime, furthermore, considers Taiwan to be its 23rd province. There are also 5 autonomous regions within China – characterised by large minority groups such as in the Tibet and Xinjiang regions – and 4 municipalities as well as the 2 special administrative regions of Hong Kong and Macau. There are also 5 Special economic zones in China that have investment incentive laws to attract foreign capital and trade.

There are some resemblances to the human rights in Western democracies in the constitution of the People's Republic of China, at a first glance, stating with the rights for free speech, free trial, freedom of religion and also property rights and even the freedom of the press. The implementation and practice of these rights is, however, not always close to the writings of the constitution. Also public punishment in China is a delicate issue to deal with if considering that the country accounts for a large majority of the world's death penalties. Since the corruption in lower and regional levels of government is considered to pose a serious problem, media has been allowed to illuminate social problems and expose corruption.

International pressure is put on China, especially from the US, for China to create a more "fair" foundation for international trade. US industry has large problems to compete with Chinese industry, but also low cost regions such as Latin America and other parts of Asia. Predominantly two issues are at stake here that are unfavourable to foreign industry: A) the set value of Chinese Yuan is to low compared to US dollars and B) the tax incentives that is provided Chinese industry both for competing on the internal and the international markets and the duties imposed on foreign imports to the Chinese market.

President Ho Jintao declared in early 2006 that the aim is to transform Chinese economy from resource and manufacturing based one to an innovation based one (Einhorn, 2006) and the long-term goal is to increase the R&D spending from currently 1.2 percent of GDP to 2 percent by 2010 and 2.5 percent by 2020. By 2050, the intention is that, China shall be the largest research nation in the world surpassing the capacity of USA. The Chinese regime dislikes being dependent on foreign key technologies and would also like to retain the picture of China as the nation of great inventions which within the country is synonym with medieval time China. Being a populous country with vast resources China takes on a broad range of sectors in its technology research approach, including ethically sensitive areas – gene therapy, genetically modified crops and stem cells – in US dominated areas – semiconductors, software, space explorations – but also in emerging renewable energy areas – solar, hydro, wind power and (renewable depending on fuel) fuel cells (Einhorn, 2006). As

means for enabling a hydrogen-based economy is the development of the country's nuclear power.

Infrastructure investments are enormous in China such as in road transports and between 2001 and 2005 the highway network in the country has more than doubled and is currently the world's next largest, only beaten by the size of the US highway system. The highway network supporting the cities of Beijing and Shanghai are massive in size. In Beijing the progress of the 6th ring of circular highways is under construction to lead traffic around the inner city area. The total amount of roads also grew considerable – 13 percent in just five years between 1993 and 1997 since proper paved roads are needed for numerous villages in rural China too. To China the massive road and highway construction to erect a dense transportation network is a keystone in its efforts to fight poverty in the nation.

China is, already today, the world's largest telecom market with close to 350 million cellular phone users and just above 200 million fixed telecom subscribers. The internet users have already reached some 90 million people. The adoption of information and communication technologies (ICT) currently taking place in China is unprecedented. In 1978 there where only 2 million fix telecom subscribers in China (Sandklef and Kiesow, 2006). Today the increase in number of mobile phone subscribers accounts some 7 million people each month. The Chinese telecom market has surpassed USA as the most important telecom market for the ICT Corporation Ericsson. The competition from Chinese counterparts has increased both in China – sometimes supported by Chinese technology standards – and globally. The new technology which is promoted by Chinese leaders is also seen as an obstacle when aiming for controlling the information flow within the country.

PII.3.2. The 11th Five Year Plan – Designing a harmonious society

Key concepts in the newly adopted 11th Five Year Plan (FYP) is the aim to A) build a harmonious society that is B) founded on a scientific concept of development. As no other preceding FYP the high focus on environmental and social issues in the 11th FYP is an indication of the imperative need for the government to diminish the social inequalities within in the country in order to diminish the risks for social unrest. The

sustainable development concept is used to avoid overheating in the rapidly expanding city regions in Eastern China. The official *China Through a Lens* (China Internet Information Center, 2005) summarises the 11th FYP similarly:

> *"Build new socialist rural areas, optimize and upgrade industrial structures, promote concordant development of regions, build a conservation-minded and environment-friendly society, further system reform and enhance opening-up, efficiently practice strategies to invigorate China through science and education and through human resource development, and give impetus to constructing a socialist harmonious society."*
>
> (China Internet Information Center, 2005)

The Central Committee of the Communist Party of China (CPC) have, moreover, decided that the 11th FYP will realise a doubling of China's per capita gross domestic product of year 2000 by 2010 and this aim will be fulfilled by improving economic structure, increased efficiency and reduced energy consumption. The energy consumption is to be decreased radically by some 20 percent per unit GDP (Chinese Governments Official Web Portal, 2005; People's Daily Online, 2005).

The 11th FYP encompasses, furthermore, the industrial aim, not on expansion in scale but to upgrade the Chinese industry structure e.g. towards the value-chain phases with higher revenue that will make the Chinese industry to a global industrial powerhouse. The resources put into research and development (R&D) will increase to 1.5 percent of GDP to create an innovative a position on the global technological frontier in the industries of attention. Related to this aim is a whole chapter dedicated to the shaping of the nation's service sector. In the strategies to rejuvenating the country through science and education and strengthening the concept of a nation of talented people China will increase the expenditures for education to 4 percent of GDP. A compulsory 9-year education will be introduced also in the rural areas of China that will be free of charge for poor people (Chinese Governments Official Web Portal, 2005; 2006a; 2006b; 2006c; China Internet Information Center, 2006; People's Daily Online, 2006c).

The regional aspect is core in the FYP where support is given to geographical areas of the country with fewer investments. A regional development strategy is developed steering investments to pinpointed areas and away from overheated ones according to the classification optimized, prioritized, limited and banned exploitation. The FYP aims at saving the resources and protecting the environment. The plan puts great emphasis in building an innovation-oriented country and China is also to develop a strategy that will produce a country of talents. During the five year period 45 million urban jobs will be created and the same number of farmers will be trained to take on chores in industry. It is, moreover, estimated that 15 million farmers will lose their lands. People's quality of life will be improved by safer food, convenient transportation, and public services to help people in an equitable manner. The medical healthcare system will cover 80 percent of the population in rural areas and 70 percent of the people in urban areas will have access to sewage treatment systems. People will also enjoy a better environment where the severe pollutions will be cut by 10 percent as of 2010 compared to year 2000 and the forest coverage will increase by 20 percent. An additional 100 million people will have access to safe drinking water (Chinese Governments Official Web Portal, 2005; 2006a; 2006b; 2006c; China Internet Information Center, 2006; People's Daily Online, 2006c).

Summing up the communique on the 11th FYP people's standards of living will be much higher both in rural and urban areas concerning housing, transportation, education culture, health and environmental conditions. On top of that there will also be some progress made in democracy and legal system as well as the culture and ethics in the general public, building on to the harmonious society.

PII.3.3. Population demographics and urbanisation

The initiation of China's one child program in the 1970's to decrease the population growth as well as improving the quality of life. Authorities have advocated late marriage, late childbearing and "one couple, one child". Since the implementation of the family planning program some 300 million births have been averted and today the fertility rate of Chinese women has gone below the replacement rate. The population is, however, still increasing and is estimated to reach 1.4 billion 2010, reaching its

peak by mid-21st century at 1.6 billion inhabitants. Thereafter, the population will gradually start to decrease.

There is a strong, unprecedented in man's history, urbanisation currently taking place in China. The urban share of the population was over 40% in 2005 which is a huge increase since 1978 when the urban share only constituted some 17% of the Chinese population. By 2030 the urbanised population is estimated to constitute 60% of the total population (UNPD, 2006; cf. Table 1). This means that the increase of the number of city dwellers in China will be 340 millions between 2005 and 2030. The internal number of migrators in China is, moreover, ranges between 80-120 million people who work part-time in the major Chinese cities, only periodically returning to their rural areas of origin (National Intelligence Council, 2004; CBC, 2004).

The huge influx of people to the rural areas and mega-cities of China is putting a lot of pressure on Chinese authorities to create new infrastructures for traffic, electricity, telecommunications, drinkable and sewage water and wastes from households and industries. On top of the influx issue is another aspect that creates increased need for development of infrastructures and that is the increased economic wealth in China that is spreading among people, especially the urban middle class. Their increased use of resources and changed consumption patterns will pose an additional challenge to resource use, roads, piped water and facilities for waste disposals. By 2020 the Chinese middle-class is estimated to account for 40 percent of the population which means that there are about 250 million people in China having a living standard that drives consumption. The middle class in China is wealthy enough for car ownership and car purchases are currently spurring (National Intelligence Council, 2004).

The control of population is a prerequisite for socioeconomic development, natural resources and natural protection or as the *Office of the State Council* describes the relevance of the program: *"This has alleviated the pressure of the excessive population growth on the natural resources and environment, thus contributing to the economic development and the improvement of the people's living standards."* (People's Daily Online, 2006b).

Now, when the population growth of China is restrained there are three demographics and socioeconomic developments of great concern. *One* is the vast migration of young labour within China from rural areas to major city areas, *two* is the surplus of men and *three* is the rapidly improving GDP per capita. The needs for environmental technologies are especially linked to the internal migration flows and the tremendous increase in people's buying power and standard of living. Aspects of male surplus are mainly of social order which could lead to social unrest, crimes, prostitution, trafficking, HIV infections and even aggression from the militia. If such a scenario occurs then the environment surely becomes severely affected. The internal migrations have also considerable social impacts. Such as together with the effects of the one child policy the migrations of young labour to the city regions may affect elderly people in rural areas.

The major need for environmental technologies will arise from A) internal migration patterns, creating highly densely populated areas in Eastern China, and B) the explosion in economic wealth with an expected doubling of the middleclass by 2020, reaching 40 per cent of the population, that can consume cars, white goods, electronics and other resource demanding gadgets currently unachievable for large portions of the population.

PII.3.4. Economy, Equality and the Environment

Goldman Sachs (2003) predicted that the Chinese economy would pass the UK in terms of nominal GDP already in 2005 and this has already happened. Just within a few years the German economy will be surpassed as well and Japan by 2015. The US GDP figures will not be passed until 2039. Even though China's total GDP will surpass the size of the USA, the Chinese GDP per capita will still be considerably smaller than the US. The per capita figures will, however, not be insignificant since by 2030 the estimated Chinese income per capita will roughly correspond to current income per capita levels in South Korea. So, the rough estimation is that the environmental loads per GDP/capita are not going to be all that different in China

compared to e.g. today's Korea, but times 1.44 billion people as of 2030 and thus considerable impacts on world economy, resources and environmental conditions[10].

Some fundamental problems of the Chinese economy that may impact the long-term economic development of the country are related to state-owned companies, the banking system, public concerns over pollution, corruption and income inequalities as well as the lack of rule of law (Morrison, 2006). Many of the state owned companies are mismanaged and more than half of them are loosing money. Poor management leads, however, not only to lousy economic statements but also results in inferior quality and severe environmental conditions. The inefficiency of these state-owned enterprises (SOE) makes it difficult for Chinese authorities to lower the trade barriers to foreign competition. The problems of SOE spills over to the banking system which has to put economic rationality aside to finance the operations of inefficient companies with low-interest rate loans of which a large share is not likely to be paid back to the creditor.

The rapid economic development of China has also a dimension of overheating the Chinese society, in general, but the costal areas in particular. Inflation is and will increasingly be a very important issue to control and keep low. The uneven development has created problems for less fortunate regions to transfer taxation revenues to the central government which has lead to the practice of unfair taxation among some regional officials. Industrial actors in the rapidly expansive costal areas are increasingly experiencing competition among employers (which affects salaries and working conditions) and higher costs such as for properties and facilities. These labour and landed property shortages have lead production using unskilled labour to increasingly locate their plants in rural areas in the interior of China or to countries in Sothern Asia. UNDP (2005a) shows in its report on China's human development that the national income inequalities has risen from previously low levels (Gini Coefficient 0.3 as of 1978) to considerable inequalities today (Gini coefficient 0.45 as of 2002).

[10] Considering that South Korea currently has about 250 vehicle per capita (OECD, 2006c; STEPS, 2005) and that China by 2030 will have an economy/capita that resembles the Korean the resulting

Morrison (2006) continues to claim that the Chinese government disregards its own environmental laws in order to promote the country's economic development. Nonetheless, Morrison illuminates issues of concern for the people's health and the economic development and refers to the World Bank figures showing that 16 out of the 20 most polluted cities in the World are located in China and over 300 million of the rural population drink unsafe contaminated water. The water table is continuously lowered, especially in Northern China. These severities lead to health problems and water shortages. If this was not enough there are also considerable arable lands lost every year due to soil erosion and due to economic development, where god fertile soil has to make way for constructions – i.e. buildings and highways. Wheat crops have, moreover fallen to lower levels since 1997. Chinese authorities aim at further expand agro production tough improved plants, fertilisers and other technological innovations that boost yields. China is already today yielding considerable crops on its agriculture fields and according to the UN World Food Programme China supplies 20% of the world's population with food by using merely 7% of the world's arable land (BBC, 2006).

Also the UN World Health Organization has stated in a study, which includes almost 300 cities, that Chinese cities dominated the top ten positions when the cities with most severe air conditions were rated. Air quality in China is generally bad and two-third of the Chinese cities were considered air-polluted. The situation is not better when it comes to the rivers where almost all rivers in China are considered polluted. Almost 50 percent of the Chinese population lacks access to clean water. The northern parts of China have a deficient amount of water and the demand from cities, agriculture and industries continuously lowers the water table. To solve these severities Chinese authorities at national level attempts to retrieve water from the south of China, from the Yangtze River, to the Northern cities of China i.e. Beijing and Tianjin. This mammothian scaled project may, however, result in huge impacts on the environment, living conditions and on the regional economy in the areas surrounding the Yangtze River from were the water is to be retried.

number of vehicles in China will then be – if following the car ownership rate versus GDP/capita relationships in STEPS – some 362 million cars on Chinese roads.

Another grandiose project in China, also affecting the environment and local communities, is the Three Gorges Dam project. The intention with the large scale dam is to make the region less dependent on coal and to diminish the air pollutions but the construction of it has forced over 1 million people to move from their farms, villages and cities due to the increased water levels up-streams from the dam construction. The local biotopes are affected and the habitats of species i.e. the river dolphin living there are endangered.

The Chinese State Environmental Protection Agency (SEPA) has, however, received a stronger position to ministry level and the annual amount spent on environmental protection now exceeds 1% of GDP. In both the 10^{th} and 11^{th} Five Year Plans have the air conditions been improved and special concerns are paid to the Beijing area as one of the commitments for becoming the host of the 2008 Olympic Games.

PII.3.5. Standards as trade barriers to foreign competition

Chinese standards are increasingly accused of being a tool for delimit foreign competition on the Chinese market, favouring domestic competitors. According to the US Government Export Portal (2004) US industry has shown significant concern with China and its development and promotion of domestic Chinese standards since the development processes of them lacks transparency, especially for foreign competitors. The US Government Export Portal and US General Accounting Office have retrieved the picture from industry that standards and certification issues pose the most significant trade barrier for importers to the Chinese market, being more significant obstacles to trade than Chinese customs procedures, tariffs and deficient property rights.

The Office of United States Trade Representative (2005a)[11] confirms the above picture claiming the severity in how standards are applied in China. The complaints of many US industries is, accordingly, that China should manipulate technical regulations and standards to favour domestic industries. This procedure of using standards for providing domestic industries with a competitive advantage has increased in importance since China attempts to adopt WTO agreements on custom procedures and tariffs. In its WTO agreement, however, China has also committed itself to ensure that its regulatory authorities apply the same standards, technical regulations and conformity assessment procedures for both domestic and foreign goods and industries (US Trade Representative, 2005a). The US report continues to argue that foreign industries often are not allowed to participate in the standard development processes as domestic firms are. Foreign competitors are then faced with changed rules of the game adjusted to the prerequisites of domestic industry. Another concern that importers to China have is the discrepancy between China's WTO agreement and the implementation of these at local level officials where there might be a combination of not understanding the national WTO agreements as well as striving for to protect local industries.

The US Trade Representative (2005a) further claims that SAC issued a strategy report where China's development of standards and technical regulation should be used as means of favouring domestic industries as tariff rates fall. In a number of industry sectors – i.e. autos, telecommunications (td-scdma instead of wcdma), wireless local area networks (WAPI instead of WLAN), radio frequency tags, audio-video coding, whiskey – China has developed its own set of unique standards even though there exists well-established international standards. These domestic standards seem to lack sound foundation according to the US Trade Representative (2005a) and may pose a barrier to foreign imports. These standards, however, also serves as source of

[11] It should be mentioned that these documents from the Office of United States Trade Representative, may not always provide an objective picture of non-US countries' work with custom procedures, tariffs, standards and technical regulations. The agency is more concerned with promoting the view of US industry to enable US officials to put pressure on foreign nations. Brazil, China, India and EU are e.g. claimed to use standards based on vague or questionable scientific bases when they do not accept the sanitary and phytosanitary standards used in US agriculture industry. However, compared to the criticism of Brazil (US Trade Representative, 2005b)and India (US Trade Representative, 2005c) that are much lighter than the severe criticism that is given China (US Trade Representative, 2005a) where it is stated that US industry is concerned about: *"China's manipulation of technical regulations and standards to favor domestic industries."*

enhancing national pride by showing the lead that China possesses in technical development. The standard initiatives by the Chinese authorities may be seen as a mean to successfully lock out Western wireless telecom system providers by developing its own version of the internationally accepted WCDMA standard in a process where foreign competitors did not manage to adapt to the new requirements in the procurement procedures of telecommunications system in China. The Chinese offensive in these areas may, however, also be evaluated against the background that after joining the WTO it became obvious that the largest market for as well as in producing ICT products is faced with a new set of barriers, namely **CHECK!!!** IPR fences and thickets. This has created enormous efforts as regards innovative activitites among Chines actors, strongly supported by the Chinese government. This may be illustrated by the development of a third international standard for the third generation of mobile telephony, TD-SCDMA. Irrespective of its advantages/disadvantages compared to the other two standards – as illuminated by Long and Laestadius (Laestadius, 2006) – the very existence of this standard may have impact on the license agreements of Chinese operators when they upgrade their existing mobile networks.

In early 2003 two EU directives, the Waste Electrical and Electronic Equipment Directive (WEEE) and Restriction of Hazardous Substances Directive (RoHS), went into effect for implementation in 2005 and 2006. The EU RoHS Directive has gone into effect and it became implemented in mid-2006 in most of the EU membership countries. The WEEE/RoHS requirements have inspired policy development of similar legislation around the world as in China, Korea, Japan and some US states, however, EU may still be considered to be in the lead. But, China has unexpectedly taken up forceful actions in its policy development process and the country has adopted the strictest forms of RoHS not allowing any exceptions and phase-in periods as is done Europe which has drained some effectiveness out of the European legislation (STR, 2006). According to the Specialized Technology Resources (2006) the strict adherence to RoHS that China has taken may *"pose a major problem in the coming years for companies that export RoHS-targeted goods to China. There is growing concern in the electronics industry that China may be using these Directives for its own market share purposes."* This has been a concern of one hearing before the Subcommittee on Environment, Technology, and Standards; Committee on science

(US) House of Representatives that took place in 2005 (House of Representatives, 2005). Also the report by Martin Charter and Clark (2006) is somewhat sceptical about the intention of the far going Chinese RoHS Directive, not seeing a clear motive. To them the concern about of the health of people may be one reason for going beyond the EU RoHS Directive and the other reason may be of strategic character to ensure the competitiveness of domestic industry.

