


MATISSE

Methods and Tools for Integrated Sustainability Assessment (ISA)


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MATISSE

Methods and Tools for Integrated Sustainability Assessment (ISA)

Results as of January 25th, 2008

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Summary

In response to the challenge of unsustainability, the MATISSE project was designed to propose procedures, methods and tools for better integrating sustainability into policy development processes and institutions. It did so by developing, testing and refining a conceptual framework for Integrated Sustainability Assessment (ISA). ISA is a pro-active, strategic and potentially transformative process, defined as:

'a cyclical, participatory process of scoping, envisioning, experimenting, and learning through which a shared interpretation of sustainability for a specific context is developed and applied in an integrated manner in order to explore solutions to persistent problems of unsustainable development.'

The project proceeded by: exploring the potential role of ISA as a complement to existing policy assessment processes in the EU; testing ISA in a number of case studies of unsustainability; extending and linking existing modelling tools in support of ISA, and developing new ones. The models and scenarios developed within the project were used in a series of case studies which:

- examined sustainability issues within the **agriculture, forestry and land use** sector;
- explored options to decouple overall levels of **resource use** from economic growth;
- scrutinised the role that ISA could play in triggering transitions in the **water domain** using the example of the Ebro River Basin;
- examined the role that **environmental technology** could play in sustainability transitions in Europe using the examples of transportation and the Czech Republic.

This work was accompanied by extensive capacity building, outreach and stakeholder engagement activities.

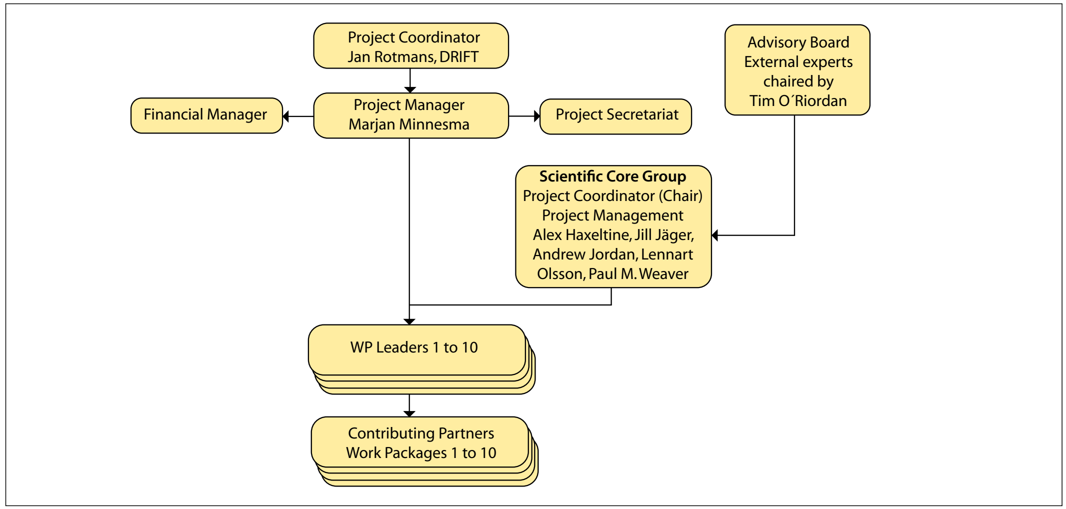
MATISSE's analysis of how policy assessments are currently being used in the EU showed that they are often limited in scope, focusing mainly on the economic impacts of new policy proposals. Furthermore, there are significant political and institutional barriers which prevent assessments from directly influencing new policies. Given the systemic nature of unsustainable development, sustainable development is likely to require broad structural changes (transitions), which depend on revising the institutional setting in which assessments take place, as well as the forms of assessment used.

The MATISSE project showed that while it is important to use conventional policy assessment processes to ensure that sectoral objectives are consistent with one another and with sustainable development, it is also necessary to use ISA to develop more comprehensive policy strategies that embed sustainable development. ISA (operating at the strategic level of policy making) and the more formal processes of policy assessment (covering the more routine levels) are therefore complementary.

The MATISSE case studies provided a real-world context for testing and further developing the ISA methodology and tools. They have shown that using ISA can change how persistent problems are perceived and open up new opportunities for finding and implementing possible solutions. Given that the European Union is increasingly embracing the goal of sustainable development, MATISSE provides a valuable contribution to the evolution of decision making and institutional design in the Union.

Introduction

Sustainable development is an overarching policy objective in the European Union. As a response to the pressing governance and management challenges of sustainable development, the MATISSE ('Methods and Tools for Integrated Sustainability Assessment') project, funded by the European Commission under the 6th Framework Programme, proposed to achieve a step-wise advance in the science and application of Integrated Sustainability Assessment (ISA). ISA is an innovative way of assessing sustainable development based on a new mode of knowledge development. Certainly ISA capacity-building is a long-term venture and there is much still to do, but the MATISSE project signals that work on a new generation of assessments with a specific orientation on sustainability and transition is underway.



MATISSE aimed to contribute to sustainability-oriented governance by providing innovative methods, tools and process-architecture for conducting Integrated Sustainability Assessments (ISA). The three-year project with 22 partners from institutes in 11 European countries (see page 48) started in April 2005. The project addressed the use of sustainability assessment in the European context, but the results are relevant generally to questions concerning the role that assessment might play in supporting sustainability-oriented governance and in the analysis of potential sustainability 'transitions'. The approach taken to learning within the project may also hold wider implications for other projects in the emerging field of science in support of sustainable development.

Fundamentally, MATISSE was a project with a mandate to be innovative methodologically; it sought to begin work on new approaches and tools for ISA that are capable of exploring transition pathways. This is an ambitious endeavour that will continue long after this project.

The main activities within MATISSE were:

- the development of a common conceptual framework for ISA
- the delivery of a portfolio of tools for ISA
- the application and test of improved and new ISA tools in four case studies
- capacity-building, communication and outreach tasks, including stakeholder engagement.

About 75 researchers participated in the project, coordinated by Professor Jan Rotmans and managed by Marjan Minnesma (DRIFT, Netherlands). The project team was supported throughout by an advisory board chaired by Professor Timothy O'Riordan, which provided high-level advice and guidance and acted as an ambassador for the project, enabling it to achieve appropriate outreach and to have impact in relevant quarters.

This brochure addresses policy makers and stakeholders all over Europe, who might be interested in implementing an ISA within their sphere of influence. It gives an overview of ISA, its tools, and how ISA is connected to related concepts. The EU-level scenarios elaborated within MATISSE and the case studies developed in order to test the ISA-concept are introduced as well.

What is an ISA?

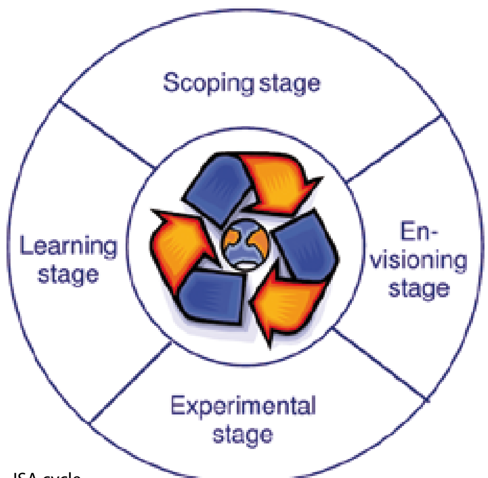
Sustainability assessment is fundamentally a 'sustainability defining and applying' process[1]. The concept of sustainable development is contested, both scientifically and socially, so by definition it is subjective and ambiguous. Nevertheless it makes sense to operationalise it, but with the acceptance that universal implementation is not possible. Sustainability is context-bound and needs to be interpreted and implemented by a range of stakeholders within that specific context.