There is, hence, a rapid development of environmental policy initiatives in China seemingly for the sake of protecting people's health and the common environment in accordance with the 11th Five Year Plan, and possibly, as some resources indicate, for ensuring a competitive advantage of Chinese industry. Western industries and policy makers, ought therefore, to incorporate the Chinese development of standards and technological legislation where environmental aspects and the technological solutions to address them may to a larger extent become a question of having the possibility of exporting Western/Swedish products at all to some the largest markets in the world of tomorrow.

PII.3.6. Industry structure

Today, there is an eruption of Chinese products on the global markets. The Chinese industry is, currently, experiencing an enormous development overflowing the global market with *Made in China* products and the domestic Chinese industry covers today most types of production, from having been primary low-tech oriented ten years ago. Today, Chinese exports include goods such as electrical machinery and equipment, computers, power tools and appliances, apparel, furniture, medical equipment, footwear and Toys & games. The imports are mainly electronic integrated circuits and sub-assemblies, electrical machinery, power generation equipment, mineral fuel & oil, liquid crystal display panels, steel products and plastics. Chinese imports are, thus, characterised by input needs for its industry production (Morrison, 2006). The industry product groups that grew the most during 2004 was handsets for telecom and radio and data processing equipment which experienced an almost 50% and 30% increase in exports, respectively. The imports to China that rose the most as of 2004 were crude oil and integrated circuits and electronic sub-assemblies with an increase on a good 40% and good 30%, respectively.

The Chinese state encourages foreign direct investments in prioritised sectors and regions and it produces an industry catalogue in which the degree of foreign involvement is set. Since 1990 the Chinese government allows foreign partners to chair in joint ventures. The government supports investments in prioritised industries and regions by various tax instruments but also in state prioritised projects such as energy, communications and transports – all which can contain elements of environmental concerns. Corporations that has received foreign investments constitute almost half of China's exports and these foreign invested firms are one important contributor to the fact that China's foreign exchange reserves more than doubled between 2003 and 2005, making China the holder of the world's largest foreign reserves. There is, thus, a significant financial strength in China's economy that provides the country the opportunity to invest in prioritised areas.

PII.3.7. Resource scarcity

The rapid economic development of China has led the country to become an important power in the fight over resources – i.e. oil and metals. A recently published report for the US Congress (Morrison, 2006) clearly states the new world order where China is vacuuming the globe for precious resources, of which many have not earlier been regarded as precious.

> *China's rapid economic growth and continued expansion of its manufacturing base are fueling a sharp demand for energy and raw materials, which is becoming an increasingly important factor in determining world prices for such commodities. China is now the world's second largest consumer of oil products (after the United States) at 6.7 million barrels per day, and that level is projected to double to 13.4 million barrels per day by 2025. According to the U.S. Energy Information Administration, around 40% of world oil demand growth over the past four years came from China and this demand is "a very significant factor in world oil markets." China has also reportedly become the largest consumer of steel, cement, and copper.*
>
> (Morrison, 2006)

Plastics have become a renewable resource which in many respects previously was of no value other than for energy recovery. Now it is worth while to recover the material since the production capacities in the world have reached and exceeds the production limits. The way we treat and view what was previously seen as waste has now to be treated as a limited resource to be implemented in resource efficient design and in design for material recycling (cf. Swedish Recycling Industries' Association, 2006).

According to OECD (2006a), see figure 3 below, many economists internationally put the blame on China – and to a somewhat lesser extent on India and other emerging economies as well – for the currently broken trend where decreasing prices have been changed to escalating price levels on commodities. The price for raw materials, according to the OECD, has increased by 70 percent, see figure 3. Already today, as stated above, China is vacuuming the world market for resources needed to keep its economic machinery running, see figure 4. But, what will happen to the world's resources and the commodity prices as well as environmental consequences from mining, emissions and disposal within a few years from now when China's economy has passed all other economies in size – as of 2039? China's policy makers see these huge obstacles arriving at unprecedented speed and have in the 11th FYP set out a route for creating a less resource dependent economy – production wise – that to a larger extent relies on developing software, intellectual properties and creating an innovative society.

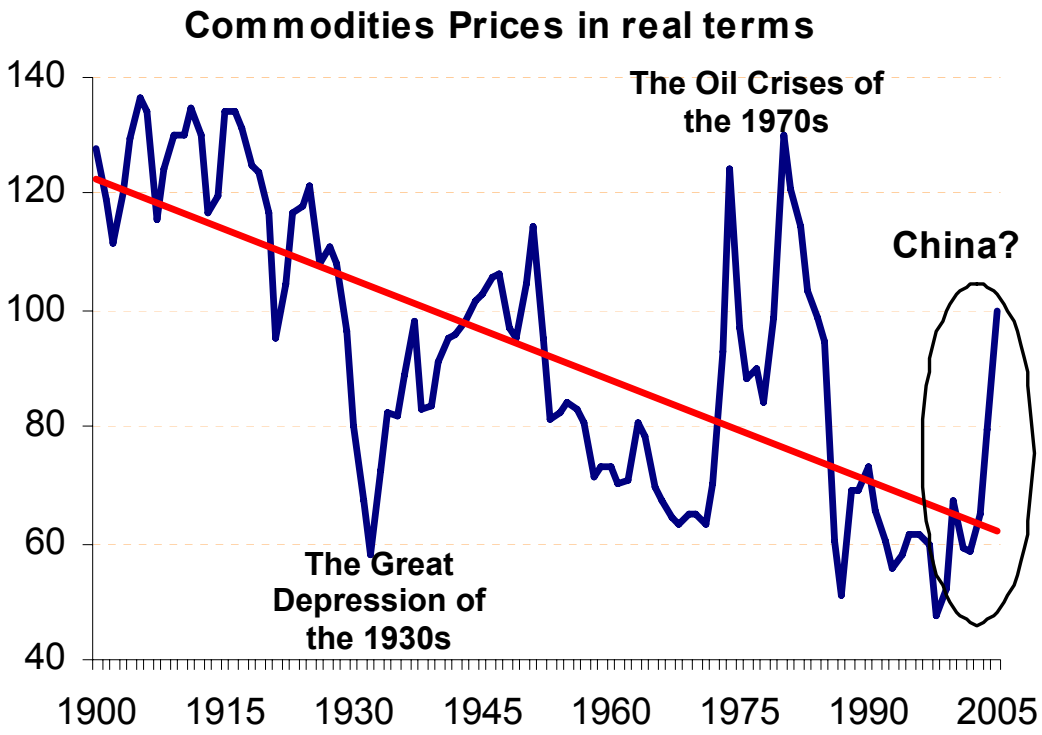

Figure 3: Has China's economic expansion lead to souring prices on commodities? (Sources: OECD, 2006a; University of Oxford).

Even though China manage to steer its economy, production wise, towards less resource dependencies the economic boom in China is currently creating a society of consumerism where the increased buying power is going for consumption patters similar to other industrialised countries of the world, let us say Japan and South Korea. So even though the Chinese industry will become much less dependent on resources in the future, let us say moving such production elsewhere in the world, the buying power of the Chinese will put a similar resource demand on the globe. If we take this new buying power and add to that the increased buying power of India, whose economy will have passed today's second largest economy, Japan, as of early 2030s (cf. Goldman Sachs, 2003) the combined demand for products will be considerably increased compared to today.

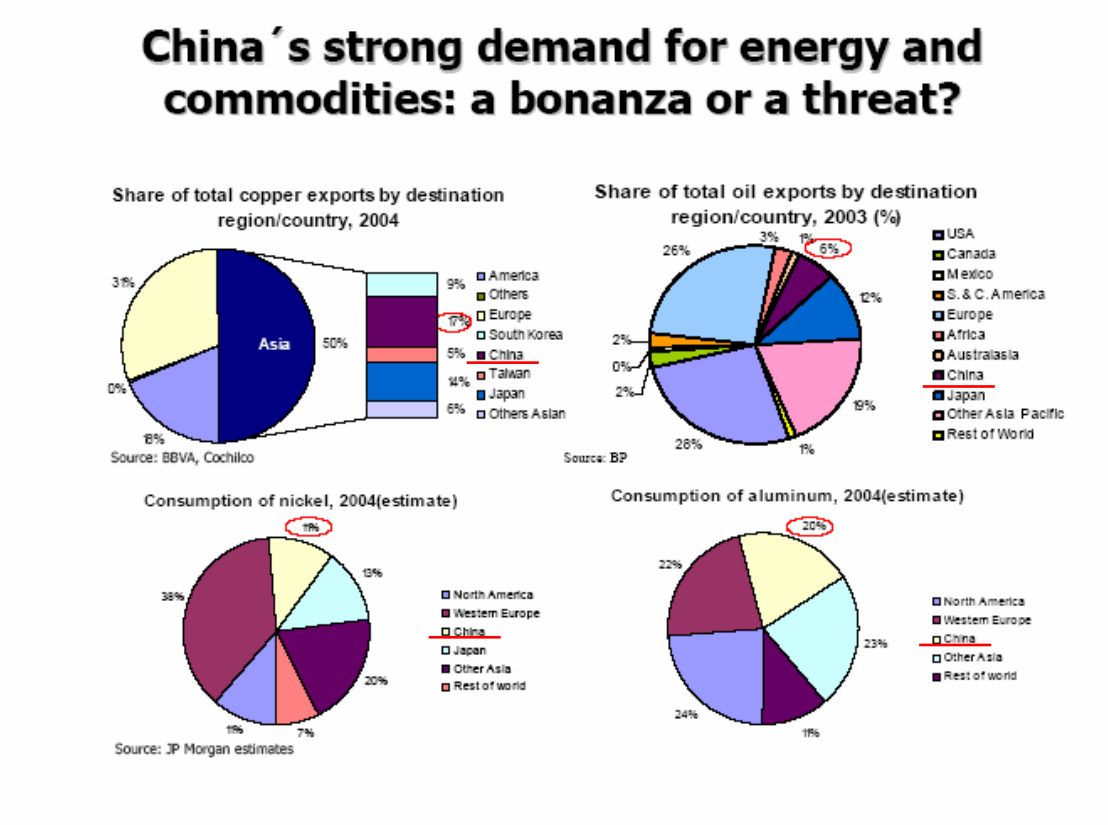

Figure 4: The size of China's demand for energy and commodities is currently in many respects similar to North America's. (Source: OECD, 2006a).

The *Commission for Africa* set out by UK Prime Minister Tony Blair (Commission for Africa, 2005) recognises that trade between Africa and China has increased dramatically over the last couple of years. During 2004 the trade reached over US$ 20 billion which is more that a 50 percent increase compared to previous year. The report on Africa identified some of the increased Chinese (and Indian) interactions with Africa, but China and India are in the report mostly referred to as developing countries that have succeeded in a number of economic and social issues.

So, in the report China is used for comparisons, comparing one developing country to an African counterpart, but China is also acting successfully in Africa where Western based corporations have pulled out for ethical reasons. E.g. when Western based corporations disinvested in countries ruled by oppressive regimes, like Zimbabwe and Sudan, China quickly took their place, buying minerals and oil as well as investing in the countries. Consequently, in the fight for resources there are other global actors that compete over natural and Economic resources such as in Africa and Latin

America, setting new rules of the game. That could have been reflected to a greater extent in the Commission for Africa, which primarily was addressed to the G8 countries. If including the new powers in Africa like China then also theses countries could be admitted to participate in discussions on social and environmental responsibility in trade and investments.

This development of increased exports to China and India from Africa and direct investments from Chinese and Indian corporations into the African continent is, however, according to an OECD (2006b) study overall a positive development for Africa even though room for improvements exists with respect to exploitation of African natural resources in a sustainable manner. Other aspects of these new trade routes is that A) African trade moves away from OECD towards China and India, B) world prices on commodities like oil and minerals rise, C) commodities that could have been used for Africa's economic diversification are now being used for the expansion of Asian competitors and C) as claimed by the European Investment Bank (EIB, 2005), due to the increased competition the EIB may have to apply other – read lower – environmental and social standards in some African investments in order to be competitive to Chinese contestants. The Swedish Daily Business Newspaper DI (DI, 2006) describes the Chinese proactviness as something that is seen as positive in Africa but that there is an inherent risk that these countries put themselves in a dependent situation characterised by huge debts to China. Huge debts from African nations have been revoked by China and the country constructs railway networks throughout (almost) the African continent. China imports cupper and oil which constitute 2/3 of China's oil imports predominantly from Angola and Sudan.

The rapid increase of car usage in China will, furthermore, greatly impact some key global resources in terms of size of availability and production capacities i.e. oil, aluminium, plastics and platinum-group materials. As shown in section PII.2.1. above the rapid economic increase in China will lead to an auto rate per capita in 2030 that is similar to today's ownership rates in South Korea. This will, besides consuming the global oil resources, give us some 360 million cars in the Chinese vehicle park as of 2030. This will require some drastic innovation to take place in the auto industry of tomorrow. One approach by Chinese authorities to solve the energy problem in the transportation sector is to create methanol and DME fuels from coal via efficient coal

power plants that applies coal gasification. From that process is syngas retrieved which is the foundation for synthesising the methanol and DME. Another way of using coal as energy in the transport sector is to create hydrogen fuel for fuel cell engines, described below.

PII.3.8. Hydrogenised Transport Systems

The conclusion from the case of the future vehicle and transport scenario of the world – section PII.2.1. – is that the vehicle sector of the future will become fundamentally altered by the economic rapid development of China and India. The auto industry has, thus, to seriously address resource, environmental and health issues in their product strategies if they are to gain/keep market share in tomorrow's car market. Auto industry worldwide – design and assembly companies and auto-part firms – ought, hence, to consider following aspects: Decrease energy consumption of vehicles, decrease resource consumption put into vehicles, increase the resource efficiency in production-use-recycling, exchange materials in vehicles, develop new fuels, innovate new engine technologies, create new infrastructures of new fuels. Improving the resource efficiency in China's energy system, especially considering its energy imports is a prerequisite for maintaining the country's growth rate (Sandklef and Kiesow, 2006). These issues will demand fuel and engine developments, but importantly also the holistic perspectives of e.g. developing infrastructures, as well as supply chains, for new fuel such as hydrogen, which is really the paramount salient that has to be solved. The engine and fuel are only aspects in the new technological system and overcoming the social and economic barriers of energy supply to fuel cell powered cars will make the huge problem of switching between GSM and 3G look really insignificant (Cerin, 2006b)[12]. Also STEPS (2005) illuminates these huge obstacles in introducing fuel cells technology as *The Chicken and Egg Problem*, where the major problems are about where to start from, who takes the first step and where the funding shall come from.

[12] One cannot sell hydrogen powered cars when there is no supply network hydrogen fuel and it is immensely difficult to build a hydrogen supply network if there are no cars (market) that can be run on the fuel. Here technologies that are not as efficient i.e. the hydrogen internal combustion engine of BMW can bridge the fuel infrastructure problem since it can run on both hydrogen and petrol. The technology can then gain a competitive advantage by being first and alone when the energy supply network is not fully covering the transport system in which the resulting path-dependence may make it

China has taken interest into fuel cell applications within the transport sector and is currently making its first steps in this direction by the use of fuel cell busses in Beijing, starting off at the Olympics 2008. The country is also to start series production of busses equipped with hydrogen fuel cell engines (STEPS, 2005). The prerequisites working for a Chinese system of hydrogen based road transports are:

A) the capability to enforce strict policies that steer the Chinese society into considerable changes as in the five year plans,
B) that the country and its major cities are experiencing some severe air pollution, causing health problems, from road traffic and coal combustion plants that need to be addressed,
C) the fact that most infrastructure in China, and India, needs to be created which provide room and incentives to go for new technologies and
D) the great abundance of coal that China has and the country is investigating how it can switch its oil dependence to produce hydrogen from coal.

Seemingly, there is a sizeable initiative taken in China to obtain a lead in innovating a hydrogen based transportation system – to solve foreign oil dependence, health and environmental problems and to create a competitive advantage for its industry. This development in China could also spillover, creating opportunities for other nation's with hydrogen transport related edge technological and system know-how, something for policy makers, e.g. Swedish and EU, to keep an eye on.

PII.3.9. Summing up on China

- The population of China just passed the 1 billion mark 1981 and will increase to 1.45 billion inhabitants by 2030 according to estimates. The largest impact on the environment and need for environmental technologies will, however, during the same time period be driven by A) the huge flux of people moving into the cities and B) the expanding economy that rapidly increases the buying power of the Chinese population.

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impossible for the competing technology (i.e. the more efficient hydrogen fuel cell engines) to gain access to the market (Cerin, 2006b).

- The internal migrations within China will increase the urban share of the population from 36 percent 2000 to 60 percent in 2030. The huge flux of internal migrators in China from rural (especially from the interior parts of China) to urban areas (especially the costal parts of China) will put huge demand on new infrastructures on piped water and sewage and treatment of wastes. The number of city-dwellers will increase by 340 million people as of 2005-2030.
- Other infrastructures that need to be invested in are the transportation systems in the cities. Currently, there are immense highway construction activities taking place in China. Between 2001 and 2005 the highway network of China more than doubled and Chinese authorities sees a future dense transportation network to be a keystone in its efforts to fight poverty in the nation. There will be enormous need to hamper the environmental effects that is associated with highway construction and heavy traffic emissions, especially in the cities containing several million inhabitants.
- According to Chinese officials some two-thirds of Chinese cities are considered air polluted and in an international comparison Chinese cities dominated the top ten positions of the most air polluted cities in the world. Half of the population lacks, furthermore access to clean water.
- In order to make China less dependent on oil imports for supporting the rapidly increasing road traffic system China is developing gasification strategies to produce synthesised liquid fuels i.e. methanol and DME for its vehicle fleet. Another strategy is to develop a hydrogen fuel cell vehicle park that is also based on coal as the primary resource of energy. The route that China eventually chooses will e.g. be important for the success of the alternative energy solutions that is under development in Sweden.
- The water scarcity especially in Northern China is a severe aspect for the supply to the major cities as well as the agriculture. Enormous efforts will be needed in e.g. how to reuse water resources and how to close industrial processes. Water scarcity in Chinese agriculture is of outmost importance. Chinese fields constitute only some 7% of global total but feed 20% of global population. The water scarcity problems of these high yielding fields are a

prioritised area that needs to be addressed. Another threat is urbanisation leading to the destruction of farm land by city and infrastructure construction.

- Environmental concerns are rising in China and considered an important issue for the country's future development and prosperity as stated in e.g. the 11th FYP. The annual amount spent on environmental protection currently exceeds 1 percent of GDP.
- There are indications that China will be developing environmental standards and technical legislation on environmental issues that are ahead of corresponding initiatives within the OECD region. There are two main reasons indicated :
    - Aim #1: There are numerous severe environmental issues that China has to address relating to the historic environmental disorders that has to be repaired, but also the huge migrations to the urban areas and the economic boom of the country's inhabitants will put enormous pressure on resources, agriculture, infrastructure, pollution and residuals as well as human health. There are, thus, issues that need to be dealt with in China, that requires a standard and technological legislation that goes further than corresponding OECD policy approaches.
    - Aim #2: China is increasingly using standards and technical legislation for the purpose of putting barriers to foreign trade and competition since the Chinese adoption of the WTO agreements has made it difficult to utilise protective custom procedures and tariffs. There are claims that the soon to be implemented Chinese RoHS directive which goes further than EU's RoHS may not only be a case of concern for the environment but a strategic tool for ensuring Chinese competitiveness, both on the domestic market and abroad.
    - Outcome of aims: Whether Chinese officials are influenced by aim #1 or #2 or a combination Western policy makers ought to pay attention to the environmental policy and standard developments in China, since what ever the main aim is, Chinese environmental policy development may become a prerequisite for the competitiveness of many Western

based companies in the nearby future both within the Chinese market but also to markets being influenced by Chinese standards.