Currently, most practical applications of sustainability assessment fulfil a pragmatic role in screening already tabled sectoral policy proposals that have no sustainability orientation per se (see pages 7-8). While the demand for screening will continue, the MATISSE project has shown that there is also a need for strategic level analyses, where the objective is to help develop long-term, cross-sectoral policies expressly designed to contribute to sustainable development.

Integrated Sustainability Assessment (ISA)

ISA is intended as a pro-active, strategic and potentially transformative process to give an explicit sustainability orientation to policy making and other undertakings that are expressly intended to address persistent complex problems of unsustainable development and take up opportunities for achieving more sustainable development.

The objectives of an ISA are to develop a shared interpretation among stakeholders of the different perspectives on and dimensions of sustainability for a particular social-ecological system (scoping), transform these into a shared vision of a sustainable future (envisioning), and explore various solution directions for a transition towards sustainability through a range of innovative experiments (experimenting), as a basis for learning about key relationships and ways of reframing problems and solutions (learning / evaluating). The formal definition of ISA reflects these means and ends:



ISA cycle

'ISA is a cyclical, participatory process of scoping, envisioning, experimenting, and learning through which a shared interpretation of sustainability for a specific context is developed and applied in an integrated manner in order to explore solutions to persistent problems of unsustainable development.'

The essential design requirements for ISA stem directly from its intended role as a transformative process for exploring and supporting reframing and reorientation. ISA represents a new mode of knowledge production that offers a forum for:

- defining 'socially- and ecologically-robust' targets and thresholds;
- integrating these as elements of operational, context-specific sustainability interpretations; and
- exploring alternative pathways of transition.

ISA brings together an integrated systems analysis and a participatory process involving a selection of relevant stakeholders and actors. The integration of stakeholders selected to represent different perspectives and interests is a basic requirement of ISA in order to develop a rich and robust interpretation of sustainability for a specific context. ISA is based on the principles of addressing intergenerational equity, the integration of the economic, ecological and socio-cultural domains and the interaction of scales.

In order to deal with the multidimensional complexity of sustainable development, ISA is designed as a cyclical, participatory process of four stages:

Scoping stage

This stage of the ISA-process involves a thorough definition of the persistent problem in question. This requires an integrated systems analysis. A stakeholder analysis is needed as well in order to explore the current and potential actor and stakeholder configurations. It is important to address the unsustainability 'problematique' from multiple perspectives. The extent to which a shared problem perception among stakeholders is already available or can be generated should be explored.

Envisioning stage

This stage involves the development of a vision of a sustainable future for the system of interest. This requires a transformation of the unsustainability problem into a sustainability challenge. The sustainability vision is not meant to be a blueprint with a high predictive value, but rather an evolutionary vision with evolving long-term targets, and multiple pathways to reach them. The process of envisioning is therefore at least as important as the vision itself. The potentially mobilizing capacity that the envisioning process contains for the stakeholders involved is of great importance.

Experimenting stage

This stage uses ISA-tools and methods to test the sustainability visions and policy proposals in terms of consistency, adequacy, robustness and feasibility. In particular, transition pathways (scenarios) from drivers to sustainability goals are analysed. Trade-offs are explored, but no formal cost-benefit or cost-effectiveness analyses are attempted, because this is irrelevant on the long time-scale of a transition period (25-50 years), during which benefits especially cannot be estimated adequately.

Learning, evaluating and monitoring stage

In this stage, learning experiences and lessons during the ISA-process are made explicit. Learning provides input for the next ISA-cycle through a possible reframing of the shared problem perception, an adjustment of the sustainability vision and related pathways, and reformulation of the experiments to be conducted. Monitoring the different stages of the ISA-process is vitally important generally, but especially for the reframing process, in terms of how the perception of stakeholders involved might have changed and to which extent the visions, pathways and experiments are adjusted.

The iterative nature of an ISA allows for a continuous learning process, in which participants adjust the scope, visions, pathways and tools, if necessary, each time that the process is repeated. For the strategic purposes of ISA, these adjustments play an important role. This means, however, that a full ISA process takes a long time to complete.

1 Varey, W. (2004). Integrated Approaches to Sustainability Assessment: An Alignment of Ends and Means. Available at: www.emrgnc.com.au

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ISA and Related Processes

Integrated Sustainability Assessment (ISA) shares some basic features of current forms of policy assessment, including Sustainability Impact Assessment, Regulatory Impact Assessment and the EU regime of Impact Assessment, referred to here as (S&R)IA. However, ISA and (S&R)IA are intended to perform different functions. (S&R)IA is, at least in principle, intended to apply and enforce the prevailing policy regime. By contrast, ISA is concerned with exploring alternative paradigms/regimes and improving the prospects for implementing promising elements of these. While (S&R)IA focuses on the shorter-term and very pragmatic concern of screening (mostly sectoral) policies and proposals, ISA is broader, strategic, explorative, forward-looking, longer-term and sustainability-oriented. While (S&R)IA is used (at best) instrumentally, ISA focuses on conceptual learning, reframing and transformative outcomes.

The premise of ISA requires a procedural and analytical approach that ensures that the assessment process takes its socio-political context into account. ISA is a cyclical, iterative, continuous process, whereas (S&R)IA is a sequential, linear process often performed once only at the end of policy development. ISA requires modulation between scales and levels within a single sustainability assessment process, while (S&R)IA is a nested set of assessment processes, whose coherence depends on having a single overarching policy paradigm as a common frame of reference developed at the highest policy levels and cascaded to lower levels. Whereas (S&R)IA is focused on predicting impacts, ISA is designed to understand the processes and relationships giving rise to development outcomes and to explore how these might be manipulated. The key analytical design differences between (S&R)IA and ISA are summarized in the table on the right.

In spite of these differences, ISA and (S&R)IA are positively correlated and should go hand-in-hand. Although there are potential benefits from screening sectoral policies of whatever orientation, the potential contribution to sustainable development that can be achieved through purely sectoral policies is likely to be intrinsically limited. Deeper integration of sustainability into policy-making will depend, firstly, upon establishing strategic directions for policy-making through ISA or ISA-like processes and, only secondly, on using an integrated regime of routine SIA at operational policy-making levels to facilitate implementation at different points and levels in the policy-making hierarchy. The MATISSE project has carried out a context-specific analysis of how policy assessments (mainly IA and RIA) are being used in four jurisdictions: the EU, the UK, Germany and Sweden. The institutional capacities underpinning assessment in these jurisdictions were summarised. Often, policy assessments are limited in scope, focussing mainly on the economic aspects of policy rather than the social and environmental aspects of sustainability. Policy formulation activities are constrained, well before the start of the formal decision-making process, for example by pre-existing political initiatives and policies, by administrative

Comparison of (S&R)IA and ISA: analytical features

Dimension	(S&R)IA	ISA
Paradigm	Regime applying	Transition oriented; regime exploring
Scope	Limited; economic aspects and compliance dominate; focus on impacts	Broad, multi-domain; focus on relationships
Goal	Goal(s) pre-set; optimisation on a single goal or a limited set of goals	Goal searching
Process/ timing	Linear, one-time only, end of process	Cyclical, iterative, paralleling other processes
Stakeholders	Mainly regime players; takes account of structural power	Niche and regime players; takes account of emerging power
Trade-offs	Trade-offs inevitable (economic concerns dominate)	Search for synergies; trade-offs residual
Evidence/ tools	Simple tools; single-scale of analysis; limited concern for causal chains	Tools and models able to represent cross-sectoral relationships; representation of structural change processes; multi-scale analysis; agent-based analysis; focus on causal chains
Learning	Instrumental learning	Conceptual learning; social learning


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procedures, international and EU legal frameworks and policy commitments. There are, hence, political and institutional barriers to direct influence of assessment on policy outputs.

The question of institutional setting is therefore extremely relevant to the distinction between (S&R)IA and ISA. The prevailing governance institutions have developed over many decades as part of the dominant development paradigm and they reflect and support the concerns, thinking and approaches of that paradigm. Thus, prevailing governance institutions are organisationally and thematically divided according to sectors, political boundaries and levels in a governance hierarchy. This fits naturally with the current paradigm that has conceptualised development as a predominantly economic process. It has been argued that 'sustainability as an emergent proposition comes into conflict with existing governance structures'[1] and that policy assessment will be useful in furthering sustainable development only when it is fully integrated into the decision-making process[2, 3]. However, progress on integrating sustainability into political institutions is only just beginning. A first step in this direction are efforts to achieve more 'joined-up' governance processes, by better coordination among still-sectoral policy-making domains to reduce conflicts between mandates. (S)IA provides an instrument to support this first step, whereas ISA could be instrumental for the more strategic step, which involves changing the policy regime so that this is deliberately targeted at sustainable development.

Given the nature of the persistent problems of unsustainable development, the resolution of these problems is likely to require broad structural changes (transitions), which depend on revision of the institutional setting in which they take place. It is one thing to assure that policies designed primarily to achieve sectoral objectives are not inconsistent with one another or with sustainable development ((S&R)IA), but it is something else entirely to develop strategies and policies designed from first principles actively to support a transition toward sustainable development (ISA).

In order to support sustainable development, future strategies and policies will most likely need to be designed with sustainability as a specific objective. These would have to be developed through systemic analyses of persistent problem causes with cross-sectoral approaches to problem solving. This is a role that ISA could play. Furthermore, through a participatory approach that engages stakeholders, experts and decision-makers in a social learning process, ISA can develop, simultaneously, strategies and action plans for a sustainability transition.

1 Varey, W. (2004). Integrated Approaches to Sustainability Assessment: An Alignment of Ends and Means. Available at: www.emrgnc.com.au

2 Devuyst, D. (2000). Linking Impact Assessment and Sustainable Development at the Local Level: The introduction of sustainability assessment systems, *Sustainable Development, 8*, 67-78.

3 Nobel, B. (2002). The Canadian Experience with SEA and Sustainability, *Environmental Impact Assessment Review, 22 (1)*, 3-16.

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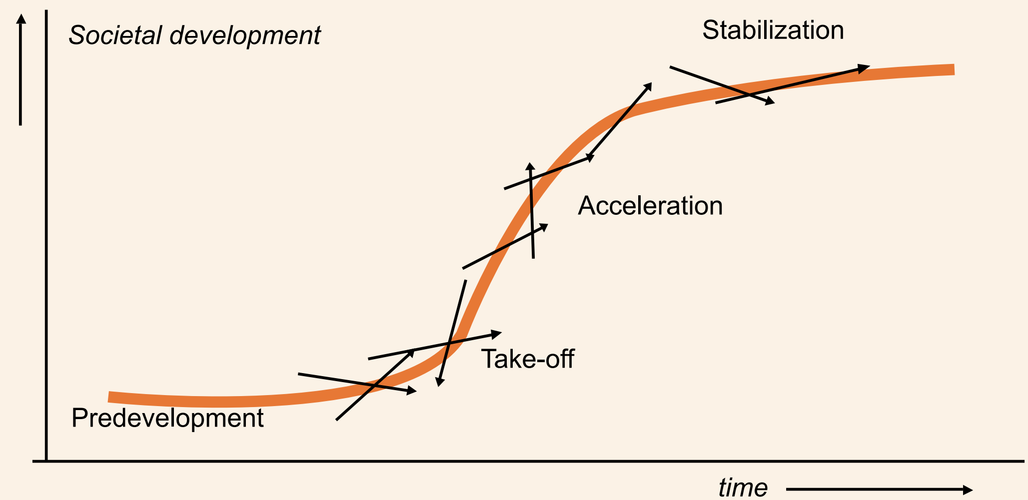
What is new about ISA?

Society faces a set of persistent problems that have a systemic pathology rooted in the prevailing development approach (see also pages 15-38). These problems have proven immune to the usual approaches to developing immediate, short-term solutions and conventional policy-making processes have difficulties in handling them. In order to find possible solutions to these problems, new approaches are required. Using a *transition-oriented* process, aimed towards searching, learning and experimenting, Integrated Sustainability Assessment (ISA) responds to these challenges.

The innovative approach of ISA is that it does not start from immediate solutions but begins with a search for solution directions by doing a set of experiments under the guidance of a long-term sustainability vision. By taking a comprehensive systems perspective, policy interlinkages are revealed and, thus, there is a greater chance of identifying 'win-win-strategies'. The ISA process can identify 'niche' development modes that are often overlooked in the policy process and are often held back inadvertently by policies that support dominant development modes. If these niches were to be supported or empowered, they might be up-scaled and eventually replace the unsustainable modes.



The four phases of a transition[1]; see also 'Developing and Linking Tools for ISA´ pp 39-42 and 'The MATISSE Scenarios' pp 11-14.

ISA helps to gain a better and systematic understanding of the complexity of sustainability issues and of barriers to moving towards sustainability. This includes improved insights into the drivers of unsustainability. ISA is a normative, long-term process including a number of cycles through the four stages of scoping, envisioning, experimenting, and learning. It is concerned with developing holistic strategies and thus is complementary to more familiar policy assessment processes. The approach is not useful for every problem but is especially useful for persistent problems.

Developing a new language, a new discourse and new and broader frames in which to discuss an issue are central to ISA. This requires multidisciplinary and multiscale analysis and participation of a wide range of stakeholders. The stakeholders become engaged in a social learning process, in which their views of the issues can potentially be changed – thus building a potential for transformative changes. This is a complex matter and a time consuming task.

The essential design requirements for ISA stem directly from its character and role in the policy development process, which is as an exploration of and instrument for regime change and transition. A suite of interlinked models, methods and approaches is needed. *Transition models* play an essential role in ISA (see pages 39-42). They are explorative and heuristic models rather than predictive models, where agents (i.e., actors represented) play a crucial role. The conventional models used in integrated assessment are good at describing different development outcomes but are not helpful in showing how to get to these outcomes (i.e., process of transition). Neither are conventional models suitable for describing structural change. *Transition scenarios* are also an innovation that plays an important role in ISA (see pages 11-14). In contrast to conventional scenarios, transition scenarios include non-linear changes, such as bifurcations, radical shifts and surprises that describe transformative change. Traditional (predictive) models, transition models and transition scenarios therefore can be linked within an ISA process to provide additional insights.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Learning from case studies

The real world context for testing and further developing the ISA methodology and tools was provided by the MATISSE case studies.

The case studies (see pages 15-38) have shown that ISA:

- Leads to a different problem perception and formulation than usual;
- Creates a scope of problem analysis different from that of conventional analysis;
- Leads to a wider range of possible solutions;
- Leads to an innovative set of transition pathways;
- Supports patterns of development that are compatible with the long-term changes occurring in the social-ecological system as whole;
- Can contribute to changing the patterns of development, as well as to increasing long-term opportunities for development and improvement of quality of life;
- Provides a structured procedure to carry out assessments and analysis that integrates multiple domains, scales, problems, languages, and institutional arrangements in a coherent and intelligent manner;
- Plays a role in identifying and structuring niche developments;
- Can be useful in analysing the influence of political stakeholders;
- Links different case studies with each other as well as different model activities; and
- Implements and analyses new scenarios by using newly-developed or improved models as well as model analyses.