- China has a rather complete industry structure ranging from resource extraction of many important minerals and energy inputs, production of low – tech goods (i.e. apparel and toys), and increasingly during the last decade a producer of high-tech appliances (i.e. electronic equipment and vehicles). The expansion of the industrial production has increasingly become dependent on imports of input materials and with increased production comes a greater need for environmental protection measures. China is to create A) an innovation based economy that will make the country less dependent on industrious production, which then to a larger extent can be outsourced and B) a society with increased internal demand for goods and services. These circumstances will result in:
    - More severe resource scarcities in the world. To a greater extent recyclable and also much more resource efficient products and services have to be introduced on the world market since prices on resources will sour and some inputs that currently are considered readily available as will become scarce as some plastics already today.
    - Increased need for production technology process solutions in China as well as in the future outsourced production facilities outside China.
- In conclusion the major need for environmental technologies will arise from
    - internal migration patterns, creating highly densely populated areas in Eastern China, adding some 340 million to the urban population, and
    - the explosion in economic wealth with an expected doubling of the middleclass by 2020, reaching 40 per cent of the population, that can consume cars, white goods, electronics and other resource demanding gadgets currently unachievable for large portions of the population.

PII.4. India

India is experiencing a rapid economic growth, but the impact on global economy is not as significant as that of China. The reason is not only a lower economic growth (which in itself is considerable: a tenth of global economic growth) but India is relatively more closed economy with considerable non-trade tariffs trade restrictions to foreign competition. Despite this both India's exports and imports increased by one third as of 2004 and there are attempts to lower the trade barriers to the average level in South Asia (STC, 2006). According to the Swedish Trade Council the IMF estimates the Indian economy to play a dominant role in world economy ahead.

PII.4.1. In Brief

The Republic of India is the seventh largest country in the world in size but is currently the second largest country in the world population wise with a population on 1.1 billion inhabitants, only surpassed by China, but with a fertility rate above 3 India will encompass the largest population in the world before 2050. India is, however, already today the world's largest democracy. Having played a dominant part in entire historic time and being a subcontinent itself India encompasses cultural traces all the way back from the cradle of civilisation. Many religions have seen their birth here and e.g. Hinduism, Sikhism, Buddhism and Jainism but also Judaism, Islam and Christianity have long been a part of the Indian heritage. In fact, the influence of the Islamic leaders that conquered India prior to the era of European trading companies makes today's India the nation with the world's second largest Islamic population, after Indonesia.

India has a Westminster-style parliament. The Prime Minister is de-facto head of state, but the President holds the ceremonial role. The real power of the President is being the Supreme Commander of the armed forces. The President and the vice-President and the Prime Minister and his/her Cabinet of Ministers constitute the executive power. The legislating parliament is bicameral, consisting of an upper house and a lower house where the members of the former are elected by state legislative bodies and the latter by direct elections. The Supreme Court tests if the laws are in conflict with the constitution.

The country is divided into 29 states and 6 territories of the union. Each state has its own government while most of the territories have an administrator that is appointed by the central government. The judicial powers of the state government covers a wide range of tasks such as sales taxes, industry policy, rural development, employment, environment et cetera. India's economy is the 12th largest economy of the world in nominal GDP. If rating the purchasing power the country's economy takes the 4th place (IMF, 2006). The nation is the second fastest growing economy of the world with a GDP growth at almost 10% a year. The inequalities in India are huge with the top 10% of the population receiving one third of all income.

The governmental control over industry has traditionally been quite large resembling a blend economy of capitalistic and socialistic influences. Since the beginning of the 1990s markets have gradually been opened up for competition. More than half of India's working force (60%) is occupied in the agrarian industries which constitute only 22 percent of India's GDP. Less than every fifth person works in industry – i.e. steel, transportation equipment, cement, mining petroleum and mining – and a barely more every fifth person works in the service sector. The considerable Anglophone middle class of India constitute the foundation for the country's software industry selling research and programming to international corporations in both North America and Europe. The software industry's expansion has led the service sector to constitute for about half of India's economy.

PII.4.2. Population trends of India

India has experienced an enormous growth in population since its independence for the British Empire. In 1947 India had some 342 million inhabitants, in 1991 the number of inhabitants had grown to 846 million and in 2001 the population of India had well passed 1 billion, namely, 1027 million inhabitants (Nagdeve, 2002). By 2025 there will be 1395 million and by 2050 India's population will total at 1593 million inhabitants, according to estimates (FT, 2005). The share of the Indian population living in urban areas was 1951 a good 17 percent and had increased to 28 percent in 2001 (Nagdeve, 2002) and the predicted share of developing countries' population to

live in urban areas by 2010 is 40% which would be a doubling since 1950 when the share was below 20% (WRI *et al.*, 2002).

The urbanisation where humans are gathered in megacities containing more than 10 million inhabitants will lead to health problems due to an increase in the pollution levels and the intensified exposure to them that can lead to premature deaths (Nagdeve, 2002). Housing problems will lead to pollution related diseases like respiratory disorders, water borne pathogenics, and tuberculosis among others. Globally urban air pollution may result in 830,000 annual deaths due to particles and SO_2 (WRI *et al.*, 2002). The need for supporting infrastructure for these new urban settlers is, hence, enormous. But it is not only the flux of people moving into the mega cities that needs support. Water infrastructure has already today a deficient coverage in Indian cities where poor people often lack piped drinking water and sewage, forcing them to collect drinking water from the same waters that people are "forced" to use for releasing the sewage and industrial affluence. There exist, thus, severe health risks associated to these shortcomings of the evolving Indian megacities. Currently, tap water is available only to 35% of the urban population and sewage pipe coverage reaches only 18% of the urban population. Even though this coverage of urban population numbers seem low the situation is even worse in rural areas. As claimed by WRI *et al.* (2002) the e.g. lower access to adequate sanitation, better quality drinking water, health services and jobs in rural areas makes it worth moving into the cities. "The rural neglect" within the developing countries makes it attractive to seek for the better services in the city and even though the poorest inhabitants in the cities cannot access those environmental infrastructures (of safe piped water and sewage and waste treatment systems) the chances of getting access is better than in the rural areas.

India is, by the UN World Food Programme (WFP) displayed as, one of the World Hunger countries (UNWFP, 2006). According to them more than one third of the Indian population are food-insecure, that is consuming less than 80 percent of minimum energy requirements. A horrifying number of pregnant women, almost 90 percent, suffer from malnutrition and anaemia. Pregnant women that suffer from anaemia alone experience an infant mortality rate on 20 percent. To fight these food deficiencies the WFP has a number of objective to be carried out as: immediate food

security for selected groups, ensure participation of women, advocate joint forest management, strengthen distribution channels for locally produced grains and increasing the agricultural production as well as creating employment.

PII.4.3. Deforestation and land degradation

Only about 5 percent of India's area is covered by dense forests and the protection of those is lax and forests are vanishing which has brought the condition in India closer to an ecological crisis (Nagdeve, 2002) if considering the unique wildlife in these habitats with e.g. elephants and big cats.

The modern agricultural methods have lead to over usage of both land and water resources as well as of pesticides and fertilisers which have increased considerably. The pesticides and fertilisers severely affect the water streams and rivers going through agricultural land. The extensive use of irrigation salinates the soil. Today's practices also contribute to soil erosion and loss of nutrients.

PII.4.4. Transports and urban areas

Transports have increased considerably in India and are nowadays the major source of air pollution in the country's mega cities. The air conditions get worsened by congestions, poor housing, poor drainage and garbage. The cars in the vehicle fleet are with almost no exception run on oil or gasoline. Combined, taken all together, these aspects create respiratory difficulties among people. The main pollutants from the road traffic are carbon monoxide (CO), oxides of nitrogen (NO_X), hydrocarbons (HC) and suspended particulate matters (SPM) and sulphur dioxide SO_2. The air related problems increases since the vehicle park constantly growths and especially fast is the growth in number of two-wheelers – in fifty years the numbers has risen from 0.27 million as of 1951 to 231 million as of 2001 (Nagdeve, 2002). Having the roads populated by two-wheelers may seem more resource efficient than having large cars clogging up the streets[13]. These small two-wheelers do, thus, pollute considerably

[13] The two-wheeler fleet in India is, however, more polluting than the auto fleet since most of the two-wheelers are still driven by two-stroke engines and due to the fact that there are only two strokes in a full circle the exhaust has to go out of the cylinder at the same time as the cylinder is being filled with

more CO, NO_X, HC as well as suspended and particular matters, but also may also – to a varying degree depending on the fuel applied – emit sulphur dioxide (SO_2) and lead (Pb).

These two-stroke two-wheelers have created an enormous health and environmental problem that Indian officials have started to address by implementing stricter emission standards that can be met by the more expensive four-stroke engines. This move in emission requirements is not appreciated by the US agency that promotes US exports. It claims that the procedure for establishment of emissions standards was vague and lacked transparency, but the biggest concern is that *even* the US manufacturers and their applied technologies fail to meet India's requirements, thus, seeing it as a trade barrier to US industry (cf. US Trade Representative, 2006c).

> *The emissions standards seem to favor small displacement four-stroke motorcycles that are primarily manufactured by Indian producers. Even the latest low-emission technology used by U.S. manufacturers fails to meet India's requirements.*
>
> (US Trade Representative, 2006c)

The internal migrations towards the mega cities combined with the rapidly growing population is, hence, putting sever pressure on India's urban transport system. The health problems arising from air are most severe in the largest mega-cities. Today, there are 3 mega cities in India, i.e. really populous cities that each have a population exceeding 10 million inhabitants. There are currently about 35 metro cities in India, that is cities with more than 1 million inhabitants. In 2001 the corresponding number was 31 and it is estimated that by 2015 India will encompass 43 metro cities and by 2020 the country will have 51 metro cities (UNPD, 2006; Nagdeve, 2002). According to the World Bank there will be about 30,000 pre-mature deaths each year, 17 million respiratory hospital admissions and some 17 million respiratory hospital admissions, not to mention all working days lost for all these people, due to the poor quality in the Indian cities. Some air quality problems are suspended particulate matters and dust-load. In fact, the dust-load in Indian cities is the highest in the world (The Tribune,

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new gas and, naturally, some new unburned gas goes directly out together with the residuals from the former.

2005). The cause is seen to be traffic conditions but also deficient coverage of piped water and sewage as well as waste.

As in Mumbai, the slum-dwellers constitute 55 percent of the city's total population and half the population lacks running water or electricity. The emissions from the huge amount of two-stroke vehicles together with the smoke from several hundred thousands of open cooking fires, diesel buses and coal-fired plants have resulted in inversion-trapped air. Breathing this air of Mumbai is the equivalent of smoking a package of cigarettes a day (Abhat *et al.*, 2002).

PII.4.5. Pollutions from Energy

India is experiencing increased environmental effects from its amplified usage of energy. A major source of this pollution is from the combustion of coal, lignite and oil. Nationally the production of energy has increased from 5 billion kWh around 1950 to 380 billion kWh around 1995. At the same time thermal power has increased in importance while hydropower has dropped from constituting half of India's electricity supply to only contribute with one fifth of the total electricity produced around 1995. The size of nuclear power is only nominal compared to India's total energy production. The production of coal and lignite has increased more than 9 times between 1950 and 1995 to 292 million tons. The production of petrol has increased 22 times between 1950 and 1995 to 75 million tons. Per capita the commercial energy use has increased from 137 kg of oil equivalent in 1980 to 248 in 1994 and in 1996 the oil equivalent increased to 476 kg according to the World Bank's World Development Indicators (Nagdeve, 2002).

PII.4.6. Water Pollution

The rapid urbanisation will also demand more water for both industrial and domestic purposes. According to the WHO (1986) the Indian water pollution comes from three major sources and if adding one important source indicated by (Nagdeve, 2002) the four main sources of pollution to water in India is: A) domestic sewage, B) industrial effluents, C) leaking waste disposals and D) run offs from agriculture. The chemicals from agriculture that runs off the fields is estimated to poison more than 2 million

people which results in some 20.000 deaths annually (WHO, 1986). Also religious practices are a source that contaminates the rivers. In India, shocking 70% of the available water is polluted and five states lack waste water treatment facilities. The city of Delhi, e.g. dumps 200 million of untreated sewage from its pipes into the nearby river, Yamuna, which has become one of the world's most polluted rivers (Nagdeve, 2002). There are numerous diseases that can be associated with water pollution. If taking diarrhoea and other gastrointestinal disorders as an example: it is estimated that more than 1 million children during the 1990's died from those diseases. But to increase the urban populations' access to sewage treatment to let 70% are investments that will cost the nation many tens of billion US dollars (cf. the China report by WRI, 2006).

PII.4.7. Summing up on India

- The population of India just passed the 1 billion mark 2001 and will increase to 1.45 billion inhabitants by 2030 according to estimates. The largest impact on the environment and need for environmental will, however, during the same time period be the huge flux of people moving into the cities and the expanding economy that rapidly increases the buying power of the Indian population.
- The internal migrations within India will increase the urban share of the population from 28 percent 2001 to 40 percent in 2030. The vast flux of internal migrators in India from rural to urban areas will put huge demand on new infrastructures on piped water and sewage and treatment of wastes.
- Other infrastructures that need to be invested in are the transportation systems in the cities. Today, the numerous two-wheelers, foremost two-stroke engine equipped, that dominate the streets severely pollute the city air.
- As much as 70% of Indian water is polluted and some huge cities do not treat the sewage water before realising it. Water problems arise primarily from domestic sewage, industrial effluents, leaking waste disposals and run offs from agriculture.
- The dust-load in the Indian cities is the highest in the world and the estimated annual premature deaths in India are 30,000 due to poor air quality in the Indian cities and 20,000 people die from contaminated water each year.

- In Mumbai alone over half the population lack running water and electricity. Even though the coverage of these commodities is low in the cities it is even lower in the Indian country side. Therefore, huge efforts are needed to also supply the rural population with water, sanitation, electricity and telecommunications. For such applications both infrastructure developments and stand alone solutions will be needed.
- Agriculture and population expansion in combination with lax regulation decreases the few forests areas left India, encompassing some rare wildlife such as elephants and big cats.

Part III:
Comparative study on environmental policy-making processes for environmentally adopted solutions and technology transformation

PIII. Comparative study on environmental policy-making processes for environmentally adopted solutions and technology transformation

There are considerable differences in national approaches and corporate responses to environmental legislation and regulatory initiatives that may impact national competitiveness which is illustrated by Porter and van der Linde (1995a; 1995b). In short the Porter and van der Linde articles argue that industries in countries with innovation-friendly, but strict, environmental legislation may receive competitive advantages internationally. The writing can also be seen as a critical petition to the legislation processes in the US which is, according to them, characterised by harsh antagonistic behaviour between regulators and firms compared to the legislation process in Germany and the Scandinavian countries. Even though the legislative processes in Germany and the Scandinavian countries were to a larger extent characterised by collaboration between government and industry Porter and van der Linde saw that legislation requirements went further in these countries than it did in the US. The other result that the authors detected is that despite further going environmental legislation the German and Scandinavian firms seemed to gain a competitive advantage over the US firms.

These examples on European legislations are, according to this view, more cleverly designed, seeking innovative stimulus through flexible and long-term instruments. Porter and van der Linde (1995a; 1995b), moreover, provide the argument for a win-win situation for business to encompass environmental concerns. The basic notion is that any waste in production or throughout the value chain of the product should be regarded as economic waste. You do not want to use more resources or create more waste than absolutely necessary for selling one product or service.

> *In short, firms can actually benefit from properly crafted environmental regulations that are more stringent (or are imposed earlier) than those faced by their competitors in other countries. By stimulating innovation, strict environmental regulations can actually enhance competitiveness.*
>
> (Porter and van der Linde 1995b, pp. 97-98)

The last part of the quote is the essence of the Porter hypothesis (Porter, 1991; Porter and van der Linde, 1995a; 1995b)[14], also known as the Porter-van der Linde thesis (1995a; 1995b)[15], which states that well designed regulation (in the US) can increase competitiveness and encourage innovation. There is, thus, a win-win situation for firms to reduce economic waste and simultaneously improving its environmental efficiency of its activities. Legislation may, therefore, act not only as a force that goes against firm rationale and delimit company revenues. On the contrary, by applying this viewpoint environmental legislation is rather an institution that informs corporations on the unforeseen corporate benefits of caring for the environment especially by delinking A) resource use and pollution generation from B) profits. The role of legislation is, hence, in this contest a catalyst for innovation.

Environmental regulation that stimulates environmental innovations can, according to Porter and van der Linde be characterised by a number of principles. The eleven design factors for innovation-friendly environmental legislation are (Porter and van der Linde, 1995a):

- Focus on outcomes, not technologies;
- Enact strict rather than lax regulation;
- Regulate as close the end user as practical, while encouraging upstream solutions;
- Employ phase-in period;
- Use market incentives;
- Harmonise or converge regulations in associated fields;
- Develop regulations in sync with other countries or slightly ahead of them;
- Make the regulatory process more stable and predictable;
- Require industry participation in setting standards from the beginning;

[14] A tem used by Ambec and Barla (2002).

- Develop strong technical capabilities among regulators;
- Minimise the time and resources consumed in the regulatory process itself.

Many of the features in the list above can be seen as a critique to the legislative process in the US at the time where industry and regulators acted as antagonists, resulting in stiff legislation not opting for industry's innovative capacities. The authors claim, as stated above, that the costs the regulative process in developing new regulations is more expensive in the US due to juridical struggles between governmental and corporate lawyers trying cut up-front costs while some legislative processes in Europe are claimed to be characterised by environmental and process experts trying to find solutions in a more collaborative way.

So, the North European legislation is to a larger extent influenced by long term goals that is designed more competently. It is taking the business cycles of industry into account, striving for long-term outcomes instead of aiming at strict short-term goals. Thereby, North European industry can make long-term plans that influence the technology choice when investing in new production method or developing new products. The argument follows as with the earlier writings of Porter that industry in a nation that faces harder conditions have a competitive advantage when competing on the international market. This would, hence, also be the case with stricter environmental legislation that is, as Porter and van der Linde put it, slightly ahead of other nations' legislation. This argument constitutes a good reason for studying the competitive advantage industries of some pro-active countries may experience due to well-designed legislation.

But, before going to specific proactive countries and their environmental legislative procedures there exists some critique that is worth mentioning. Massive critique has been raised on the theoretical arguments and the empirical soundness or a lack of thereof by Palmer *et al.* (1995), Jaffe *et al.*, (1995), Faucheux and Nicolaï, 1998, US EPA website (2003) and Swedish EPA report (Cerin, 2005). The critique involves another front as well, namely, the danger of indulging industry and the public into the beliefs that environmental improvements are not costly which may prevent expensive

[15] A term used by Palmer *et al.* (1995).

environmental measures from taking place. The empirical evidences supporting the arguments of Porter and van der Linde (1995b) have been criticised already from the beginning, in the same number of the journal, by Palmer *et al.* (1995). They surveyed firms that had been affected by environmental legislation and found increased costs for most of them even those that had been referred to by Porter and van der Linde as success cases. Also the report by the Swedish EPA (Cerin, 2005) criticised the theoretical discussion of Porter and van der Linde as being to thin, not considering asymmetric information, transactions cost and property rights of agents over the value chain to satisfactory, which had led to over simplification in reasoning and generalisations in conclusions.

However, despite the critic on these seminal articles by Porter and van der Linde, many critics show some support to the work. Especially the aspects of the articles concerning incentive schemes for spurring innovations and gaining a competitive advantage on the international market have won receptive ears among companies, legislators and NGO's, even though some regards the costless claims of environmental legislation to be built on lose grounds.