1 Rotmans, J.; Kemp, R.; van Asselt, M. et al., 2000: Transitions and Transition Management. For a Low Emission Energy Supply. A Study for the 4th National Environmental Policy Plan (NMP4). Maastricht.
Available at: www.icis.unimaas.nl/projects/nmp4/downs/00_35_ab.pdf

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The MATISSE Scenarios

A Scenario Task Force worked throughout the MATISSE project on the development of scenarios. The first need was for a baseline scenario to be used in the case studies and model integration studies. We selected the baseline scenario used by the European Environment Agency in the European Environment Outlook of 2005[1].

The baseline scenario was not more than a set of assumptions, so we decided to develop an accompanying narrative. In doing so, however, we found that for crucial assumptions in the baseline scenario, there were two directions in which the story could develop. This led to the development of two scenarios that took these bifurcation points and developed the stories accordingly: 'Motivated Europe' and 'Old and Dense Europe'. These storylines have been quantified and used with a variety of models. A 'Transition Scenario for Europe' was also developed, to illustrate how more drastic diversions from current trends may contribute to a more sustainable future.

OLD AND DENSE EUROPE	Key Dimensions for Development	MOTIVATED EUROPE
No structural influences of government	Institutions	Structural influence of government with respect to policies and subsidies
Lack of educational system while more skilled people are needed	Education – Migration	Investments made in educationalsystem. air chances for migrants in the labour market
Pressure on health care sector due to aging population	Health care	Shift to a more caring society
Increasing air pollution through increased car ownership, growing amounts of construction waste, energy demand, and commuting	Pollution	Decreasing air pollution through increased use of public transportation, R&D for technological breakthroughs for cars, improved urban planning, carsharingand car-free cities
City centres are for business, green areas are for living	Infrastructure	City centres become the place for living, working and caring
Slow penetration of renewable energy, no major innovations in modes of transport	Technology	Innovations in sustainable modes of transport including smaller cars and new ngine technology
High trade barriers due to failing WTO negotiations; Intensification of land use leads to competition between nature and agriculture	Trade	Successful WTO negotiations lead to abandonment of 20-25% of current agricultural land. organic farming, low input farming, grazing etc supported
Absolute levels of resource use increase. Increased imports of metals (problem shifting to areas outside of Europe)	Resources – Material flows	Rate of increase of material usestagnates as a result of technological developments, efficiency improvementsand more durable products

The Baseline Scenario

The EEA baseline scenario includes existing trends and the effects of policies in place and/or in the process of being implemented by the end of 2001. The EU-25 population remains rather stable peaking in 2020 at around 462 million and declining there-after (458 million in 2030). Rising life expectancy combined with declining birth rates and changes in societal and economic conditions lead to a significant decline in average household size and growth in the number of households. The EU benefits from economic and monetary unification and a continued increase in world trade. The assumptions for economic growth reflect the trend of structural change in developed economies away from the primary and secondary sectors. The MATISSE baseline scenario includes the European Emissions Trading Scheme (ETS) and a stronger growth in oil prices than the EEA baseline.

The Bifurcation Points and Two Variants of the Baseline

As noted above, in developing a storyline for the EEA baseline scenario, a number of bifurcation points were identified on a set of key dimensions along which the storyline could follow a different course (see table).

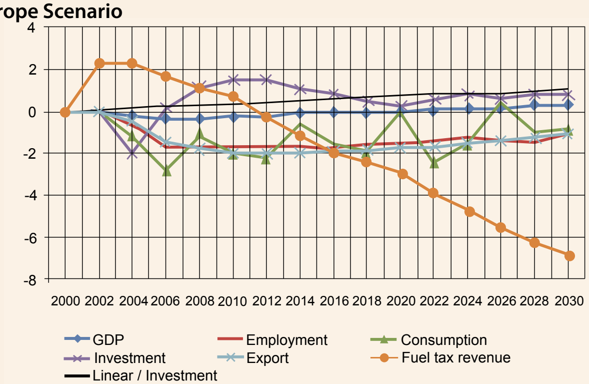
Old and Dense Europe ['negative' variant of baseline scenario]: Europe becomes a region of disparities and tensions. There are clear distinctions between rich and poor, Western and Eastern Europe and skilled and low-skilled workers. Some see an increasing growth in pollution due to an increase in per capita car ownership and increased commuting distances. Growing (although stabilizing) populations and individual living continue to intensify demands for water, food, resources, transport and space. There is a growing disparity between Europe and the 'rest of the world' in terms of resource use per capita, i.e. land, raw materials, energy. Problems are increasingly shifted to regions outside of Europe, by importing resources and exporting wastes. Migration rates exceed birth rates so Europe has become increasingly multicultural. Together with the inadequate educational system for low-skilled workers and the absence of cultural integration, this leads to poor skilled and disoriented [young] migrants. There is an unmet need for labour, while at the same time there is increased time pressure on those that do have required skills. One consequence of lower household sizes and independent living is the growing stock of buildings and infrastructure, which have led to a further expansion of settlements and road area at the expense of productive soil. The trend of separating working from living leads to city centres filled with larger business parks but also to uncoordinated land planning outside city centres.

Motivated Europe ['positive' variant of baseline scenario]: In this scenario seeds of change can be identified regarding awareness of sustainability challenges and a shift away from a focus on economic growth within Europe. The transformation of Europe to a more service and knowledge-based economy together with the withdrawal of elderly from the labour market means there is a growing demand for high-skilled young people. Investments are made in the educational system with a focus on training low-skilled young immigrants as well as their parents. The overall air pollution significantly decreases, in spite of the ever intensifying passenger, freight and air transport. Initially this is achieved through policies that stimulate people to use public transport when commuting. This is supported by subsidies for R&D towards technological breakthroughs for car engines. Also, cities are made more attractive for living and working and policies concerning car-sharing and car-free cities are introduced. Thus, within Europe a culture arises where living, working and caring are integrated, balanced and organised around the city centres. As the barriers for trade from WTO negotiations and related CAP reform become less strict, 20 percent to 25 percent of current agricultural land is freed up for less intensive uses. Organic farming, low-input farming, grazing and free roaming of animals increase.

Box A

Economic Impacts of the Motivated Europe Scenario

Assuming that in the Motivated Europe scenario, about 12 million people move into urbanised zones and external costs are internalised for all modes of transport, the ASTRA model shows only a very small change of GDP over the time period 2000-2030 compared with the baseline scenario, higher levels of investment and reduced levels of employment and exports. Not surprisingly, fuel tax revenues decline sharply in the Motivated Europe scenario.



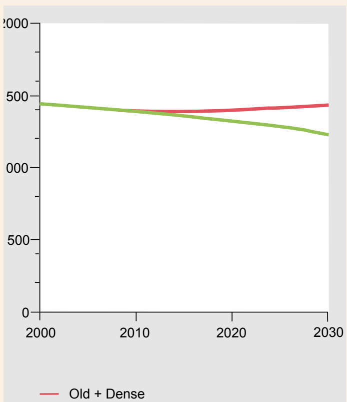
Overwiev of economic impacts of the Motivated Scenario in EU-27 [% to Baseline]

Box B

Impacts on Agricultural Land Use

On the basis of results from the EURURALIS scenarios[2] it is possible to draw conclusions about agricultural land use in the MATISSE scenario variants. We assume that in Old and Dense Europe market/ farm income support remain at current levels and there is no biofuels policy. In contrast, for Motivated Europe we assume that there is a fully liberalised market and trade, farm income is cut to 50% of current levels and the current biofuel directive is implemented.

Agricultural land area in the EU-15 (2000-2030)



In the Old and Dense scenario there is a small decline of agricultural land area in the EU-15 and then a return to the levels of the year 2000. In contrast, in the Motivated Europe scenario there is a continuous decline of agricultural land area, which is 15% below the area in Old and Dense Europe by 2030. The differences between the two scenarios for the EU-10 are much smaller, because they are less sensitive to changes in the Common Agricultural Policy (CAP).

Various models were used to test the scenario assumptions and to illustrate scenario outcomes, in particular the ASTRA model, the IMAGE model and the E3ME model.

Box A gives an example of the results of the Motivated Europe scenario using the ASTRA model.

Box B shows results relevant to agricultural land use in the Motivated Europe and Old and Dense Europe scenarios using the IMAGE model.

The MATISSE Transition Scenario

The scenario narratives and quantifications developed in most scenario exercises assume that changes are linear and smooth. The MATISSE project, in contrast, also considered transitions or 'radical systemic innovations'. The project was interested in how novel and radical solutions emerge (as socio-technical 'niches') and become sufficiently powerful to challenge and, ultimately, overthrow a dominant solution (the pre-vailing 'regime' of production and consumption including the associated practices and set of actors) resulting in a transition.

For this purpose, it is necessary to develop 'transition scenarios', in which 'niches' emerge and challenge the dominant regime. Developments are not assumed to be linear but to take place in a distinct sequence of phases – a predevelopment, a take-off, an acceleration and a stabilisation phase (see graph page 9).

In the MATISSE Transition Scenario, by 2030 the dominant practices, rules and assumptions of the European Union have changed dramatically from those that were in place in 2007. The prices for energy, resources and land more properly reflect the value of eco-system goods and services. Society measures its progress not in terms of economic wealth but in terms of wellbeing of people and the environment in Europe and worldwide. Paid work is distributed, so that all people who want a job have a job, while work that was previously unpaid (caring for the young, the old and the sick, voluntary work to support environment and society) is paid through a guaranteed basic income for all citizens. Previously low-wage work has to be paid better and has gained prestige.

This results in a more equal distribution of work and income between the genders.

In the **pre-development phase** before 2007, some European countries had begun to experiment with ecological tax reform, but there were barriers to a European-wide introduction. At the same time, however, there was increasing public awareness of the dangers of climate change and a 'sustainability wave' began to sweep across Europe. In the **take-off phase** between 2008 and 2012, a coordinated network of actors developed around three concepts: a European ecological tax reform, new measures of progress based on wellbeing and a different 'work-life-balance'. These concepts became increasingly used in individual countries and developed at the European level. In **the acceleration phase,** 2013-2022, the concepts diffused rapidly and major technological and societal changes resulted. By 2030, Europe is in **the stabilisation phase**, the speed of technological and societal change has decreased and a new dynamic equilibrium is being reached.

Box C shows some results from the E3ME model illustrating this scenario.

1 http://reports.eea.europa.eu/eea_report_2005_4/en/outlook_web.pdf
2 http://www.eururalis.eu/general6.htm

Box C

Modelling the effects of ecological tax reform, increased R&D and improved material efficiency

Using the E3ME model a series of sequential scenarios have been developed, each of which examined the effect of a particular driver of change. These scenarios involve

- the widespread introduction of a revenue-neutral carbon levy on energy throughout the EU-25 (cost borne by all fuel users; set at 200 Euro per tonne carbon in addition to baseline assumptions of existing ETS);
- levels of business R&D are raised towards national targets (stimulated by the increased cost of energy);
- Manufacturing and construction use 20% less manufactured inputs by 2015 and more modest reductions after 2015 (as a result of increased cost of energy, attention is paid to the effective use of all input costs).

Some results for the EU-25: Impact of the carbon levy

- **Impact on GDP is small** (0.3% in 2020 and 0.7% in 2030), though there is a larger impact in value-added (0.7% and 1%).
- **Revenue recycling has a significant influence on the overall impact.**
- **Impact is greater in EU-10 than EU-15** (2% vs 0.6%). The GDP impact is negative in some countries, but the scale is small.
- **Impact on employment is positive, but small** (0.5% higher, 1m in 2020), with greater relative impact in EU-10 than EU-15. **Employment is higher in all broad sectors**, with short-term (to 2015) increases greater in manufacturing, and longer term in financial and business sector.
- **Energy demand is reduced** (10% lower in 2020 and 15% lower in 2030). **Impact is stronger in EU-10 than EU-15. Demand from all sectors falls:** strongest reductions in energy industry's own use, iron & steel, non-ferrous metals, air transport. Power generation mix increases towards renewables. **Greenhouse gas emissions 10% lower in 2020.**
- **Total Material Requirement is lower (1-1.5%). Changes dominated by energy products:** increase in agriculture/fall in coal (direct extraction and imports) an imports of manufactured fuels. **Varied, but small, impact on other commodities** reflecting changes in sector growth profiles.

Agriculture, Forestry and Land Use (AFLU)

The interactions of Agriculture, Forestry and Land Use activities with climate change, the natural environment, and economic/social conditions are very complex. Their analysis requires input from a wide range of disciplines and of a wide variety of analytical tools. The overall objective of the AFLU case study was to develop and apply a methodology for carrying out integrated policy assessment in the AFLU sector. While keeping AFLU as the focal point both in terms of policies and objectives, this work also addressed wider concerns in the fields of the economy, the environment, ecosystems and sustainable energy provision.

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What was done?

The objectives of this case study were to develop and apply a methodology for carrying out an ISA in the AFLU sector, to examine the sustainability issues affecting the AFLU sector, and to identify quantifiable objectives and policies for promoting them. The study also explored possibilities for improving the chances of attaining a number of sustainable development objectives simultaneously.

The stages of the ISA cycle were:

1) Scoping Stage

The scoping stage involved the development of the conceptual framework for performing integrated policy exploration in the AFLU field, where a thorough analysis of the Agriculture and Forest system in Europe was made, the historical evolution of sustainability in Agriculture and Forestry was presented, and the different dimensions of the unsustainability 'problematique' from the different perspectives of involved actors – both institutional and individual – were explained. At the end of this stage a conceptual model of each of the two systems (agriculture and forestry) was formulated. This model integrated the following aspects: the actors involved, objectives, functions and the overall governance.

A stakeholder meeting was organised with the aim of broadening the range of sustainability concerns addressed in the case study and ensuring that the work is relevant to stakeholders. It also aimed to prepare the ground for the active involvement of stakeholders in the policy exploration exercises at the end of the project.

Several stakeholders agreed that alongside traditional concerns (such as food security, food safety, environmental protection and health), agriculture has to respond to evolving concerns, such as the quality of the environment, sustaining rural communities and territories, poverty alleviation in developing countries and trade liberalisation issues. Stakeholders voiced strong concerns on unsustainability aspects of the AFLU sector: e.g. human health, environmental and socio-economic issues.

2) Envisioning Stage

This task involved the identification of measurable sustainable development indicators in relevant domains (agriculture, forestry, land use, economy, environment, climate change, social cohesion, ecosystems) and the definition of appropriate policy instruments for influencing the selected sustainable development indicators. It aimed to provide a set of key sustainable development indicators for the AFLU case study.