Dobers (1997) describes the actual policy process as a market a pre-market where actors compete to get the best roles of the game, that is the game to come. According to Dobers these markets drive technological change and work as means of diffusion. Taking this line of reasoning one step further: Being successful in the legislative process then the process itself ends up as the disseminator of technologies. If an actor is able to steer – influence – the legislative process into a direction that fits the abilities of the actor it will provide a competitive advantage for the actor. If the actor is extremely successful then the actor has created a regulatory supported path-dependence that encompasses the offerings and specific know-how of the actor itself.

Since, in the beginning of a policy creation process there is limited reliable information about the different technological choices possible the decisions by involved actors may be characterised by bounded rationality, using simplistic decision models to cope with a complex environment (cf. Simon, 1955), which gives the actor that has information advantage some opportunities. Establishing a path-dependence creates an enormous competitive advantage for the actors whose technology is

dominating the market segments even though other solutions may be better technically, economically and environmentally (cf. Nelson and Winter, 1982). So, if following these thoughts on industry evolution the industry adoption process – starting point as well as noise from unintended occurrences – is vital for the final outcome in the market and as Dobers has shown, which too often is overseen, is that this struggle over path dependence s, especially for environmental and health matters, may start early in the regulatory design processes. On top on this in this section of the report, discussions are also made on C) the policy making process that takes place aside from authorities in Japanese conglomerates and D) examples provided on policy measures taken on renewable energy power generation around the world.

Now, after this theoretical discussion let's take a closer look at the policy-making processes for environmentally adopted solutions and technology transformation by examining two cases A) the introduction of the three-way catalytic converter (in California, Japan, USA, Chile, EU, Germany and Sweden) and B) the collaboration between ministries, industry associations and telecom industry (operators and manufacturers in Japan) to see how the theories connect to the cases described. Both cases have a strong Japanese focus.

PIII.1. Environmental Policy Making Processes in Japan – A case of East Asian corporatism

The rapid economic development in Japan has evolved the country from severe poverty levels since the end of the post-war occupation – as of 1952 – to an economic world power. Japan has the highest average post-war (WWII) GDP growth counting from WWII until today. One drastic slowdown in economic growth occurred during the aftermaths of the oil crises in the mid 70's. The otherwise huge economic growths in the 60's, 70's and 80's slowed down remarkably again in the 1990's and turned into economic recession by the turn of the millennium. Recently, the economy recovered and the economic expansion in Japan is now once again surpassing the GDP growths in many other industrialised countries. Japan is a predominant trade country and its largest export markets are USA and China followed by, but at

considerably lower levels, South Korea, Taiwan and Hong Kong. Japan's largest import partners are China and the USA.

Japan, one of the world's leading industrialised countries in the world, is a dominant player in international trade and one of the most advanced producers of products of motor vehicles, electronic equipment, machine tools and chemicals among many other sectors. The automotive and electronics industries are often considered the largest sectors in Japan and constitute a major driving force in Japan's industrial sector. Some other industries worth mentioning of importance are service sectors like banking, transports and telecommunications.

The successes of these industries are, thus, of great importance for Japan and it is therefore, interesting to see how the Japanese policy making process works. How are the policy makers a developing policies that delimit environmental harm without intruding on the success of Japanese exports?

As detected by research, e.g. Bauner (2004), Broadbent (2003), Edman (2003), Japanese policy makers include and collaborate closely with its domestic industry in the policy process, often through industry associations. In this, one could find support from the Porter and van der Linde arguments concerning industry participation. However, when comparing the situation of one country to another; one should pay sincere attention to the cultural and natural (i.e. ecological, resource and pollution) conditions since these may be paramount in detecting the causes of human interaction and resulting activities.

One characterisation of Japan's society is its corporatism[16]. The country's East Asian type of corporatism is to a much higher extent integrated by social networks even compared to the European varieties that exist in Austria and Germany[17] (cf. Broadbent, 2003). According to Broadbent and Ishio (1998) Japanese business sectors do merely have quasi-autonomy from Japanese ministries and the industry sectors cannot be viewed as a class of entirely own self-interests. This so-called business-state integration is one reason for swiftly turning around Japan in the 1970's from a country with severe environmental problems to become a proactive nation in managing environmental aspects. Calder (1988) has a similar description of Japanese policy development during crises where pro-environmental agencies provide necessary policy suggestions.

Accordingly, the Japanese policy process may not just be copied by Western economies without paying large concern to cultural differences such as the natural hierarchy and the loyalty to personal and organisational networks as well as the conformity in these networks to accept the official form (Lebra, 1976) which makes the implementation of environmental policies from government to businesses a more straightforward process (cf, Nankane, 1970). It is, moreover, shown by Bauner (2004) that the Japanese legislators consulted Japanese auto industry and adjusted phase-in periods as well as technology solutions to the needs and capabilities of the domestic industry. Edman (2003) illustrated, furthermore, that Japanese ministries collaborated

[16] The term corporativism can be interpreted in various ways, either as A) a holistic term for different sorts of corporatism or B) a label for the historic view on corporativism which is a society form where the legislative powers belongs to assemblies constituted by various civic groups such as economic, industrial or other types of groups. In this case, however, it is the East Asian state corporatism that is of greatest relevance in order to understand the society structures and the interactions between actors. The East Asian model is characterised by governments that use organisations that have a somewhat semi-official status as means for industry and society interaction. In the case of Japan there is some culture – in society in general and particulary in the contracts between state, industy associations and individual industry firms – of obeying state officials as a relic from the period (pre-1945) when the state official was a servant of god – i.e. the Japanese Emperor – whose directives he handled down. However, this tradition seems to weaken slowly over time (Broadbent, 1998). The political system or societal arrangements of small northern and western European countries can be termed neo-corporatism which is characterised by negotiations between three parties: the government, industry associations and labour unions but serves merely as a mean for dividing capital among them.

[17] Another type of policy process struggle: As described by Böcher and Töller (2003), there are other actors than those fighting for dominance (e.g. establishing technological path-dependence) in the environmental policy landscape, but fighting for creating new policy mindsets. In Germany, identified as the environmental policy pioneer in Europe (cf. OECD, 2001), drastic changes in policy ideas was permeated into policy instruments during the 1980s and 90s moving regulatory instruments from command-and-control towards eco-taxes and voluntary agreements. A prominent name in the push for

with the industry associations of cellular phone producers and telecom providers to establish a take back system for recovery of used terminals.

Another aspect that differ countries in their environmental policy development processes – such as how the participating actors behave – is the influence of natural and social intensities of pollution (Broadbent, 1998). This can be seen in the policy processes where initiatives to diminish air pollution from road traffic is driven by areas of severe air conditions like the regulations to improve the air qualities of the Los Angeles, Santiago and Tokyo areas. So, comparing policy processes of different nations have to include both cultural and environmental perspectives.

PIII.2. CASE: Policy Processes in Vehicle industry – Introducing the Catalytic Converter

PII.2.1. The Budding of Japanese Environmentalism

Due to the economic post-war boast in Japan the domestic standard of living rose rapidly and reached levels similar to those in Europe and USA. As a result, vehicle fleets, distances travelled and the congestions intensity increased considerably as well as the associated environmental problems, but so did also the environmental effects from industrial activities. Between 1955 and 1970 the demand for energy more than fivefold and the sulphur dioxide emissions consequently did so too in 1968 (Bauner, 2004; cf. EAJ, 1997). As a result, environmental awareness and public support for stricter environmental regulation grew which resulted in the creation of the Japanese Environmental Protection Agency in 1971. The first task of the agency was to implement stricter regulations for abating emissions from vehicles and industry.

The Swedish expert on the introduction of vehicle catalytic converters, David Bauner (at Industrial Economics and Management, Royal Institute of Technology), has detected how the Japanese policy development followed the US, and especially the Californian, regulative initiatives closely but, in interaction with the of Japan's auto industry to incorporate domestic industry prerequisites (cf. Bauner, 2004). His

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this alteration was von Weizäcker and such agent are in the paper labelled the *Policy-entrepreneur* which is an actor that is devoted to a policy idea and place in vital role in altering the policy process.

research has followed the private and public dependencies in creating emission abatement systems for the automotive industry.

PII.2.2. Policy Developments in California, Japan, USA and elsewhere

The American Muskie Act, denominated after Senator Muskie whose bill was passed by US Congress in 1968, for delimiting vehicle emissions greatly influenced the goals of the newly established Japanese Environmental Protection Agency. In fact, Japanese regulators closely followed the US vehicle policy development for vehicle emission control systems and especial concerns were paid to the Californian regulatory initiatives. The Japanese Environmental Protection Agency arranged hearings on the three-way catalytic converter with domestic Japanese car manufacturers and Japanese university professors to get a clear picture on the state of vehicle emission control technology in the country as of early 1975.

When governmental officials in 1975 realised that the domestic vehicle producers were not going to be able to meet the stringent NO_X emission targets – requiring a 90% reduction of NO_X emissions – for 1976, the bill became postponed another two years until 1978. The Japanese regulators realised, consequently, that the NO_X abatement targets would be out of reach in the short time span without the three-way catalytic converter solutions.

By 1978 these solutions would be accessible to most Japanese vehicle manufacturers, however, not industrialised by all. This delay can be seen as an attempt to incorporate the investment cycles in industry, taking into account that the, at the time, current catalyse technologies available just could not do the work. The Japanese requirements on three-way catalytic converters were implemented one year after corresponding Californian requirements, but well ahead of corresponding US national emission standards coming into effect as late as 1983.

The US legislation was, thus, implemented after a decade of negotiations between governmental bodies, industry and NGOs (Bauner, 2004). The policy process was trichotomised between federal authorities, vehicle manufactures and NGO's communicating partly through legal processes (Grad *et al.*, 1975). The Japanese firms,

however, saw the potentials for rapidly increasing exports and recognised the growing public concern in the US for the increasing emission levels arising from traffic. This concern became legislated in California which was closely followed by Japanese legislators. In fact, by following the Californian regulative initiatives for introducing three-way converters Japan got a go-ahead start internationally, also compared to the big three automakers in Detroit. Californian legislators put the local environmental concern foremost, whose air pollutions was more severe than elsewhere in the US, and had less concern for the US (domestic) auto industry. The arguments and concerns of the big three automakers, being based in a city faraway in the American so-called Rust Belt, did not have the same closeness to the Californian public concerns as the urban air conditions of the state's major cities worsened.

The antagonistic process between federal legislators and the US auto industry, shown above, links rather well with the American policy process criticised by Porter and van der Linde (1995a; 1995b), seemingly leaving the US industry and public authorities with considerable legal process costs, but even more burdensome a competitive disadvantage compared to its Japanese contenders. The legislative advantage for Japanese auto industry for competing in the international arena is well illustrated in the table of three-way catalytic converter introduction by markets below (table 3), based on Bauner and Laestadius (2005) and Bauner (2004):

Regulative Area	**Year**
California	1977
Japan	1978
USA	1983
Germany	1989
Sweden	1989
Chile	1993
EU	1995

Table 3: Ascending chronological order of policy supported introductions of the three-way catalytic converter in selected world markets.

If looking globally at the introduction of the three-way catalytic converter we see that Japanese legislators quickly followed the Californian lead. Japan did not only follow the Californian legislation on catalytic converters, but was also on the cutting edge on reducing emissions from passenger cars by adopting and adjusting the *Muskie act* adopted by US Congress 1968. This adherence to the development of US policy measures has an explanation in the expansion of Japanese domestic demand for vehicles as well as the expansion of its auto industry production (cf. Bauner, 2005). At the time Japanese auto industry export was restricted to Asian markets but the country saw the potentials in penetrating the North American passenger car market.

Except for the resistance of the US auto industry the introduction of three-way catalytic converters the introduction of the new technology was also stalled by an unresolved gas issue. Until recently lead has been added to gasoline for lubrication purposes as well as for superior octane figures, but Japan pioneered in phasing out the lead content in petrol for environmental reasons during the early 70's and the toxic metal was phased out already in 1974 (Bauner, 2005). The public opinion was supportive to these measures, although the refinery industry manufacturing gasoline was somewhat more reluctant. The collaboration between legislators, industry (i.e. gasoline producers and distributors and vehicle manufacturers) and other stakeholders was, accordingly, of cooperative nature and information was traded among the involved actors.

The early de-leading of petrol that took place in Japan is in fact a removal of one important reverse salient that obstructs the introduction of a technology. As described by Hughes (1992) the change of a new technology may be hindered by conditions that reside outside the thought of application that is to be introduced. These, reverse salients – in this case the supply of un-leaded fuel for three-way catalytic converters – that are a part of the wider system has to be identified and addressed if a change is to take place. Even though they may at first sights appear insignificant their presence can constitute the critical problem that stalls changes of greater magnitude. So, the introduction of the three-way catalytic converter was dependent not only on government initiatives and vehicle manufactures, but also the solutions enabled by the automotive component manufacturers (like catalytic converters), oil refiners and fuel distributors.

PIII.2.3. The Chilean Context

When looking at how the Japanese and US automakers and governments dealt with the introduction of the three-way catalytic converter in South America the process in Chile constitutes a good example how different approaches to environmental technology may affect tomorrow's market shares. Besides, Chile is the South American market that first enforced policies on three-way catalytic converters and, consequently, also on unleaded fuel. In fact, when the first democratically elected government took over the Pinochet junta in December 1989 the new civilian Minister of Transport found a signed document of its predecessor and Pinochet. The proposal applied the emission requirements on vehicles. The newly elected Chilean government, however, had to rework the proposal for legitimacy reasons (since it could not officially use a proposal from the former undemocratic regime). Because, the foundation for the proposal was already done the work with implementing the new proposal went fast, although obstacles existed.

The Chilean authorities applied a remarkably short phase-in period for the three-way catalytic converters, and the authorities could draw on the experiences from markets already having introduced catalytic converter requirements. By 1992 new cars in the capital Santiago and other heavily populated areas in central Chile were equipped with the catalytic converters. In 1994 it became mandatory for new cars nationwide to be equipped with three-way catalytic converters.

There where no domestic Chilean car manufacturing industry in the country at the time, but the policy process got resistance from France and the USA since their auto industry have auto plants in Argentina and Brazil, seeing the Chilean market as an output for their production. Consequently, the Ambassadors of France and USA paid visits to the Chilean presidential palace, explaining the need to halt the process of introducing the catalytic converter in Chile (with requirements similar to those in the US and some European countries.). The reason for their objection is that the auto plants of e.g. GM and Renault was producing cars exclusively for the South American market where no such restrictions were in place. It would thus be expensive for these manufacturers to change the production lines in these factories only for the Chilean

market. The policy process in Chile should hence be slowed down (Bauner and Laestadius, 2003).

The Chilean policy process was despite these attempts not stalled. This can be illustrated by the number one selling car on the Chilean market 1991, Chevrolet Chevette, which was withdrawn from the Chilean market the following year due to inability to change production in time (Bauner and Laestadius, 2003). It was difficult for them to ad the cost of a catalyst to the end consumer. The situation was completely different for Japanese auto manufacturers. They did not have any production in South America adjusted for a non-catalytic vehicle market. Before the stricter emission standards in Chile, it was expensive for Japanese car manufacturers to sell vehicles to Chile since – due to the lead content in gasoline sold in Chile – Japanese auto makers had to make modifications backwards by taking away the catalytic components. As a result from the introduced emission standards in Chile Japanese auto makers quickly gained a large share of the rapidly growing Chilean vehicle market. Linking back to Porter and van der Linde (1995a) the phase-in period of the three-way catalytic converter policy process was long enough for Japanese firms to quickly supply the market with products fulfilling the needs. The US counterparts, however, needed more time for adjusting their production processes and lost considerable market shares. Some of the valuable phase-in period was, instead, spent in opposing the Chilean legislative process.

PIII.2.4. The European Context

Swedish three-way catalytic converter legislation was, heavily, influenced by the developments in the EC and by German initiatives. The process towards unleaded fuel and three-way catalytic converters was slow in Europe where nations tried to block tightened emission standards to defend their own domestic auto manufacturers. When Germany threatened to introduce unleaded fuel and catalyst requirements unilaterally 1983, the European Commission agreed on a directive the following year.

So, in 1985 Germany announced the directive that will require all new gasoline-driven vehicles had to comply with the US EPA-83 regulation. In Sweden, the fear of going ahead of other European countries and introducing petrol not available on the European continent was now relieved, and unleaded petrol was made available on the

market (Bauner and Laestadius, 2005). In order to support domestic car manufacture interests the three-way catalytic converter on new cars was not made mandatory until 1989, but rebates on car price tags were awarded those that bought a car with catalytic converters during the phase in period between 1986 and 1989. Germany introduced a program for tax rebates, both for new cars and for simpler catalytic converters to be installed on cars already in use.

PIII.2.5. Behaviour of Industrial Actors

In the Californian policy process the US automakers declared the demands in producing such cars to be unrealistic. Volvo was then a small player in the Californian market and saw, thus, an opportunity to gain market share as well as improving its reputation as a European luxury car maker taking social responsibility. Together with German based mechatronic company Bosch and US based catalytic converter company Engelhard, Volvo developed the three-way catalytic converter. Volvo then demonstrated, to the US Senate that – unlike the claims of US auto makers – it was possible to produce such a cleaning solution. In the Swedish market, however, Volvo did not make use of such a proactive strategy. On the contrary, later during a similar legislative process in Sweden Volvo took a position comparable to the one that the American car producers took in California. Volvo, thus, opposed the converter requirements on cars in Sweden which delayed the implementation of the requirements for a few years (Cerin, 2005).

Why this apparent inconsistency in approaching the comparable regulatory process in different markets? Well, as described in a Swedish EPA report (Cerin 2005), in the Californian market, Volvo was a small premium player, being able to pass on the extra costs for catalytic converters to the customer and even earn an extra premium on its new exclusive environmental image. Sales can boost (still residing within a distinctive niche of the market) with increased premium appeal. In Sweden Volvo was the dominant player with a share on about one fifth of the total market and could not pass on the costs to a large mass of not so concerned customers. Volvo had, therefore, in Sweden to compete in (mass) segments with generally lower prices and the customers prepared to pay extra for a better environment represented a relatively small group compared to Volvo's existing market share.

Looking back at the Porter and van der Linde (1995a; 1995b) view that lax legislation would hamper environmental technological solutions seems not always to be the case. Volvo placed itself on the technological frontier in the anticipated US and Japanese markets that had much stricter regulations implemented. The Swedish car manufacturer engaged small technology companies for catalytic converter system development, held several patents and got well ahead of many competitors several times larger than Volvo (Bauner and Laestadius, 2005).

So, the corporate strategic evaluation of the future conditions of anticipated future regulation and restrictions in the company's (potential) markets seems to be decisive for the environmental business proactiveness of the company. The aspect whether domestic environmental regulation supports large companies in this undertaking may not be equally important. In this exploration of market potentials in foreign markets as well as incentives for technological innovation Japanese firms had benefited from the domestic regulation process while the Swedish manufacturers had not the same early support from environmental regulations. The support from the Swedish policy process was a late and silky introduction of catalytic converters on the home market by during the first years using tax relieves instead of mandatory requirements on consumers buying new passenger cars, but not really supporting innovations for a competitive advantage abroad[18].

PIII.3. CASE: The Policy Making Process in Telecommunications industry – Japan

The communication between individual companies and policy makers is rare according to Edman (2003). Industry's views are represented by industry associations instead. These associations work as intermediates negotiating with policy makers at

[18] Relating to this case for lax Swedish environmental policy development in the auto-industry is the case of chlorine free bleaching in the Swedish pulp and paper industry. For a decade Swedish pulp and paper industry apposed strong public opinion against using chlorine bleaching, since it would both be costly and of lesser whiteness. In the small European neo-classic corporatism both industry and unions were against the creation of policies restricting the use of chlorine and the Swedish EPA was not supportive to chlorine-free paper. An NGO, however, got the association of municipalities in Sweden to influence its members to only procure copy paper that was no-chlorine bleached. One producer took the bate, changed production technology and received huge market shares of premium character on top of that. Consequently, after one year all major producers of copy paper that had claimed the impossibility of producing chlorine-free paper had such *environmental* products on the market. This process provided the Swedish pulp and paper industry a competitive advantage. Porter and van der

governmental bodies. If the government wants to retrieve the views of certain companies then the contacts, according to Edman, go through the industry association requesting it to extract answers for the respondents from the government. Edman, moreover, found that the associations themselves believe they retrieve not enough feedback from this process.

If looking specifically at the policy process to develop regulations for recycling terminals, phone units, within the Japanese cellular phone industry there are two key industry associations that negotiate with authorities. One of them is the association of manufacturers, CIAJ, and the other one is the association of operators, TCA. These industry associations also, apart from policy development discussions, are also keeping track on international standards and regulations for harmonisation purposes (Ashford, 1993; Edman, 2003). These information bridges (cf. Cerin, 2005) also enable the collection of information for the actors in the policy process such as collection and recycling data of cellular phones.

Besides being an information bridge between government and industry sector the industry associations may take an active role in establishing environmental programs such as in the case of recycling of cellular phones in the telecom industries where the associations of operators and manufacturers worked together (Edman, 2003). Also the Japanese Ministry of Economy, Trade and Industry (METI) expressed in the strength of the collaborative nature between ministries and industry associations. According to METI itself it does not communicate directly with manufactures and operators. Instead the ministry communicates with industry association that also provide the ministry with company stances in return.

Fiscal support to individual companies is not common but Japan has semi-governmental banks where SME's can apply for funding. The aim is to maximise public utility and interest through investments in production facilities or technology. Also this process, according to Edman's interviews (2003), is carried out in collaboration with industry associations. The ministry (in this case METI) believes the industry associations collect a better picture and constitute a superior devise for

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Linde (1995a), however, erroneously claim that this is a case of clever and flexible Swedish legislation (cf. Cerin, 2005).

permeating the view of the ministry. Industry associations are in general good followers of government directives. The ministry sets up councils compromised by authorities, industry representatives, and so-called talented people. The ministry does, however, in practice tend to supply the committee with guideline drafts to be processed in an authoritative manner.

The experience among the interview corporations in Edman's study, on the collaboration between industry and government, support the view of ministries and industry associations displayed above. NEC for instance is a member of many industry associations and competitors share information with each other at these meetings and NEC too discloses information about their environmental aspects. Not only companies attend the meetings, as shown above, but government attends and shares information regarding coming legislation proposals. According to NEC, government and companies cooperate to find room to establish new technological solutions as well as finding market opportunities for those. SonyEricsson's experience is that they do not receive feedback from government directly but the association of Communications and Information Networks provides a forum for retrieving information from governmental bodies. The industry association also requests SonyEricsson to write reports as input for the association's communication with the government.

Despite this collaborative environment among ministry, industry association and companies, the environmental proactiveness varied among Japanese telecom providers. The NTT DoCoMo is a well recognised leader for its environmental proactiveness globally and the second largest player, J-Phone, is increasingly taking a proactive stance, but other operators in Japan have not reached as far. This could, however, be more a reflection of company size since the other operators are small compared to NTT DoCoMo (58% market share) and J-Phone (18%) market share, leaving the rest with small pieces of the pie. Company size is, as the Swedish EPA report (Cerin, 2005) explains, decisive for likeliness for a company to be able to engage proactively in many environmental issues.

PIII.3.1. Recycling of electronics

Considerable amount of Japanese electronics firms of which some produce cellular phones have been recognised for their work with environmental issues such as Sony and SonyEricsson by Greenpeace (Greenpeace, 2006) and NEC by Technology Forecasters (Gordon, 2006) even though the Japanese consumer electronics firms were still behind their European counterparts, on for example recycling, a couple of years ago which was considered a problem that needed to be resolved due to the limited availability of landfills in Japan (cf. Edman, 2003). Estimates indicate that Japan will run out of landfills by 2008 and this obstacle has now been aggressively addressed in Japan both in the design of electronic goods, home appliances among several other products – design for environment – as well as recycling facilities – recycling technologies. Today, Europeans go to Japan to study recycling facilities (Gordon, 2006). Examples on innovative solutions where Japan is several years ahead of competitors on the global market are gas-electric hybrid vehicles, unleaded and unbromided electronics and circuit boards without bromide and recycling technologies, all belonging to product groups that constitute a significant share of world trade figures. According to Gordon this aggressive greenness strategy of Japan and its companies will give and already have given them a competitive position in the increasing market for products and services that enable a more environmentally sound solutions.

PIII.4. The Policy Making Process in a Japanese Conglomerate

Top management commitment is a prerequisite for company engagement in evolving new technological solutions as well as being proactive in the legislative processes. The pro-activeness in policy processes is also depending on company market capitalisation size and, of course, the size of its revenues. A blue-chip multinational company whose top management is committed to environmental issues has an advantage over competitors in retrieving of good picture of the future international needs of people (consumers) and environment as well as going from there to explore new solutions both to services offered and to policy makers. These companies influence both competitors in the industry – horizontally – and upstream in the supply chain – vertically. Through horizontal competition and vertical pressure the advancing company may, thus, create an upstream change that involves firms of considerably

smaller size on the global scene. The advanced company may also play the role as providing the legislator with possible solutions.

One company, being the forerunner in many environmental aspects is Toyota i.e. on three-way catalytic converter, hybrid engines and fuel cells. Toyota has also created a research institute – Toyota Genesis Research Institute established 1997 – to collaborate with research institutes world-wide to serve the long-term interests of humanity. The institute makes global social forecasting and the results are used for carrying out research together with universities research institutions as well as with Toyota Technological Institute and Toyota central laboratories. The outcome shall contribute to the world in a broad range of fields and projects that the Toyota group is facilitating. Questions that the Genesis Research Institute is working with are "Will cars run on gasoline in the 22nd century? How much of the Earth's forests will be left? What will be the average life expectancy? Will Japanese people still be eating rice? Will any of us still be wearing cotton clothing? Will the sun still be shining brightly above us?" (Genesis Research Institute, 2006). Such questions could then permeate e.g. through facilitation projects, into the product strategy of Toyota.

PIII.5. The impact of Company Size when Comparing Policy Processes

Japan is often referred to when it comes to big leaps in environmental technology such as the development of alternative engines for vehicles like the hybrid and fuel cell engines. An ITPS report (Andersson and Tanaka, 2006) describes the successful environmental strategies in Japan where the applied broad definition of environmental technology is seen to have lead to innovations of greater magnitude. It is, however, important to consider the size of these Japanese conglomerates and their access to capital for research, before expecting similar scope and results from the Formas-VINNOVA programme with an annual budget on SEK 30 million that is to be matched with industry funding.

Large corporations may have the strengths to develop strategies ahead of national legislation, but this does not appear to be common practice in the domestic markets where the large corporation is the dominant player. One such case is Volvo which took a lead internationally on the three-way catalytic converters. The pulp and paper

case shows that a small player in a domestic market – like Volvo in a foreign market where it is a niche player – can be the actors that go ahead of legislation. In Sweden Munkedal was a niche player in its domestic market, but saw the potentials of first mover advantage in supplying the market with non-chlorine bleached paper. The common issue in the two cases is that legislation did provide the support for retrieving a competitive advantage on important markets.

As shown in the catalytic converter policy cases above, however, the Japanese policy process was characterised by close cooperation between government and industry through industry associations where the legislators worked for retrieving a good picture of Japanese technology and their status compared to international initiatives. The Japanese legislators quickly adopted the Californian emission requirements and implemented similar standards just a year after and Japanese car manufacturers have gained competitive advantage in many markets worldwide.

Two aspects that policy needs to deal with and to create an understanding about is

- seeking export opportunities of environmental technology
- the institutional picture – power relations, asymmetric information, cultures of actors, institutions and society structures of different nations.

Even though a critique is brought forward so far in Part III on Swedish legislation, there are of course positive sides as well but the greatest leaps forward can be achieved by highlighting some aspects that can be improved for increasing Swedish competitiveness in the international scene of environmental technology.

PIII.6. Renewable energy and power generation policies

About 17 percent of the world's primary energy is constituted by renewable energy sources. Large scale hydro plants, traditional biomass plants as well as newer supplements i.e. small hydro, modern biomass, wind, solar, geothermal and biofuels.

Internationally the most renewable energy policies were created during the late 1990's and early 2000's and these measures have generally exerted significant influence on the creation of renewable energy markets. As also shown above in the report policies

for addressing environmental aspects have significant impact on the development and dissemination of renewable energies (cf. also REN21, 2005). However, most analysts do not recognise the magnitude of governmental support for renewable energy in many OECD countries. Countries and markets with strong solar power policies are Germany, Japan, South Korea, Italy, Spain, but also China and California (cf. Stauffer, 2005). One example, provided by Stauffer, on such is Germany where utilities have got a price on 70 cents/kWh for photovoltaic generated solar power which well exceeds the estimated 40-50 cents/kWh costs for producing it.

The International Energy Agency (IEA) has, however, stressed that a single policy will not make a change but a set of policies are often required (Sellers, 2004). Having set overall policy targets are seen as important for the assurance of longevity and predictability of policy support and by 2005 some 43 countries had national targets for renewable energy supply (REN21, 2005). Notably all EU-25 countries had set targets but neither the USA nor Canada had come up with something similar, nationally. However, some 18 US states and 3 Canadian provinces in have taken the lead in North America with set renewable portfolio targets.

Most renewable energy targets are set for the 2010 or 2012 and some countries have goals for 2020 as well. Among the 43 countries around the world that have Renewable energy targets 10 are developing world nation, encompassing the vast spurring economies of Brazil, China and India. The targets for these latecoming economies, the EU and the USA are (REN21, 2005):

- **Brazil:** As of 2006 shall 3.3 GW be from wind, biomass and small hydro be added.
- **China:** As of 2010 shall 10% of electricity (of expected 60 GW) originate from renewable energy, and 5% of primary energy originate from renewable sources

  By 2020 shall 10% 5% of primary energy originate from renewable sources
- **EU-25:** As of 2010 shall 21% of electricity originate from renewable energy, and 12% of primary energy originate from renewable sources

- **India:** As of 2003-2012 shall 10% of all added electricity (of expected 10 GW)
- **USA:** No national targets, but 20 states have targets ranging between a 5-30% renewable energy share of electricity.

So, this little exposé of the economic superpowers of today as well as tomorrow indicates that there is a global market for renewable technologies with huge growth potentials. A few EU-countries Germany, Spain and Denmark have, moreover, implemented feed-in policies that have really spurred innovations and investment activities, according to REN21 (2005) as well as raised the attention and interests towards renewable energy generation. In Germany, for instance, renewable energy generation have under the feed-in policies more than doubled in merely four years from 14 TWh (in 2000) to 37 TWh (in 2004). The USA was actually the first country to adopt feed-in policies for renewable energy in 1978, but those policies were terminated in the 1990's. Unlike Germany, Spain and Denmark, Sweden has not been a forerunner in this policy area and adopted its first feed-in policy 1998. These national feed-in tariffs differ are differently designed, varying from country to country, but they usually last for a 15-20 year period with varying decline of support during phase out. A law was passed in January 2006 in China requires the access to the electricity grid from renewable energy sources. The Chinese legislation is a result of benchmarking against the German incentives policies that lowers the barriers for introducing renewable energy sources into the German grid (DAKS *et al.*, 2006).

Renewable Portfolio Standards (RPS) policies are another policy way to promote renewable energy supply that has been introduced in a number of countries. Also this policy area is an American invention where the first regulations in the world have been implemented in a large number of states in the USA, dating back to 1997. The USA has, however, not yet a national RPS policy and Germany too is lacking such an instrument. Japan and Sweden both introduced Renewable Portfolio Standards during 2003 (cf. REN21, 2005). In Japan the percentage renewable energy required from utilities is 1.35 percent by 2010. This is a rather low figure compared to e.g. some European countries i.e. Poland that requires 7.5% of its electricity to be constituted by renewable energies and Sweden that starts off (2003) with a renewable energy quote

on the same level as the Polish goal for 2010. As of 2010 Swedish RPS will reach 16.9%. The Swedish system is designed accordingly: the electricity producers (utilities) receives one electricity certificate for each MWh electricity that is produced with renewable resources. These certificates follow "the MWh" down to the customer. The utility customers have to, in their turn, acquire a quote of electricity that will give them electricity certificates corresponding to 16.9 percent of total electricity purchased (STEM, 2005; EMMA, 2006).

The electricity certificate system provides the producers of renewable energy with a market price that fairly well covers the extra costs for generating renewable energy. Previously in Sweden, some utilities received financial support from the government but the intention with the new policy is to provide the production for renewable electricity with more stable conditions and less dependent on the fluctuations in the state budget (EMMA, 2006).

Few countries have policies that promote rooftop solar photovoltaic applications for easy access to the electricity the grid. These policies have, according to REN21 (2005), spurred the rapid growth of the grid-connected market in recent years. In Germany guarantied feed-in tariffs have been applied in combination with low-interest loans until 2003 when the interest subsidies were terminated. The support programs in Germany have contributed to more than 160,000 rooftop solar homes with a total installation on 700 MW. In Japan they had rooftop solar policies between 1994 and 2005 where capital subsidies initially covered 50% of the costs, but declining to only constitute 4% as of 2005. Japan has today more than 200,000 homes equipped with rooftop photovoltaic solar applications. During a similar period – as of 1992-2003 – the average annual price drop for photovoltaic panels for residential customers is 7 percent (Stauffer, 2005).

A small number of countries have created net metering policies. Net metering allows for two-way flows between the grid and customers (electricity consumers) with their own electricity generation. At times when the self-generation exceeds the consumption the electricity meter runs backwards. The customer pays for net consumption and if there is a surplus in the energy going out to the grid that surplus can then e.g. be transferred to the next billing period, benefiting the end customer

(REN, 2005). As of 2005 the REN21 global status report had identified seven nations that had applied the net metering laws. In Japan a net metering system is implemented in the energy industry, based upon a voluntary arrangement. Net metering laws are also implemented in a majority of the states and provinces in North America and in 2005 a US federal law was passed requiring all US electricity utilities to provide net metering systems until 2008.

This policy how to get access to the electricity grid is a very important step to take since most companies that develop photovoltaic solar applications are small or mid sized and the property owners are in many cases private family house owners, associations of family houses, condominium associations or smaller landlords (of apartment houses). These actors usually are not in possession of massive bargain power and without legal support it can be very expensive for them to get access the grid for selling surplus energy – even thought they are already hooked up to the grid as consumers receiving electricity for consumption. It is in Sweden, for example rather costly for such small electricity producers to get access to the grid for supplying excessive energy since the oligopoly like situation on the Swedish electricity market dominated by just a few energy suppliers has lead to high fees for metering the energy being supplied to the grid. Not being able to benefit from the excessive energy that is generated will of course be a reverse salient in the implementation of small family house yard placed wind mills and roof mounted photovoltaic solar cells.

PIII.7. Summarising the section on environmental policy making

We see clearly from this exposition on environmental policy processes as means for driving innovation and enforcing technological change that strict legislation does not necessarily lead to innovation and business offsets that provides the domestic industry a competitive advantage which is quite in line with the Jaffe *et al.* (1995) study, comparing US legislation with foreign. We do also, however, see that the policy process have the ability to provide business with a competitive advantage if the process is focused on A) taking the advantage of domestic business investments cycles, B) exploring the space for business opportunities, domestic or global, by being

on the environmental technological solution frontiers, and C) developing a strong marketing research to understand and influence the trends in policy processes (e.g. in nations that are environmental frontiers and those catching up in need of technology) and stakeholder engagements around the world.

So far these suggestions go in line with Porter and van der Linde (1995a; 1995b) as well and as the claim that regulators must be competent knowing the technical abilities of the industry. This knowledge is vital but is, however, still far from providing the legislators with the holistic picture, since it leaves out structural lock-ins that may be imperative to the likeliness of a successful policy that drives innovation – technological and social – that has the potentials to contribute to decreased environmental impacts and at the same time creating a foundation for domestic competitive advantage.

Consequently, as the *Ecological Economics* article by Cerin (2006a) describes – when applying the theorem by the Nobel Prize Laureate, Coase (cf. 1937; cf. 1960; cf Stigler, 1966) – that the theoretical discussion of Porter and van der Linde are too thin, not considering asymmetric information, transactions cost and property rights of agents over the value chain to satisfactory, which had led to over simplification in reasoning and generalisations in conclusions. If we retain a better understanding of the actual policy process – the incentives behind actors, the struggle for path-dependence and attempts lock-out, a better understanding of the needs as well as the market potentials for the solutions domestically but very crucially globally on the vast growing markets.

As Dobers (1997) has shown the so often overseen struggle over path dependence is an important market, *pre-market*, where ideas and technologies compete over supremacy in the subsequent market, *the real market*. Especially for environmental and health matters the market life-cycle starts early in the regulatory design processes. It is, moreover, not as simple as to just copy the interaction model of the policy process in another country since the structures in society go much deeper than that (cf. Broadbent, 1998; 2003; Broadbent and Ishio, 1998). The policy process involving the government-industry-NGO structures of a nation has to bee understood in order to adopt them to own domestic conditions. How does the influence from state-

coroporatism and neo-corporatism affect the policy processes of Japan and small open economies of Northern and Western Europe?

Continuing the discussion, vital for success (innovations) as we have seen in Part III of the report is to understand the institutional context that the nation provide for environmental technologies to evolve in. Even though Swedish policies to support e.g. solar cells may appear similar to those in let us say Germany and Denmark in some respects (like energy certificates or feed in tariffs) that is no guaranty for a similar development. The development of solar power is also heavily dependent on the organisations playing on the energy market. In Sweden a few multinational energy utility corporations keep a very high fee for linking solar energy on to the electricity grid. Much higher than the actual cost which is possible to enforce since there is in this area of businesss a market situation in Sweden that strongly resembles oligopoly.

Some large corporations have well adopted strategies for future global environmental technologies such as Toyota and Volvo has had. The interesting case with Volvo is that it reached its international success with the three-way catalytic converter with little help from the Swedish legislative process. Volvo saw the potentials with the new technology and took a proactive role in the Californian market where it realised that the catalytic approach will give them good image and increased market shares and since Volvo was a niche player on the Californian market it could pass on the additional costs for the converter to the end customers. But, more than a decade later in Sweden Volvo was (is) the dominant player and could together with the industry stall the legislative process for a few years in a Swedish neo-corporativistic manner (cf. Cerin, 2005).

Another case of Swedish corporatism is the pulp and paper case where industry and labour unions worked against non-chlorine bleaching policies for a good decade. Even the EPA was not pushing the issue. Then these structures were altered since, due to the influence of a persistent NGO and public green procurement, a small player on the Swedish market saw the potentials for growth and excessive revenues – and got rewarded big time in return. Within a year the large players followed suit.

Although some critique have been brought forward here on Swedish legislation process, there are of course positive sides as well, but the greatest leaps forward can be achieved by bringing forward some aspects that can be improved for increase Swedish competitiveness in the international scene of environmental technology. Actors in the environmental policy making process, especially regulators, should have an aim of looking ahead detecting the coming trends globally, especially what is taking place in vast markets such as the spurring latecoming economies where the need for environmentally adopted solutions soon will rapidly increase. There is, thus, if we are to better understand how to stimulate environmental innovation processes, from invention to market penetration, we need more multidisciplinary research that understands the interactions between actors in society, based upon power relationships, information, asymmetries, self-interests et cetera.