The indicators cover

- general agro-economic indicators (e.g. agricultural output, sectoral employment or income),
- agricultural land uses (e.g. changes in the share of crop range type, amount of fallow),
- environmental indicators (e.g. excess nitrogen use, or sales of pesticides),
- energy use (net energy use by each agricultural sector, energy use deriving from fertilizer use), and
- R&D issues (expenditures on agri-environmental management research).

With input from stakeholders, visions of the future AFLU sector were developed. These clearly showed that agriculture is moving from a single functional activity, namely food production, to a multifunctional activity (produce healthy food, maintain landscapes, enhance biodiversity, secure a clean environment, provide employment, produce energy, sequestrate carbon, maintain rural areas). Some of these functions are marketable in the sense that they can be remunerated through existing or future markets (e.g. carbon trading).

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Stakeholders also supported the identification of possible policy instruments for influencing sustainability in the AFLU sector. Potential policy instruments were evaluated on the basis of data availability, modelling potential, cost estimation potential and impact on a wider range of diverse sustainability indicators (possible synergies, conflicts or trade-offs). The list included financial/economic instruments (e.g. direct subsidies to planting, silviculture operations, harvesting, energy production), legal/regulatory frameworks (maximum discharge of polluting chemicals), the implementation of climate policies (carbon taxes), and expenditures on agri-environmental research.

3) Experimenting Stage

Having thus identified measurable targets and instruments, the complete path from instrument application to impact on the sustainability indicators was modelled. For this purpose large-scale models were used in order to maintain consistency with other sustainability impacts via the detailed treatment of a large number of key factors incorporated in these models.

Modelling work consisted of substantial extensions and re-fashioning of existing models and the construction of new ones in order to create the capability for carrying out the detailed policy impact analysis necessary. A considerable amount of the modelling effort was concentrated on partial equilibrium models in the AFLU sector covering Europe and the world. A specific task consisted of devising direct and indirect ways of measuring costs of implementation of sustainable development policies. For this purpose new and extended large-scale general and partial equilibrium models were used.

The Integrated Policy Assessment (IPA) methodology applied in the AFLU case study placed considerable stress on uncertainties associated with different policy impacts and their interconnections. In order to quantify the risks attached to the efficacy of the application of instruments, purpose-built stochastic models capable of producing joint distributions of such impacts were used. The IPA was carried out using a decision support tool capable of exploring policy priorities in order to minimise risks, hedge against uncertainty, and maximise the economic, social, environmental, energy, and infrastructural benefits of their implementation. The tool integrated the results of the large-scale partial and general equilibrium models and incorporated the risk information derived from the stochastic models.

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Results

Several versions of the Integrated Policy Assessment Tool have been constructed using the methodology outlined above covering different scales of sustainability policy exploration ('macro' and 'meso' levels). The most interesting outcomes concerned exploration of policy instruments in the broad area of reform of the Common Agricultural Policy (CAP) of the EU and a variety of measures supporting the use of biomass/bio-fuels as a means of promoting climate change mitigation. These exercises have revealed many areas of conflict and synergy and have provided indications about the conditions under which robustness of conclusions and stability of policy recommendations can be achieved.

The CAP has been a cornerstone of European integration from the beginning and has absorbed historically very large shares of the 'common' budget. Its main aim has been to ensure a viable European agricultural sector in view of food security, social cohesion and land management and maintenance. Starting in the 1990s it has been undergoing profound reform with the aim of increasing its effectiveness (the achievement of its aims at lower cost). The most notable transformation so far has involved a shift from market support (guaranteed prices) towards direct payments to farmers (on a land utilisation basis). In recent years there was a gradual emergence of 'Rural Development' as an alternative form of support. The process of CAP reform is still ongoing: it is highly dependent on the pressures of existing lobbies and power structures (strong stakes of beneficiaries). But it is also subject to considerable pressures from agents promoting agri-environmental policies, the World Trade Organisation, taxpayers, consumers, and the need for operational simplification in order to ease the administrative burden. At this stage, however, CAP reform is still in a state of flux with many alternative courses yet to be determined. In recent years the promotion of bio-energy sourcing acquired considerable momentum as a means for increasing renewable energy shares to support energy security and climate mitigation. In promoting bio-energy it is often assumed implicitly that some of the aims concerning a viable agricultural sector will also be served. The extent of commitment to this option is still under considerable debate, due to the effects it may have on the AFLU sector, biodiversity and eco-systems, as well as the high costs of implementation (especially with regard to bio-fuels).

The main findings from the analysis carried out in the case study concern the potential conflicts and synergies between these two categories of policies as well as the high risks and opportunities involved in terms of their impact on the global agricultural system. Alternative policies differentially affect EU farm welfare, vulnerable farmers in developing countries, food prices to consumers and global nutrition prospects. The key appears to be the evolution of yields in food production: in the past few decades they have improved sufficiently to ensure a constant if unspectacular improvement in levels of food supply. This pace may be slowing down and its future course is more uncertain than is often assumed. The promotion of better practices together with R&D could go some way in alleviating possible bottlenecks.

The policy exploration has been carried out using the IPA tool which is designed to take uncertainty and its structure explicitly into account. In this tool minimising the risk of unsustainability is the policy objective. Under certain conditions, broadly corresponding to what in probability theory is considered to be 'normality', the IPA has produced results involving balanced mixes of policy characteristic of hedging stances. Policy mixes change as ambition of achieving sustainability is increased but at the same time the risk of failure also increases. Two versions of policy mixes have been considered: one involving small shifts in policy (nudging towards sustainability) and another involving much larger scale policy doses. The latter necessitated an explicit incorporation of nonlinearities (a more complex model) but in general did not affect greatly the results (often even enhancing their robustness). Thus, the main characteristic of results from these policy exploration exercises is their great stability over large stretches of sustainability ambition followed by radical shifts at particular thresholds. This means that the pay-offs between different sustainability objectives are not smooth. They constitute a set of distinct policy clusters with distinct characteristics. This in itself does not pose particular problems for stakeholder interaction: it may even be advantageous in that it enables a focus on a limited set of distinct policy stances.

Increasing Resource Use Efficiency without Problem Shifting

Issues of resource use, resource scarcity and resource efficiency are currently gaining renewed economic and political momentum both at the national and the international level. Human-caused material and energy flows are one of the key causes of both social and environmental problems today, and can serve as an indirect indicator of pressure exerted on the environment by humans.[1, 2, 3, 4] For a more sustainable use of natural resources in Europe, it is vital to understand current as well as past patterns of resource use within as well as across countries. This is especially true with regard to the European enlargement, as levels of material and resource use of the new member states might undergo changes following their accession. The notion of industrial or socio-industrial metabolism has been introduced as a concept to describe the use and transformation of resources and the flows of materials induced by economic activities. A rapidly expanding field of research has emerged that serves to measure and analyze the socio-industrial metabolism of national economies using Material Flow Analyses (MFA) and related indicators.[5] Material flows cross the functional boundary between the environment and the economy and can be regarded as indirect pressure indicators for environmental degradation.

For example, the extraction of primary material, which is at the start of the production-consumption chain, is associated with environmental pressures such as landscape disruption and subsequent impacts on the water cycle and biodiversity. In addition, since matter can neither be created nor destroyed, the higher the amount of material input into the economy, the higher will be the ultimate output in the form of emissions and waste as both materials and energy.

What was done?

This case study explored potential options to decouple overall levels of resource use from economic growth by analysing economy-wide material flows and driving forces and by using models to examine technological and institutional potentials for minimizing resource use and waste generation for selected products. The work aimed to derive insights into the driving forces of resource use for specific countries, as well as addressed the question of what sort of

development one might expect with regard to the further technological and socio-economic convergence of the Czech Republic (chosen for study as one of the new member states of the EU) and the EU-15.