Two aspects that policy needs to deal with – to create an understanding about

- seeking export opportunities of environmental technology, influencing the actors in the legislative process to strive for that goal.
- the institutional picture and power relations, asymmetric information, cultures of the actors, institutions and structures of society at different nations.

Consequently, the imperatives of multidisciplinary research – even thought it is often neglected in the field of environmental policies – is the understanding of actor behaviour, power and information asymmetries as well as an understanding of society structures covering both government and industry. In order to be successful, an understanding of these aspects should not only be restricted to the conditions in the own country or to the country/countries targeted for exports, but also knowing the strategies and capabilities of competing field – nations and corporations.

One current and interesting case of policy development is the creation of an ethanol market for road vehicles. The Swedish government has supported the development of ethanol in Sweden – i.e. to Domsjö in Örnsköldsvik to build up a domestic industry. This is also pointed out by the former Swedish Prime Ministers to the researcher in the *"Commission against Oil Dependency"* that made an objection to import tariffs on Brazilian ethanol. The PM criticised the stand on just low prices for the consumers

and stressed the importance of building up an own industry and knowledge (Kommissionen mot oljeberoende, 2006).

This is an important task that policies can play which shall not be overseen. Much of Sweden's stock of large firms has been created in development-pairs between state owned firms and domestic private firms where engineers from both sides collaborated in the technology development (cf. Fridlund, 1994; Fridlund, 1999). Here, by building up the domestic ethanol production in Sweden the future actually looks somewhat brighter for Swedish forest based industry since it will have a very difficult time to compete with fast growing areas in the tropical regions of the world, risking a considerable phasing out of Swedish produce (of e.g. pulp and paper) to merely deal with niche products. The environmental technology pursuit may in this case actually work as one enabler of Sweden's forest industry of tomorrow (cf. Larsson, 2006; cf. Novotny 2006a; cf. Novotny, 2006b). Environmental policies should, hence, not be looked upon only as side activities that improve the environmental conditions but also seen as a true industry enabler if the policy creation processes are played right.

PIII.8. Summing up Part III

- The cases in this part of the report show that the included Swedish policy processes has not provided Swedish industry with a competitive advantage on the international market. Instead lax regulation has been adopted. This is the situation with the three-catalytic catalytic converter legislation as well as the fight to ban chlorine bleaching in Swedish pulp and paper industry.
    - In the three-way catalytic converter case the big player Volvo together with other actors, like Bosch, took the lead in Californian legislation showing that it indeed was possible to manufacture cars with the catalytic technology, contrary to the claims of the big three auto manufacturers in Detroit. In Sweden though it took another 8 years for similar legislation to be introduced.
    - In the Swedish pulp and paper case did industry and labour unions together work against attempts to make the bleaching of paper chlorine free and the Swedish EPA did not either push for stricter regulation. Thanks to a persistent NGO green procurement solved the knot and

soon, after 10 years rejection of the idea, the whole pulp and paper industry could produce chlorine free paper and won market shares internationally. In this case industry needed help in understanding the market and access to public customer that could ensure an initial market for the investments into chlorine free bleaching. This could also be the task of environmental regulations, helping industry actors understand the (international) market.

- In the often foreseen pre-markets takes the first struggle over path dependence place and it is here where ideas and technologies can gain supremacy in the subsequent real market. These pre-markets, the policy processes, are often the important starting points for markets dealing with environmental and social concerns.
- There are numerous factors that influence the proactiveness in national environmental policy processes which should be understood if the aim is to successfully implement foreign policy methods with similar outcome at home.
    - One important factor for the establishment of successful environmental policy processes is determined by the economic conditions in the country, but also the severity of environmental aspects and resource scarcities play an important role.
    - When comparing environmental policy processes it is important not to compare apples with oranges. When the policy processes of Japan are discussed the market capitalisation size of the involved Japanese conglomerates tends to be neglected when comparing with the Swedish policy processes where most concerned companies are considerably smaller.
- When analysing the policy process of another country it is vital to understand the underlying society culture. Without such understanding the copy of policy processes may not lead to successful outcomes.
    - In Japan the underlying culture affecting business life is often referred to as East Asian Corporativism where state and industry associations form network for collaboration. There is a higher degree of obeying state officials in industry organisations perhaps since formerly (pre-1945), these officials where servants of god (the Emperor).

- In small open European economies the underlying culture in business life is often referred to as Neo-Corporativism where a collaborative culture between government, industry and labour unions exists.

- When comparing the environmental policy processes of Japan to Sweden it is imperative to recognise the prominent role played by industry associations where industry and government meet. According to the cases in this report the joint efforts is to seek business opportunities from domestic industry's know-how and technological solutions.
- The environmental policy process in Sweden ought to be seeking export opportunities for the domestic industry and not lock the industry into rendering endemic solutions. Such process requires the collaboration from both industry and government, where industry associations are proactive, not only seek the solution that fit the laggards of the industry sector.
- Consequently, to better understand the policy processes and retrieve the necessarily holistic picture for successful implementation of policy variants applied to domestic conditions. To increase the Swedish policy capability extensive multidisciplinary research – e.g. into asymmetric information, power relationships, societal culture, economic, technical, resource and environmental conditions of the country – have to be applied.

Synthesis and Implications for the Formas-VINNOVA Programme

B. Synthesis and implications for the Formas-VINNOVA Programme

As described above in this report the task is to provide information for supporting Formas and VINNOVA in their development of a common strategy on their forthcoming collaborative environmentally adopted program. The programme is assigned to Formas and VINNOVA by the Swedish government and the aim is to create a jointly financed research program on environmental technology that will constitute a foundation for collaboration between firms and public research from various disciplines. Small and mid sized enterprise shall be prioritised in the program. Important outcomes are to support knowledge and competence on environmental matters.

B.1. Synthesis

The assignment from Formas and VINNOVA is to create a report that is divided into three rather distinct areas. The report is, consequently, divided into three main sections, dealing with one task each. The first one deals with environmental technology, the second provides a picture of developments in the spurring latecoming economies Brazil, China and India and the third task is to compare the environmental policy processes of different countries such as Japan, Germany and Sweden. The following discussion will be divided into the three distinctive segments of the report and a common discussion and recommendations takes place in the last section of this report: *Recommendations to the Formas-VINNOVA Programme.*

Definitions of environmental technology

- *Use a wide definition on environmental technology*

  There are several definitions on environmental technology applied today, but the most interesting definitions from a Formas-VINNOVA programme perspective is the wide scope that ETAP has adopted – encompassing any technology that is designed to prevent or reduce the environmental impacts – and the categorising of environmental adopted products and services that NUTEK has created into 1) Pure environmental technology, 2)

Environmentally efficient products and 3) services and Innovative environmental solutions. This categorisation can be used for explanatory reasons, while the ETAP should set the limits for the technologies considered in the programme.

- *Implications for research:*

  Formas and VINNOVA should preferably not try to develop their own definition on environmental technology for the program, but to focus on supporting projects that can contribute to decrease or prevent environmental impacts.

Trends in latecoming economies that will have major impacts on the environment

- *Urbanisation*

  The vast internal migration of people within China and India will increase the urban population in these two countries alone by some 614 million city-dwellers while the rural population will decrease by some 138 million people as of 2005-2030. This new urban population will need access to safe piped water and sewage as well as to waste disposal systems in order to protect the environment and public health. In China as of 2006-2010 alone the Ministry of Construction and the 11th FYP have set aside US$41.3 billion for constructing and extending the access to sewage treatment and recycling facilities. By 2010, the aim is that 70 percent of the urban population shall have access to sewage disposal. The demand for environmental infrastructures is, hence, enormous but also the demand for low polluting transportation infrastructures. The cities and rivers of China, India as well as Brazil suffer, furthermore, already today from low air qualities and contaminated water, respectively. The access to piped water and sewage is too low, especially in China and India, leading to premature deaths. The situation is severe in the cities but the access rate to environmental infrastructure is even lower in rural areas. There is, therefore, a vast demand for stand alone water and sewage solution that in cases require stand alone energy supply.

- *Consumerism*

  The enormous economic growth and industrial development of foremost China and India is the alteration of the way the population is living. The

consumption patterns will change towards more energy and transport content in food, more home appliances, electronic goods, apparel and furniture will be demanded not to speak of the increased use of vehicles. Already by 2030 the number of cars in the world will be more than doubled and the number of cars in China and India will surpass more than half a billion. This rapid increase will put extra strengths on global resources like iron, copper and oil which require new more resource efficient solutions such as lighter vehicles, more efficient engines and alternative fuels to be developed. Vehicles and the enormous future demand for electronic goods will, furthermore, consume precious metals making high yields in recycling a prerequisite. The estimated future demand 2030 form the auto industry on e.g. aluminium, plastics and platinum-group metals is seriously making world demand surpassing current production limits. The innovation pressure – for more environmentally adopted solutions – in this sector and other industries competing for the same resources will be gargantuan.

- *Implications for research:*

  Both the environmental concerns arising from the urbanisation process in China and India and the escalating force in Brazil, China and India's consumption patterns are two major trends that significantly will affect human health, environment and resources scarcity. The needs arising from urbanisation is largely associated with access to environmental infrastructures such as piped drinking and sewage water and waste disposal systems. Another need related to urbanisation but also to the shift towards a consumerist society is the need for a transport infrastructure that is less polluting when the Chinese and, to somewhat lesser extent, Indian vehicle parks explode in size. The economic buying power of the vast latecoming economies will demand much more resource efficient solutions (less and greater reuse of materials) spilling over to the solutions available for the rest of the world.

  Both the environmental infrastructures and the innovative solutions to the resource scarcity problematic ought to become an aspect of Formas and VINNOVA's joint research strategy on environmental technology. The limited resources to Formas and VINNOVA's joint research program may, however, make it less practical to focus on and striving for implementing radical innovations and system changes of greater magnitude. The development of

environmental infrastructure solutions, a knowledge well advanced in Sweden, may therefore pose a more realistic technology area to focus on. The character improvements in environmental infrastructure can oftentimes be closer to technological development than radical innovations and one area in need of support is to demonstrate technologies to potential customers abroad.

Environmental policy developments to be considered in Swedish policy processes

- *Policy processes in Japan, EU and USA.*

  Especially in markets for environmental and social goods the game for market dominance start early in – sometimes even initiating – the policy process where the player behind the dominant technology may gain path dependence by influencing the rules of the coming market. In Japan, the case studies (e.g. on vehicles, telecom and recycling) indicate the practice of, government and industry collaborates through industry associations throughout the policy process that is characterised by a consensus of searching for domestic industry competitiveness which in the observed cases have been realised by Japanese industry. The US policy processes are to a higher degree characterised by less collaboration and later inclusion of industry actors into the talks and negotiations. Policy measures taken by individual states – e.g. on energy and transports – may, however, be on the front edge internationally even in areas where the federate level of the USA is considered to be lagging behind. In Europe the nation being on the environmental policy frontier could be consider to be Germany whose initiatives (e.g. on vehicles, energy and recycling) also influences the stand taken by other EU member states.

- *Policy processes in China and India*

  There are plausible indications that important prerequisites for international trade in various areas may in the very nearby future be set by the environmental requirements, standards and technical legislation – concerning environmental aspects – implemented by the vast economies of China and India that are on the frontier compared to those discussed in the traditional OECD countries. Two major reasons for the proactiveness is seen as a response to more severe environmental conditions – e.g. concerning health, toxicity, resource scarcity and local biotopes – compared to Western countries

but claims are also made that the proactive environmental policy measures taken could be a sign of supporting domestic industries against foreign competitors, foremost nationally but gradually when the economic power grows stronger also internationally.

- *Implications for research:*

  If the Swedish environmental policy process is to support not only improved domestic environmental conditions but also provide a competitive advantage of the nation's industries the process should also focus on taking the advantage of domestic business investments cycles, exploring the space for business opportunities – domestic or global – by being on the environmental technological solution frontiers, and developing a strong marketing research to understand and influence the international trends in policy processes and stakeholder engagements around the world. In doing so, the regulators need to have the ability to create an understanding among the involved industry actors about seeking export opportunities of environmental technology. The regulators also need to understand the institutional picture i.e. power relations, asymmetric information, cultures of the actors, institutions and structures of society, both domestic and internationally.

  In order to provide better input to environmental policy processes it is imperative to apply multidisciplinary research to understand the holistic picture actor interaction in the play over technological superiority. This aspect of research ought, hence, to become an aspect of Formas and VINNOVA's joint research strategy on environmental technology. The limited resources to Formas and VINNOVA's joint research program may, however, call for an exclusion of these aspects, for the benefit of direct technology investments.

Tomorrow's demand for environmental technology in the key latecoming economies is, consequently, chiefly:

- *Environmental Infrastructures*

  The great influx of people to the urbanised areas, especially within China and India, require enormous investments into environmental infrastructures i.e. access to piped drinking and sewage water, waste disposal and treatment

systems. The general access today in Brazil, China and India to these infrastructures is deficient, leading to premature deaths and loss of working days due to illnesses. The access to clean water and systems for treatment of sewage and disposals is even lower that can be solved with stand alone solutions supported by local energy production.

- *Transportation infrastructures*

  The rapid expansion of the transport infrastructures in the larger cities causes premature deaths due to inferior air qualities. There is, hence, a need for lighter vehicles, less polluting engines and fuels as well as looking into the possibilities for substituting individual travels by car to public transportation and telecommunications.

- *Industry processes*

  The expansion of industrial production require solutions of both integral process and end-of-pipe character. In latecoming economies demands from local subsidies of Western companies based or Western based companies procuring goods on documented environmental work will push facilities in e.g. Brazil, China and India towards greater environmental concerns, but also governmental policy actions such as in China are increasingly addressing environmental measures to be taken.

- *Agriculture – forestry*

  The agriculture is in several areas of Brazil, China and India experiences droughts and decreasing water tables due to too extensive irrigation. The harsh exploitation of agricultural land in China and India is supporting a huge number of humans considering the size of farm land which may lead to increased sensitivity and increased risks for decreased crop yields in the nearby future and in Brazil newly established farm land only endure a few seasons of agriculture before new rain forest areas have to be cleared. Agricultural land is also threatened by land loss by erosion, road and urban construction. Agriculture affects, moreover, the surrounding environment with run offs – of pesticides and fertilisers – and decreased biodiversity due to deforestation to give way for new farm land.

- *Resource scarcity*

  The increased wealth in the latecoming economies will make many resources

that currently may be considered abundant scarce, leading to a great need for innovations to exchange materials, make products weight less and increase recycling. Products active during use should also consume less energy.

B.2. Recommendations to the Formas-VINNOVA Programme

Formas and VINNOVA have received a relative small amount of money for a task that is to operate in a domain which is enormous. In 2003 total Swedish expenditure on R&D (GERD – Gross Expenditure on R&D) was approximately SEK 70,000 (or USD 10,000) million of which approximately 65% was financed and 74% was performed within the business sector while 35 and 26% respectively within universities and government bodies (OECD, 2005c). The total budget for the Formas-VINNOVA programme on environmental technology is SEK 15 million during 2007 and thereafter SEK 30 millions annually. This is just a fraction of a percent of Swedish research. In addition the Swedish export of products related to environmental technology (as defined by Swedish Trade Council) is approximately SEK 25,000 million. Also in relation to environmental export figures the allocated money to be permeated through the Formas-VINNOVA programme is just a fraction of a percent (0.12%). This fraction is still more reduced if related to the total turnover (2003) of the primary environmental sector (as defined by Statistics Sweden, 2005) which was SEK 131,000 million. One conclusion from this observation is that the funds in question will – if handled in isolation - have no immediate impact on the behaviour and performance, at large, of Swedish industrial competitiveness in the environmental technology field. To be useful the money should be allocated to qualified projects of potential strategic interest and with a *"catalytic"* character. In the following we argue for what could be included in – and should be excluded from – such a policy.

First of all, and following our arguments mentioned above, we are of the opinion that Formas-VINNOVA should focus on technologies. The focus on "technology" rather than on "products", "firms" or "industry" is important. This distinction is in fact far from upheld in official documents we have consulted. (cf. e.g. Swedish Trade Council, 2005 and the above quoted NUTEK definition). For Formas-VINNOVA it is essential to be clear on this topic. What should be supported – according to our view – is technological development which often takes place through various forms of R&D

and related activities. The technologies may potentially be more or less connected to ("embodied" in) various products and processes and it is not even necessary to exactly identify what is a product and what is a process. In addition, some of the "products" may be intangible in character, i.e. "services" – not even this distinction is of primary importance to identify and to evaluate their environmental impact.

A strong focus on technologies has the advantage of creating a clear division of labour between Formas-VINNOVA, on the one hand, NUTEK, Swedish Trade Council and SWENTECH, on the other. The more commercial parts of the environmentally driven SME-related (business development process) topics as regards products and services of ecological significance may be dealt with by e.g. NUTEK and Swedish Trade Council can continue or rather expand its important support activities for firms with environmentally related exports (however defined). As shown by an ITPS report (Schwaag Serger and Widman, 2005) Swedish SMEs have difficulties accessing the Chinese market and breakthroughs are made by larger companies in Swedish vehicles, power, heavy industry and telecom sectors. Possibly, other actors, as well, could support international demonstration and implementation projects i.e. IVL Swedish Environmental Research Institute and SWENTECH.

Although the government bill is strongly focused on collaborating with actors that focus on business development aspects (Regeringen, 2005a:60) it is also important that at least one actor in the network for supporting Swedish environmental technology argues for frontier technologies in the environmental field. ITPS (Schwaag Serger and Widman, 2005) sees great potentials for reducing the increasing resource use in China such as in energy production, products and technologies. One example is innovating resource efficient vehicles and vehicle technologies in which advanced research currently is taking place in Sweden. The same report also recognises the potentials of demonstration projects like the "Sustainable City" carried out by a collaboration of Swedish actors i.e. firms and municipalities to market Swedish environmental solutions in city planning. These undertakings by various organisations – including municipalities, IVL Swedish Environmental Research Institute and SWENTECH – to promote and demonstrate Swedish environmental technology are of outmost importance in overcoming the barriers for creating a market presence on the Chinese market for Swedish Environmental technologies.

These actors and actions can be seen as locomotive organisations and are an important institutional solution that may be the engine in getting products from a local community out on the global market as described by Mascanzoni and Novotny (2000) concerning the role of locomotive fair sized firms in Italy with a global presence that provide smaller suppliers with access to the global market.

The very (small) size of the funds in question supports our discussion above on narrowing the scope of what may be included in the technological R&D work which should be supported in this programme. Allowing all – or most – forms of resource savings to be included makes the programme meaningless. There may, hence, also be strong practical reasons supporting the academic interest in using a "narrow" definition of Environmental Technology.

Consequently, as we see it, there is no reason to adopt any of the definitions discussed in sub section PI.2. above, which in various degrees have been developed in political processes related to trade policy and industry consideration. Turning the definition problem upside down *we suggest that instead of trying to identify an "environmental technology" or a set of environmental technologies the Formas-VINNOVA programme may focus on all technologies which potentially may have a substantial impact in the ambition to reduce environmental damage; be they - global or local – as well as considering the market potentials, primarily from an international perspective*. The technology must not necessarily be radical from non-ecological perspectives – the important thing is its potential from an ecological perspective, compared to existing state of the art technology, to contribute to reduced resource depletion and to pollution generation as well as to ensure sustained biodiversity.