This was done using ISA methods and tools that also support the detection and assessment of environmental problem shifting (for instance moving production outside the EU) associated with increased materials and resource productivity. The case study developed a multi-level analytical framework for the analysis and assessment of the socio-industrial metabolism, which incorporated the elements of the ISA-cycle.

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The analysis and the assessment of the economy-wide material flows were done on three levels: the macro-, the meso- and the micro-level. The purpose of this analysis was to provide a complete description of the situation of the material and resource use as well as the productivity. The macro-level refers to the economy-wide or regional scale, the meso-level applies to the sectoral scale, while the micro-level relates to the product and/or producer level. On the macro-level, the focus was on:

- Germany, as a representative of an old member state of the EU;
- the Czech Republic (CZ), as a representative of a new member state; and
- the EU-25, while distinguishing between EU-15, as a benchmark representing th established Western European part of the EU, and the new member states.

The analysis across these three levels (macro, meso, micro) was undertaken in order to

a) capture the drivers for resource use at and across the different levels and
b) explore technological and institutional potentials for minimizing resource use at these levels and how these measures feed into and interact with the next higher levels.

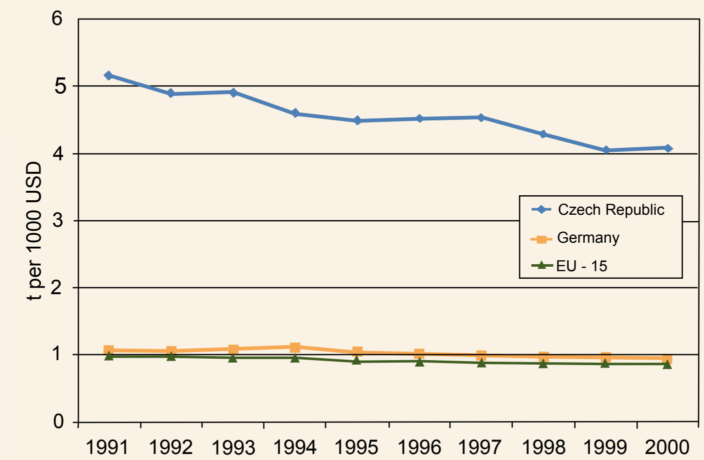
In order to capture the essentials of the system, different sub-case studies were developed at each level, focusing on relevant resource and product groups. The scope of the study was discussed with expert groups and stakeholders. The main methodology used on the macro-level was a comparative analysis of the aggregated indicators *Direct Material Input (DMI)* and *Total Material Requirement (TMR)* and their components over time. The DMI measures the direct input of materials for use into the economy, i.e. all materials that are of economic value and are used in production and consumption activities. DMI equals domestic extraction used plus imports. The TMR measures the total 'material base' of an economy in terms of primary materials. TMR equals domestic extraction used plus unused domestic extraction plus imports plus indirect flows associated with imports.

Results

At the *macro-level* the modelling focused on material and resource use of the EU-25 with a special focus on the Czech Republic. The driving forces of material and resource use of the Czech Republic were analysed by looking at the past and current trends of resource use in the Czech Republic as compared to Germany and the EU-15. This analysis served as a basis for developing alternative scenarios in conjunction with the case study on environmental technological change (see pages 35-38).

Altogether, the analysis revealed that the material and resource basis of the Czech Republic underwent significant changes in the 1990s (see graph on the right). Most of the dynamics tend towards a higher similarity in terms of material use, resource requirements and related productivity to the old member states of the EU, probably due to a convergence of production technologies and use patterns in industry and households. At the same time, the volume and structure of the material and resource input of the Czech Republic resembles the German pattern to a higher degree than the EU-15 average, despite the fact that the German GDP is much higher. This implies that the physical structure of both economies is rather similar; for instance, with regard to overall material and resource use per capita, but also with respect to the direct use of biomass, the disproportionate use of brown coal, a comparable level of construction mineral use, and a high dependence on metal resources for manufacturing. The degree to which future development of the Czech economy will continue towards lower material and resource use and further increase of resource efficiency will critically depend on whether the major trends will follow the historical German path or orientate more towards the average EU-15 performance.

At the *meso-level* the focus was on the PGM (platinum group metals) system, with a link to the work done within the hydrogen case study (see pages 31-34). In the scoping stage PGM flows to Europe from the rest of the world, as well as within Europe were analysed. This included the identification of the major industries and product groups driving the use of PGM in Europe, as well as the environmental pressures associated with the production and use of PGM. Among the different industries the automotive industry was identified as the single largest user of primary PGM as well as the source of the largest losses of PGM in the system (due to exports of cars). In addition the issue of problem shifting was highlighted, as the introduction of automobile catalytic converters led to a reduction of diffuse air pollution in Europe on the one hand, but at the same time the increased demand for primary PGM is linked to increased environmental pressures (e.g. mining wastes and atmospheric emissions) at the production sites in Russia and South Africa in particular. The experimenting phase thus focused on the automotive industry in particular, modelling the future development of the European passenger car fleet as well as conducting an *ex-ante* assessment of introducing fuel cell vehicles based on PGMs. In addition technological and institutional potentials were explored to minimise the environmental pressures associated with the production and use of PGM. In the case of passenger cars, increasing the recycling rate of catalytic converters was found to be an effective measure to minimie losses and reduce the dependency on primary PGM. At the same time, the demand for cars also has a decisive influence, as potentials for recycling are limited in the case of a physically growing stock of products when demand exceeds the generation of waste. For the *ex-ante* assessment of fuel cell vehicles, it was shown that the widespread introduction of fuel cell



Material intensity (DMI per 1000 US $) Czech Republic, Germany, EU 15, 1991-2000 vehicles requires important technological improvements to re-duce the PGM content of the fuel cell stack and in order to reduce pressures on reserves and the environment (see figure below). In addition, independently from technological progress, the basic design of future fuel cell vehicles will have a large influence on the total PGM requirements. As the power of the vehicle seemed to be a key driver influencing the PGM content of the fuel cell, developments towards lighter vehicles could present a viable option to reduce environmental pressures.

The dematerialisation of the car was thus a further case study that was taken up at the *micro-level*. Here the trade-off between diff-erent substitution strategies was shown (e.g. aluminium vs. steel) and different potentials for minimizing resource use associated with the production of cars were explored. Among these, radical changes in product design (e.g., towards lightweight cars) were shown to have the greatest potential for minimizing overall re-source use.

Increasing resource productivity and life-cycle-wide dematerialisation of products and services is a key strategy to sustain the environmental basis of economy and society. The example of cars shows that synergies between materials reduction and climate protection can be com-bined – a happy outcome, which is probably also beneficial for innovation and competitiveness.

Lessons learned

ISA by definition allows for a more integrative, multidisciplinary and system-wide approach and therefore elements and links can be cap-tured that traditional mono-disciplinary assess-ments fail to incorporate. Such a system-wide and multi-level perspective is especially im-portant for detecting problem shifting and for *ex-ante* assessment, for example when new technologies are being pushed (e.g., fuel cells, biofuels) and the consequences of such a development cannot yet be observed from past developments. The experience from the work conducted has shown that it is not only possible but necessary to repeat this type of case study for other product groups/materials in order to get a better understanding of the complexities of the socio-industrial metabolism. ISAs of this type would also bring invaluable insights for other emerging technologies.