Focusing on technologies we still have the problem of whether the Formas-VINNOVA programme should explicitly address specific areas like *"wastewater treatment"*, *"air treatment"*, *"energy saving"*, *"process/control technologies"* etc. Even in this case we are of the opinion that Formas-VINNOVA should have an open minded policy and leave to the applicants to argue why their suggested technological R&D work qualify as having potential ecological significance. And even small reductions (incremental innovations) may be important if they relate to large scale processes/systems.

The government bill on the task given to Formas and VINNOVA assumes that the research programme in environmental technology should be co-financed from the government (through Formas and VINNOVA) and the industry beneficiaries (Regeringen, 2005:159f.). This is an often used means with the intention to expand R&D resources for a certain end. This report is not the place to analyse the advantages and disadvantages with that model in detail. However, it should be remembered that even if the allocated government money is expanded with such a model the total amount thus made available is still very limited and it may be argued that its relevance for business development in the short term, in general, will be low.

This elimination of compulsory co-finance for each individual project may contribute to a more long term vision in the programme than would otherwise be the case. It would also open the funding for academic research of significant ecological potential although not necessarily profitable in the short run – an approach which has been advocated by some academics at Formas-VINNOVA workshops in strong opposition to the stand taken by the participating SMEs. Another important flaw with the argument is that it represents the dichotomy to the intention written by the Government in their bill explicitly stating co-funding as a prerequisite for participation in the program. The argument given by the Government, in its bill, and by the participating SMEs indicate that there have to be a real stake in the project funding to ensure commitment from the participating laureates – a paradigm of thought shared with prominent person's like Aristotle, Jefferson and Smith.

Consequently, the non co-financed approach neglects the strong emphasis on environmental business development in the government bill. As indicated – although not analysed in depth – in sub section PI.2. above it may well be the case that short term (Swedish) business development in the environmental areas is more of an institutional problem than a question of R&D. The focus of the Formas-VINNOVA strategy may focus on the long-term and multidisciplinary research similar to funding bodies like Mistra, but the company focus in the bill set the Formas-VINNOVA program out to be more short-termish providing increased opportunities for enterprises to realise environmental technology undertakings.

Summarising our arguments in this sub section and thus in the report as a whole we may say that within the framework of the tasks given not only to Formas and VINNOVA but also to actors like Nutek, SWENTECH and Swedish Trade Council we argue that Formas-VINNOVA should focus on the vertical axis in figure 5 below, i.e. technology development thus leaving the horizontal task of environmentally driven business development to the other actors on the scene. In fact we have no problems to identify other actors outside those already mentioned in the Swedish landscape which can support this horizontal activity; e.g. Swedfund is one example. And, as is the message in the recent Bråsjö & Blomkvist report (2006), the potential competitive advantage of Swedish environmental industry also has this non-technological dimension worth to develop. There are advantages – analytically as well as from a policy perspective – not to blur concepts or to use vague or unclear definitions of them on all levels of policy formation as well as it may be wise to establish some division of labour between government bodies as regards different policy instruments. As we have shown the unclear definitions of sustainability and environmental technology in the general policy discourse must not necessarily spill over on those actors which have to implement policy.

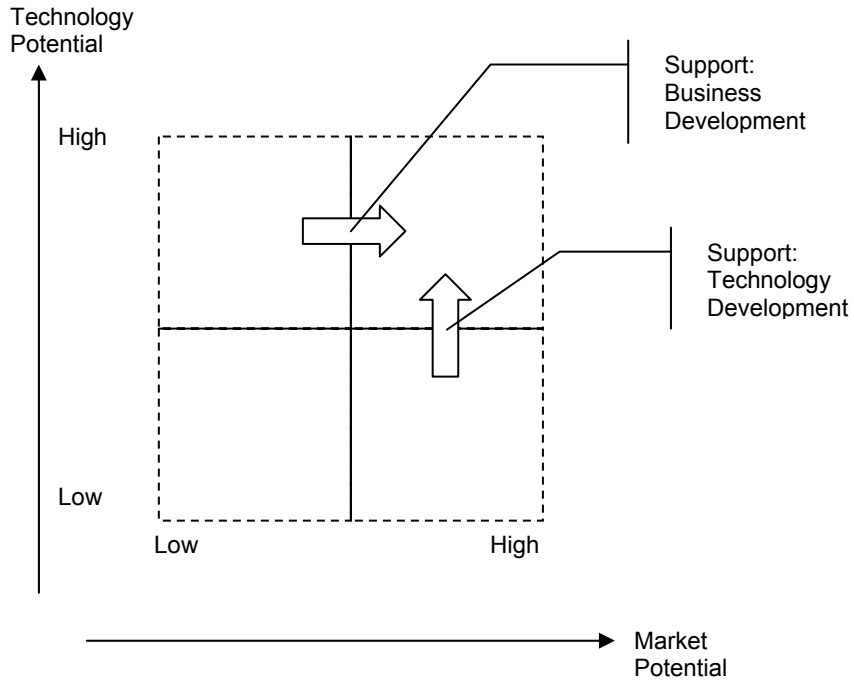

Figure 5. The four-fielder of Technology Potentials and Market Potentials of Application.

Even if Formas and VINNOVA choose to focus its investments on the suggested areas above there exist numerous fields where there is a *"Technology Potential"*. The program should, hence, make a heavy selection if the financial assets available shall have the potentials to make a significant impact. Our firm opinion is that the Formas-VINNOVA program shall have clear distinctive selection criteria presented in the call for applications, making the applicants argue for why the *Technology Potential*'s within the field addressed by the application is worth supporting.

Here it is suitable to separate short and long term project. Possible selection criteria for projects with a short time frame are today known market potentials, potentials arising from legislation as well as the competitive situation in the segment among other things. Concerning projects of the longer time-frame the market potentials and the prerequisite for those should be the foundation for selection as well as known development efforts in other countries that are related to the proposed project.

Applying such procedures will improve export potentials for Swedish environmental technology as well as growth capabilities for Swedish companies to establish a niche on foreign markets as means for further international expansion.

If Formas-VINNOVA bridge the gap between technology and market development by collaborating with other domestic actors that put efforts into to the horizontal plane of the technology-market four-fielder (see figure 5) there will be fine prerequisites for lifting the field of environmental technology potentials and refraining it from being merely potentials to realising the immense growth in environmental solutions demand that currently is budding in the vast late-coming economies of the world today and tomorrow.

Identified scopes of Existing funding Bodies for Environmental Technology Related Projects					
Funding body	**Environmental aim**	**Company size**	**R&D stimulation**	**Export stimulation**	**Amount SEK**
Elforsk					
Formas					
Nutek		SME	Strong	Moderate	
"The SIDA billion"			No	No	1 billion (almost). No obligations for the receiving party.
Swedish Trade Council			No	Strong	
VINNOVA		Large			

Suggested scope for the Formas-VINNOVA Programme

Funding body	**Environmental aim**	**Company size**	**R&D stimulation**	**Export stimulation**	**Amount SEK**
Formas-VINNOVA Program			Moderate	Strong	15 million 2007 and thereafter 30 million annually. Funding has to be matched by the same amount by the beneficiary.

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Appendix 1 – The budding of environmental and social concerns

Environmental problems have been a policy concern since the beginning of the industrial revolution. The modern discourse, however, has its origin primarily in the 1960's, then concerning phenomena such as lead in biocides, and controlling emissions from point sources – i.e. chimneys, public and industry wastewaters. Two books of very different character, and selected from a long list, may illustrate the take off of a new environmental awareness. The first was *Silent Spring* (Carson, 1962) focusing on the consequences of using pesticides. The second was a small study by Erik Dahmén on the overuse of natural resources and suggesting models for pricing the environment (Dahmén, 1968). The by then dominant mindset of seemingly unrestricted growth got further questioned by the *Club of Rome* reports by Forrester (1971) and *Limits to Growth*, by Meadows *et al.* (1972) which laid the ground for a long lasting debate on whether growth was possible, was wanted and, if so, what the long term conditions for growth were. A detailed review of that discourse falls outside this report.

Of importance, however, is the official attempt to solve (some of) the controversies regarding *Our Common Future* (WCED, 1987), a study which emanated from the limits to growth discourse. The report, oftentimes referred to as *the Brundland Report*, introduced a concept of sustainable development (sustainability) consisting of a balance between natural systems (eco-systems) and the human (social and economic) systems. Environmental degradation must, it is argued, be overcome but without bowing out the needs for economic development, social equity and justice. Such a development – if met – is a process that *"meets the needs of the present without compromising the ability of future generations to meet their own needs"* (WCED, 1987) and puts the equality concept not only in a traditional intra-generational setting – between North and South – but in an inter-generational setting – striving for equality between generations. The in the 1960's and 70's dominant non-growth – zero-growth and steady state – advocators were, it may be argued, increasingly pushed aside when the notion of sustainable development came into play during the 1980's and 90's (cf. Welford, 1996; cf. Kågeson, 1998).

The Brundtland sustainability concept thus rests on three pillars; economic development, preserving the environment and social equality. It is, as e.g. interpreted by Welford (2002), probably not sustainable to attempt to solve environmental problems without solving today's social inequalities. So, we are dealing with a trinity in the bottom line – economic, environmental and social – and duality in the time line – present and future.

There are, however, risks associated with the application of this sustainability concept as e.g. a report from the Swedish EPA states (Cerin, 2005): *"By jointly applying economic, environmental and social issues – constituting the commonly used triple bottom line in the sustainability discourse – environmental issues can be given a lesser importance by being disrupted and put against the others, and of course visa versa when needed."* The Swedish EPA report also states the interdependency of the three dimensions of sustainable development that has to be embraced and taken into account not to fall into too narrow thinking – environmental problems cannot be solved unless solving sever social inequalities[19].

The concept of sustainable development has won large terrain in the political agenda internationally in the UN – e.g. Rio de Janeiro, 1992; Johannesburg, 2002 (UN DESA, 2006) – and from there permeated down to national levels. The concept has found its way into national statements, strategies and visions (see e.g. Swedish Ministry of Sustainable Development, 2002; UK Department for Environment, Food and Rural Affairs (Defra, 2006). It is stated in the Swedish text that sustainable development is the overall goal for Swedish government policy, nationally as well as internationally, where the vision is solidarity between countries and generations. The environment is condensed to aspects in a long-term horizon as well as in natural resource perspective. In the British sustainable development strategy – for securing the future – pressing issues like loss of biodiversity in rainforests, over fishing

[19] One example on leaving out one or two components of sustainable development is the Swedish Agency for Economic and Regional Growth – NUTEK (NUTEK, 2003) that left out the social dimension of their sustainable development perspective where the focus is on defining environmental technology as an enabler for sustainable development. Also NUTEK recognises that the social dimension cannot be disregarded since all dimensions of sustainable development interacts and reinforces each other.

resulting from consumption patterns as well as the devastating loss of infants and juveniles due to severe poverty are given a more prominent role.

Also the international business community has embraced the concept of sustainable development by e.g. engaging in the organisation World Business Council for Sustainable Development (WBCSD) which is supported by some 180 transnational corporations. Although sustainable development is part of the organisation's name it is not easy to find their definition on the concept but the concept shows up in the organisation's mission, which *"...is to provide business leadership as a catalyst for change toward sustainable development, and to support the business license to operate..."*. Furthermore, the United Nations has since the World Economic Forum, January 1999, in collaboration with industry and other organisations developed the 10 principles that constitute the core of the Global Compact (GC). GC sees itself as a mean for *"producing practical solutions to contemporary problems related to globalisation, sustainable development and corporate responsibility in a multi-stakeholder context."* The indicator may here be seen as a means of operationalising the concept of sustainable development into ten value areas of which one is to *"encourage the development and diffusion of environmentally friendly technologies."*

Appendix 2 – Demographic Developments as of 1950-2030

World

Indicator	1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000	2005	2010	2015	2020	2025	2030
Rural population (thousands)	1 787 705	1 906 963	2 031 459	2 180 259	2 367 741	2 557 870	2 705 993	2 860 273	3 008 650	3 140 989	3 240 771	3 314 299	3 368 353	3 400 408	3 400 783	3 362 873	3 286 551
Urban population (thousands)	731 765	850 436	992 353	1 157 715	1 328 847	1 515 870	1 736 302	1 983 674	2 270 869	2 551 364	2 844 802	3 150 451	3 474 571	3 819 023	4 177 106	4 542 366	4 912 553
Percentage urban (%)	29.0	30.8	32.8	34.7	35.9	37.2	39.1	41.0	43.0	44.8	46.7	48.7	50.8	52.9	55.1	57.5	59.9

Size class	1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000	2005	2010	2015
10 million or more														
Number of agglomerations	2	2	2	2	2	3	4	7	10	13	17	20	21	22
Population (thousands)	23 613	26 932	30 842	35 461	39 489	53 185	69 249	104 507	144 875	183 795	239 655	292 593	326 655	359 238
Percentage of urban population	3	3	3	3	3	4	4	5	6	7	8	9	9	9

Brazil

Indicator	1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000	2005	2010	2015	2020	2025	2030
Rural population (thousands)	34 457	37 438	40 061	41 886	42 468	41 371	39 640	39 090	37 639	35 877	32 699	29 395	26 740	24 616	23 012	21 896	20 902
Urban population (thousands)	19 517	25 448	32 681	42 443	53 521	66 753	81 975	96 973	111 756	125 499	141 159	157 010	171 757	184 785	196 182	206 033	214 603
Percentage urban (%)	36.2	40.5	44.9	50.3	55.8	61.7	67.4	71.3	74.8	77.8	81.2	84.2	86.5	88.2	89.5	90.4	91.1

Size class	1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000	2005	2010	2015
10 million or more														
Number of agglomerations	0	0	0	0	0	0	1	1	1	2	2	2	2	2
Population (thousands)	0	0	0	0	0	0	12 089	13 395	14 776	26 122	27 902	29 802	31 752	33 304
Percentage of urban population	0	0	0	0	0	0	15	14	13	21	20	19	18	18

China

Indicator	1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000	2005	2010	2015	2020	2025	2030
Rural population (thousands)	482 641	522 642	552 246	601 097	686 138	766 369	802 657	824 101	838 752	837 023	818 180	784 026	745 945	707 351	666 173	621 694	573 781
Urban population (thousands)	72 119	86 363	105 246	128 093	144 537	161 439	196 220	246 074	316 554	382 308	455 800	531 817	608 587	685 630	757 766	819 732	872 671
Percentage urban (%)	13.0	14.2	16.0	17.6	17.4	17.4	19.6	23.0	27.4	31.4	35.8	40.4	44.9	49.2	53.2	56.9	60.3

Size class	1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000	2005	2010	2015
10 million or more														
Number of agglomerations	0	0	0	0	0	0	0	0	0	1	1	2	2	3
Population (thousands)	0	0	0	0	0	0	0	0	0	10 423	13 243	25 220	27 531	40 495
Percentage of urban population	0	0	0	0	0	0	0	0	0	3	3	5	5	6

India

Indicator	1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000	2005	2010	2015	2020	2025	2030
Rural population (thousands)	296 625	325 629	363 058	402 141	445 259	488 295	529 745	579 533	632 411	686 773	738 604	786 428	826 904	857 271	874 413	875 338	859 121
Urban population (thousands)	60 936	69 467	79 287	93 016	109 652	132 406	159 111	186 520	217 004	248 799	282 480	316 942	356 388	403 096	457 619	520 158	589 957
Percentage urban (%)	17.0	17.6	17.9	18.8	19.8	21.3	23.1	24.3	25.5	26.6	27.7	28.7	30.1	32.0	34.4	37.3	40.7

Size class	1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000	2005	2010	2015
10 million or more														
Number of agglomerations	0	0	0	0	0	0	0	1	2	3	3	3	3	3
Population (thousands)	0	0	0	0	0	0	0	10 341	23 197	36 128	41 585	47 521	52 567	57 453
Percentage of urban population	0	0	0	0	0	0	0	6	11	15	15	15	15	14

Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, World Population Prospects: The 2004 Revision and World Urbanization Prospects: The 2005 Revision, http://esa.un.org/unup, 03 October 2006; 11:59:50 AM.

Appendix 3 – Social conditions that may threaten stability

One major problem facing China and India is the rapidly increasing number of males being born compared to females which will create a surplus of men not being able to marry and danger of violence, prostitution, trafficking and HIV infections. One short-term benefit for China, according to the BBC (BBC, 2004) is the flux of spare male labour from the countryside into the cities of China that is one part of *China's economic miracle*. Each year there are 2 million surplus males in China which will result in a female deficit around 50 million individuals (NBC, 2004). The sex imbalance situation is as extreme in India as in China with similar numbers. The Nobel Prize laureate Dr. Amartya Sen has described the sex imbalance problem and some the problems connected to it in *"More Than 100 Million Women Are Missing"* (Sen, 1990). The great deficit of women – leading to large groups of young men finding themselves without spouses – in both China and India, as well as other Asian states, may lead to instability in these nations and diminishes the possibilities for meaningful democracy and peaceful foreign policy (den Boer, 2004; Hudson V and den Boer, 2004). According to them are young men with little chance of forming families much more prune to coalitional aggression, both within and outside the militia.

The *"2002 Revision"* has also found that the HIV/AIDS epidemic will considerably decrease the pace of global population growth. The most severely affected countries are, however, the sub-Saharan countries in Africa where the current HIV prevalence on 20 to 30 per cent of adult population hugely impacting population growths. The impact of the HIV/AIDS epidemic is in Asia and Latin America is, compared to Africa, still low. The projected effect on population numbers is projected to be a decrease on 1 per cent while the decrease in the most affected African countries is a 10 per cent decrease. However, due to the large populations of Brazil, China and India the death numbers will be quite substantial. The number of deaths in India alone is estimated to have been 2.3 between 2000 and 2003 while the corresponding numbers for entire Asia is 3.5 and for Latin America including the Caribbean is 0.7 million. The development of the spread of HIV in Asia and Latin America requires careful monitoring since the numbers in Asia is projected to peak at 17 million excess deaths in 2020-2025.

Bilaga 4

inno Scandinavia AB • Kaptensgatan 15 • 11457 Stockholm • Telephone: +46 8 545 676

Hur stärka svenska miljöteknikföretags konkurrenskraft genom FoU-samarbeten?

Företagens syn på utmaningar, behov och viktiga insatsområden

En sammanfattning av intervjuer med svenska miljöteknikföretag

inno Scandinavia AB

Augusti 2006

Följande redogörelse baseras på intervjuer med svenska miljöteknikföretag och ger en bild av deras behov och tankar kring hur svensk miljötekniksektor kan öka sin konkurrenskraft i ett internationellt perspektiv genom FoU-samarbeten.

Intervjuerna har utgått ifrån fyra generella frågeställningar;

1. Var finns den största geografiska och teknikmässiga marknadspotentialen för svensk miljöteknik?
2. Vilka är de största utmaningarna för den egna branschen respektive för den svensk miljötekniksektor i stort?
3. Vilka tidigare erfarenheter av FoU samarbete med universitet eller andra företag finns?
4. Hur ska ett FoU-projekt (och FoU-program) läggas upp för att småföretag ska vara beredda att satsa egen tid och egna pengar?

Alla intervjuade företag är små eller medelstora med spridda verksamhetsområden inom bland annat vatten- och avloppsrening, alternativa energikällor (solenergi, vindkraft, vattenkraft), energieffektivitet och återvinning.

1. Största marknadspotentialen för svensk MT

Marknadspotentialen för svensk miljöteknik uppges vara enormt stor. Generellt sett verkar det finnas två typer av geografiska marknader som är intressanta. Den ena typen är miljömedvetna marknader i långt utvecklade länder, framföra allt Västeuropa. Den andra typen tillhör tillväxtmarknaderna där det finns ett stort behov av enkel miljöteknik.

Alternativ till fossila bränslen för miljövänlig energi samt avfalls- och reningsteknik, är två teknikområden som pekats ut som speciellt viktiga och med hög marknadspotential för svenska miljöteknikföretag.

”- Vi har hela tiden nya kunder som knackar på dörren och som vi inte kan mätta. Vi har inte tillräckliga resurser för att komma vidare” (Intervju med Ecooil)

Geografiska områden

- Efterfrågan på miljötekniklösningar finns i hela världen; Europa, Kina, Indien, USA, Sydamerika och även Afrika anses ha en oerhörd potential.
- Intresset för naturenergi är stort i främst USA och Europa och efterfrågan på reningsteknik (spec. för vatten) i Östeuropa, Australien och Afrika. Bioenergi och pelletsförbränning har stor potential i Baltikum och norra Östeuropa då Ryssland börjat strypa olja och gas. Kina satsar hårt på vindkraftverk.
- Bl.a. byråkrati gör att det är svårt och resurskrävande att exportera till många tillväxtmarknader, t ex Östeuropa och Asien.
- På grund av smidighet och miljömedveten är den västeuropeiska marknaden fortfarande dominerande.
- EUs miljölagar ökar efterfrågan av enklare teknik, såsom luft- och vattenrening och avfallshantering, i nya och blivande EU-länder. Sveriges ofta avancerade miljötekniklösningar måste kunna förenklas.

Teknikområden

- Bioenergi och alternativ till fossila bränslen (vindkraft, vattenkraft, solenergi, värmepumpar, pelletsförbränning, naturolja etc.) anses vara allra viktigast
    - Ex 1. Pelletstillverkning av restmaterial såsom olivkärnor, torv, hampa och olika grödor

- Ex 2. Utveckla ny teknik istället för ny råvara! Dieselmotorn var först konstruerad för palmkärneolja. Vi bör anpassa ny teknik till de råvaror vi har och inte tvärt om.
- Ex 3. En utmaning för pelletstillverkningen är att utveckla brännare som optimerar förbränningen av olika restprodukter då varje material kräver olika tekniska egenskaper hos brännaren.
- Ex 4. Energiframtagning ur avfall
- Ex 5. Tillämpning av solenergi t.ex. soldriven kyla
- Ex 6. Direktraffineringsteknik för t.ex. rapsolja

- Vatten- och avloppsrening och avfallshantering
  - Ex 1. Forskning gällande hur mycket ska vi sortera ut och hur mycket ska vi sönderdela innan förbränning behövs
  - Ex 2. Membranlösningar för vattenrening bör utvecklas
  - Ex 3. Vattenrening m.h.a solenergi nytt teknikområde
  - Ex 4. Utveckling av avfallshantering på plats istället för deponi

2. Främsta utmaningarna för svensk MT-sektor

Sverige anses ha stor kompetens inom miljöteknik. För vissa områden uppges dock att kompetensen är spridd på olika universitet och nya upptäckte stannar ofta på forskningsnivå. Export är en nödvändighet för många företag då den svenska hemma marknaden anses vara för liten. Samtidigt påpekar många att en stark hemmamarknad att bygga upp kompetens på är nödvändig för att lyckas vid en exportsatsning. Med de ökade möjligheter som export ger kommer också utmaningar, t.ex. nya språk, nya lagar, logistik, resurskrävande processer och ökad konkurrens. En annan betydande utmaning som svensk miljöteknik möter är t.ex. att svenska miljöteknikföretag är små och konkurrerar med stora internationella företag som kan pressa priser och tvingar svenska miljöteknikföretag att konkurrera med tekniklösningar och spetskompetens, därav är FoU mycket centralt.

”För att kunna börja exportera måste företaget bygga upp kompetensen på en stark hemmamarknad, men i Sverige är intresset och efterfrågan svag jämfört med många andra länder” (Intervju med Sunstrip)

Allmänna utmaningar

- Kompetens är spridd på flera svenska högskolor och finns, t.ex. inom solenergi, främst bland äldre forskare.
- Systemlösningar där konsulter och tillverkare arbetar tillsammans för att erbjuda helhetslösningar kommer att bli viktigare i framtiden.
- Efterfrågan på långsiktigt hållbara miljötekniklösningar måste stimuleras; Politiska beslut och lagändringar är främsta verktyget för att styra efterfrågan på miljötekniklösningar och tjänster. Andra medel uppges vara teknikupphandling, skattelättnader etc.
- Sverige riskerar att hamna efter då politiska beslut i t.ex. många andra europeiska länder har stimulerat miljöteknikbranschen kraftigt de senaste åren. Svensk politik och lagar uppges ha en bromsande effekt på utveckling och internationella konkurrensmöjligheter.

Utmaningar vid export

- Bygga upp kompetenserna via en stark hemmamarknad
- Språkkunskaper
- Lära känna enskilda länders behov och förutsättningar
- Tydliggöra kompetenser
- Långsiktigt perspektiv krävs, vilket är svårt för SME med små resurser.
- Sverige har mycket att lära av andra länder, t.ex. är Tyskland starkare inom solenergi (pga. lagändringar)
- Produktion i Sverige är dyrt, svenska företag måste konkurrera med ny teknik, hög kompetens och långsiktigt hållbara systemlösningar.

3. Erfarenhet av tidigare FoU-samarbeten

De flesta intervjuade företag har erfarenhet av FoU-samarbete med universitet och andra företag. Samarbeten med universitet handlar ofta om uppdragsforskning och examensarbeten, medan samarbete mellan företag är vanliga inom t.ex. EU-projekt. Generellt sett är svenska miljöteknikföretag positivt inställda till att samverkan med både akademin och andra företag i FoU-projekt, dock upplever företagen att vissa problem kan uppkomma.

”Det går för långsamt för universiteten och ofta uppfyller dom inte avtal i tid. Vi företag måste kunna ställa högre krav på forskarna”. (Intervju med Sunstrip)

Samarbete med Universitet och Högskola

- De flesta företag har eller har haft samarbete med högskolor
- Samarbeten gällande uppdragsforskning och examensarbeten är vanligast
- Problem vid samarbete med universitet;
    - Upptäckter blir offentliga
    - Forskaren blir ofta ägare av resultaten
    - Stora skillnader i tidsplan - universitet är ofta för långsamma
    - Företagen upplever ibland att startsträckan i början av ett FoU-projekt är för lång
    - En del företag har dragit ner på högskolesamarbetena pga. att universiteten idag agerar som egna konsulter och man vill inte skapa sig en ny konkurrent
- Fördelar med samarbete med universitet;
    - Tillgång till kompetens som inte finns internt i företaget är det främsta incitamentet
    - Kan ge tillgång till betydelsefull labb- och testutrustning
    - Ökade resurser ger möjlighet till nya forskningsområden

Samarbete med andra företag

- Många företag har samarbetat med andra företag i exportsatsningar
- Exportsamarbeten är ofta systemlösningar där företagen kompletterar varandra

- Den tillgång till kunskap som finns i ett nätverk är en stor fördel, medan risken för att varje enskilt företag fokuserar på sitt eget syfte och inte på samarbetets gemensamma mål, kan vara en nackdel.

4. Upplägg av FoU-projekt

För att ett FoU-projekt ska vara intressant så måste det vara till direkt nytta för den egna verksamheten, ha kundfokus och kunna ge resultat inom 3 år. Företagen har framförallt påpekat att det är viktigt att göra ansökningsprocessen så enkel och snabb som möjligt då resurser för att söka externa medel är begränsade. Tydlighet vad gäller krav (partners, finansieringsgrad, aktiviteter organisation etc.) har understrukits.

”Vi måste i förstadiet av ett FoU-projekt sätta oss ner med forskarna och tydligt definiera gemensamma mål, och vi måste börja med att plocka ner forskarna på jorden” (Intervju med Industrial Quality Recycling)

Projekten ska

- Vara relevant för den egna verksamheten
- Vara behovsorienterade med tydligt kundfokus (d.v.s. ha marknadspotential)
- Vara långsiktigt lönsamma
- Ge resultat inom rimlig tid, högst 3 år
- Ge resultatet som är direkt användbara på marknaden, dvs. ej grundforskning
- Gärna styras m.h.a en referensgrupp/styrgrupp/projektgeneral (se Energimyndigheten) tillsatt av VINNOVA och Formas

Utlysningen / Anmälningen ska

- Var pedagogisk och tydlig
- Kräva lite tid och resurser; gärna en 2-stegs princip där den första idéskissen inte behöver vara så omfattande
- Klart informera on vad ansökan ska innehålla; gärna färdiga ansökningsmallar
- Tydligt informera om krav och begränsningar för projekten som t.ex. medfinansiering. VINNOVA och Formas bör ha höga och tydliga krav.
- Tydligt informera om vad projektet kommer att ge företaget t.ex. hur stor ekonomisk ersättning
- Ha en kort handläggningstid! (Forska&Växa har lyfts fram som ett positivt exempel)
- Uppmuntra systemlösningar där företag samarbetar för att erbjuda helhetslösningar
- Involvera t.ex. SIDAs biståndsexportsatsningar, då miljöteknik är en viktig del av bistånd.

VINNOVAs publikationer

Juli 2007

För mer info eller för att se tidigare utgivna publikationer se www.vinnova.se

VINNOVA Analys

VA 2007:

01 Nanoteknikens innovationssystem

02 Användningsdriven utveckling av IT i arbetslivet - Effektvärdering av tjugo års forskning och utveckling kring arbetslivets användning av IT. *För svensk respektive engelsk kortversion se VA 2007:03 och VA 2007:13*

03 Sammanfattning - Användningsdriven utveckling av IT i arbetslivet - Effektvärdering av tjugo års forskning och utveckling kring arbetslivets användning av IT. *Kortversion av VA 2007:02, för engelsk kortversion se VA 2007:13*

04 National and regional cluster profiles - Companies in biotechnology, pharmaceuticals and medical technology in Sweden 2004. *Finns endast som PDF. För svensk version se VA 2005:02*

05 Nationella och regionala klusterprofiler - Företag inom fordonsindustrin i Sverige 2007

06 Behovsmotiverade forskningsprogram i sektoriella innovationssystem

07 Effekter av den svenske trafikksikkerhetsforakningen 1971-2004. *För kortversion på svenska respektive engelska se VA 2007:08 och VA 2007:09*

08 Sammanfattning - Effekter av den svenska trafiksäkerhetsforskningen 1971-2004. *Svensk kortversion av VA 2007:07, för engelsk kortversion se VA 2007:09*

09 Summary - Effects of Swedish traffic safety research 1971-2004. *Kortversion av VA 2007:10, för kortversion på svenska se VA 2007:07.*

10 *Under produktion.* Effects of Swedish traffic safety research 1971-2004. *För kortversion på svenska respektive engelska se VA 2007:08 och VA 2007:09*

11 Svenskt deltagande i sjätte ramprogrammet. *Finns endast som PDF*

12 The role of Industrial Research Institutes in the National Innovation System

13 Summary - User-driven development of IT in working life - Evaluating the effect of research and development on the use of information technology in working life. *Kortversion av VA 2007:02, för svensk kortversion se VA 2007:03*

VA 2006:

01 End of an era? Governance of Swedish innovation policy. *För svensk version se VA 2005:07*

02 Forskning och utveckling vid små och medelstora företag. *Finns endast som PDF*

03 Innovationsinriktad samverkan. *Finns endast som PDF*

04 Teknikbaserat nyföretagande i Sverige 1990 - 2003. *Finns endast som PDF*

05 Offentligt stöd till universitetens samverkansuppgift - en internationell kartläggning. *Finns endst som PDF*

06 Inkubatorer i Sverige - analys av indikatordimensioner och nyttoefektivitet. *Finns endast som PDF*

VINNOVA Forum

VFI 2007:

01 Universitetet i kunskapsekonomin *(Innovationspolitik i Fokus)*

VINNOVA Information

VI 2007:

01 Forska&Väx - Program som främjar forskning, utveckling och innovation hos små och medelstora företag

02 MERA-programmet - Projektkatalog. *För engelsk version se VI 2007:03*

03 The MERA-program - Projects. *För svensk version se VI 2007:02*

04 DYNAMO 2 - Startkonferens & Projektbeskrivningar

05 IT för sjukvård i hemmet - Projektkatalog. *För engelsk version se VI 2007:13*

06 VINNVÄXT - Ett program som sätter fart på Sverige! *För engelsk version se VI 2007:09*

07 Årsredovisning 2006

08 Het forskning och innovationskraft - VINNOVA 2006. *För engelsk version se VI 2007:10*

09 VINNVÄXT - A programme to get Sweden moving! *För svensk version se VI 2007:06*

10 Red-hot research and innovation power - VINNOVA 2006. *För svensk version se VI 2007:08*

11 Research and innovation for sustainable growth. *För svensk version se VI 2006:20*

12 Projektkatalog - Genusperspektiv på innovationssystem och jämställdhet. Forsknings- & utvecklingsprojekt för hållbar tillväxt

13 *Under produktion.* IT in Home Health Care. *För svensk version se VI 2007:05*

VI 2006:

01 VINNOVAs verksamhet inom Transporter. *För engelsk version se VI 2006:07*

02 Årsredovisning 2005

03 Paving the Road. For Transport Innovation and Research

04 Drivkraft för tillväxt. VINNOVA 2005. *För engelsk version se VI 2006:08*

07 VINNOVA´s activities within the Transport Sector. *För svensk version se VI 2006:01*

08 A driving Force for Growth. VINNOVA 2005. *För svensk version se VI 2006:04*

09 Komplexa sammansatta produkter - Projektkatalog 2006

10 VINNVINN - Mötesarena för nya affärsmöjligheter och arbetstillfällen

13 VINNOVA´s Activities in Biotechnology.

14 Arbetslivsutveckling - VINNOVAs satsningar inom arbetslivsområdet

16 Competence Centres in Figures - Kompetenscentrum i siffror

17 E-tjänster i offentlig verksamhet. *För engelsk version se VI 2006:18*

18 E-Services in Public Administration. *För svensk version se VI 2006:17*

19 Effektiv Produktframtagning - Projektkatalog 2006

20 Forskning och innovation för hållbar tillväxt. *För engelsk version se VI 2007:11*

VINNOVA Policy

VP 2007:

01 Innovativa små och medelstora företag - Sveriges framtid. SMF-strategi från VINNOVA

02 Forskningsstrategi för miljöteknik - Redovisning av regeringsuppdrag till Formas och VINNOVA. *Finns endast som PDF*

VP 2006:

01 På spaning efter innovationssystem. *För engelsk version se VP 2006:02*

02 In search of innovation systems. *För svensk version se VP 2006:01*

VP 2005:

01 Kunskap för säkerhets skull. Förslag till en nationell strategi för säkerhetsforskning. *För engelsk version se VP 2005:03*

02 Strategi för tillväxt - Bioteknik, en livsviktig industri i Sverige

03 Knowledge to safeguard security. Proposals for a national strategy for security research. *För svensk version se VP 2005:01*

04 Produktionsteknik & Fordonstelematik. Förslag till FoU-program

05 VINNOVA´s views on the European Commission´s proposal for the Seventh Framework Programme on Research & Technological Development 2007 - 2013. Position paper

VINNOVA Rapport

VR 2007:

01 Design of Functional Units for Products by a Total Cost Accounting Approach

02 Structural Funds as instrument to promote Innovation - Theories and practices. *Finns endast som PDF*

03 Avancerade kollektivtrafiksystem utomlands - mellanformer mellan buss och spårväg. Tillämpningsförutsättnin gar i Sverige. *Finns endast som PDF*

04 VINNVÄXTs avtryck i svenska regioner - Slutrapport. *För engelsk version se VR 2007:06*

05 Utvärdering VINNVINN Initiativet

06 Effects of VINNVÄXT in Swedish regions - Final report. *För svensk version se VR 2007:04*

07 Industry report on exhaust particle measurement - a work within the EMIR1 project. *Finns endast som PDF*

08 Swedish innovation journalism fellowships - en utvärdering. *Finns endast som PDF*

09 *Under produktion*

10 Miljöbilar och biodrivmedel - Hur påverkas Sverige av EUs direktiv?

11 Evaluation report by the VINNVÄXT International Review Team. *Finns endast som PDF*

12 *Under produktion.* DYNAMO Arbetsgivarringar för ökad rörlighet

VR 2006:

01 Det förbisedda jämställdhetsdirektivet. Text- och genusanalys av tre utlysningstexter från VINNOVA

02 VINNOVAs FoU-verksamhet ur ett jämställdhetsperspektiv. Yrkesverksamma disputerade kvinnor och män i VINNOVAs verksamhetsområde

03 ASCI: Improving the Agricultural Supply Chain - Case Studies in Uppsala Region. *Finns endast som PDF*

04 Framtidens e-förvaltning. Scenarier 2016. *För engelsk version se VR 2006:11*

05 Elderly Healthcare, Collaboration and ICT - enabling the Benefits of an enabling Technology. *Finns endast som PDF*

06 Framtida handel - utveckling inom e-handel med dagligvaror

07 Tillväxt stavas med tre T

08 Vad hände sen?- Långsiktiga effekter av jämställdhetssatsningar under 1980- och 90-talen

09 Optimal System of Subsidization for Local Public Transport. *Finns endast som PDF*

10 The Development of Growth oriented high Technology Firms in Sweden. *Finns endast som PDF*

11 The Future of eGovernment - Scenarios 2016. *För svensk version se VR 2006:04*

12 Om rörlighet - DYNAMO-programmets seminarium 12 - 13 juni 2006

13 IP-telefoni - En studie av den svenska privatmarknaden ur konsument- & operatörsperspektiv

14 The Innovation Imperative - Globalization and National Competitiveness. Conference Summary

15 Public e-services - A Value Model and Trends Based on a Survey

16 Utvärdering av forskningsprogrammet Wood Design And Technology - WDAT

VR 2005:

01 Effektivt arbete i processindustrin Hur man gör. Från strategi till genomförande

02 Teori och metod för val av indikatorer för inkubatorer. *Finns endast som PDF*

03 Informations- och kommunikationsteknik i USA. En översiktsstudie om satsningar och trender inom politik, forskning och näringsliv.

04 Information and Communications Technology in Japan. A general overview on the current Japanese initiatives and trends in the area of ICT.

05 Information and Communications Technology in China. A general overview of the current Chinese initiatives and trends in the area of ICT.

06 Hälsa & lärande. Frågor för hälso- och sjukvårdssystemet

07 Samhandling för innovationsledd tillväxt

08 Tekniköverföring från landbaserade fordon till mindre fartyg - fas 1. *Finns endast som PDF*

09 Nya emissionskrav för dieselmotorer - en katalysator för svensk industri? *Finns endast som PDF*

10 Samarbete mellan KTH och kring-liggande industriforskningsinstitut - nuläge och utvecklingsmöjligheter

11 ICT-based Home Healthcare. *Finns endast som PDF*

12 Kompetensutveckling i små och medelstora företag - SMF. En kvalitativ studie av konferensdeltagares utsagor

13 The KTH Entrepreneurial Faculty Project

14 OLD@HOME Technical Support for Mobile Close Care. Final Report. *Finns endast som PDF*

15 Värdeskapande innovationsmiljöer

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VINNOVA är en statlig myndighet
med uppgift att främja hållbar tillväxt
genom finansiering av behovsmotiverad forskning
och utveckling av effektiva innovationssystem.

VERKET FÖR INNOVATIONSSYSTEM – SWEDISH GOVERNMENTAL AGENCY FOR INNOVATION SYSTEMS

VINNOVA, SE-101 58 Stockholm, Sweden Besök/Office: Mäster Samuelsgatan 56
Tel: +46 (0)8 473 3000 Fax: +46 (0)8 473 3005
VINNOVA@VINNOVA.se www.VINNOVA.se