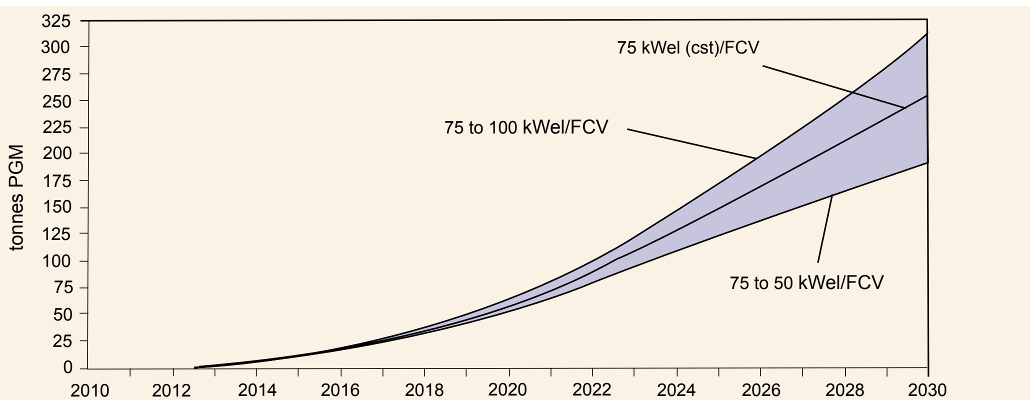
1 Schmidt-Bleek, F., 1993. *Wieviel Umwelt braucht der Mensch? MIPS – Das Maß für ökologisches Wirtschaften*. Birkhäuser Verlag, Berlin, Boston, Basel.

2 Ayres, R.U., Simonis, U.E. (eds.), 1994. *Industrial Metabolism: Restructuring for sustainable development*. UNU Press, Tokio.

3 Weizsäcker, E.U. and Lovins, A., (1997). Factor Four: doub-ling wealth – halving resource use. Earthscan, London.

4 Bringezu, S., (2002). Towards Sustainable Resource Mana-gement in the European Union, Wuppertal Papers 121, Wuppertal.

5 Bringezu, S., Schütz, H. and Moll, S., (2003). Rationale for and Interpretation of Economy-Wide Material Flow Analysis and Derived Indicators. *Journal of Industrial Ecology* 7 (2): 4-67.



Platinum cumulative primary input for a given FCV introduction scenario and for different evolutions of the fuel cell stack power

Further Reading

van de Sand, I., Markosova, K., Kovanda, J., Schütz, H. and Bringezu, S. (2007): Comparison of material use and resource intensity of the Czech Republic, Germany, EU-15. Analysis of the input structure and major trends of the physical economy between 1991 and 2000. MATISSE Working Paper 13. Available at: www.matisse-project. net

Dematerialisation, Resource Use and Economic Growth

With a focus on dematerialisation in Europe, this case study concentrated on resource use at global, European, and national scales and looked into driving forces, dynamics of change and policy options for dematerialisation. One goal was to provide tools for forecasting material resource use and identifying feasible policy options.

Global level

On a global scale this MATISSE case study performed a metabolic study of the evolution and the current patterns of global production and consumption of four materials: copper, aluminium, cadmium and zinc. The criteria for the selection of metals were environmental, strategic and economic relevance in the past, available information and expected increase of use in the future.

The scoping stage focused on identifying the key sustainability issues of the social metabolism of metals. From a world history perspective, the evolution of per capita metals use has been tremendous. For example, copper, which is one of the oldest metals in use, an increase in per capita consumption from prehistoric times to the time of the ancient agrarian civilisations by a factor of 10 and again by a factor of 50 from then to the present day can be observed. Considering that high levels of metal production are a typical characteristic of an

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industrialised economy and that the majority of the world's population is only at the beginning of a transition from an agrarian to an industrialised society, we can expect a further substantial increase in the demand for metals.

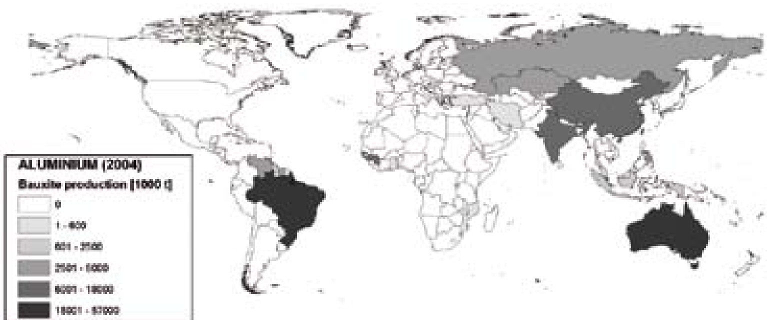
For the industrial metabolism, the flows of material between economy and biosphere, metals are prime strategic raw materials. Their manifold and valued material qualities make them essential and partly non-substitutable components of numerous industrial products and inputs to manufacturing. There are two main *sustainability concerns* related to metals use that dominate the literature: the environmental impacts associated with the industrial metabolism of metals and the potential of resource scarcity or even depletion[1, 2, 3]. Although less often addressed, a third aspect concerns the social impacts of metals use, especially mining activities, including violent conflicts over access to land and resources. *Adverse social effects* of the metals industry are serious as well, though less often analysed. They are most severe in densely populated developing countries.

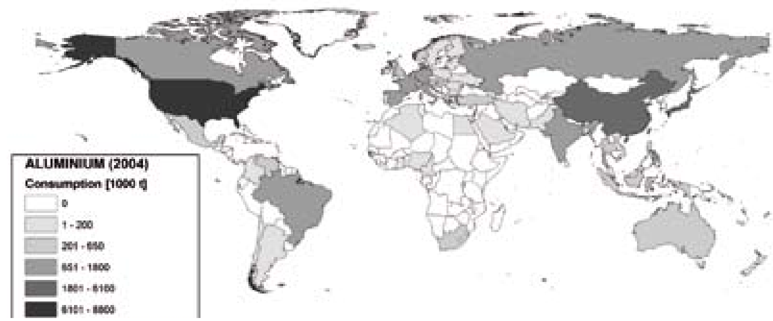
What was done?

One focus of the case study was to build up a database to consolidate existing data covering:

- historical time series on production and consumption of the selected materials, for roughly 100 countries in the world that represent some 90 percent of the world's population and GDP; and
- traded commodities.

To get some insights into trade flows, we focussed on the European Union and established a *dataset on imports and exports of metals and derived products* differentiated according to trading partner. The traded products include basic commodities, semi-manufactured and high-manufactured goods of the particular metals and thus cover different stages in metal processing. Finished goods were not considered





in the analysis because of the unknown mix of different materials, which would distort the material balance approach. Data for European trade flows were taken from the Eurostat trade database 'Comext'.

Findings

Total metals consumption in the EU increased constantly from 1970 to 2004 by 130 percent for aluminium, 50 percent for copper, and 60 percent for zinc. Figures for per capita consumption reveal the same trends: aluminium consumption doubled from 10 kg/capita to 20 kg/capita, copper increased from 7 to 9 kg/capita, and zinc rose from 4 to 6 kg/capita. Only cadmium consumption decreased. The decrease over the period was from 24 to 14 kg/capita.

To give a more detailed example, Bauxite production and Aluminium consumption patterns with a focus on EU-15 are discussed here. As on the global level, aluminium consumption grows at the same rate as economic value-added is produced. No decoupling is visible for this metal at all, in contrast to what one would expect for an industrialised region. Unlike consumption figures, bauxite extraction follows a decreasing trend from 5 million tonnes in 1970 to 3 million tonnes in 2004. The only EU-15 country, where bauxite is still extracted is Greece. Bauxite mining in France, Italy, and Spain ended during the 1980s. The next steps of processing, i.e. alumina production as well as production of aluminium, is nevertheless growing from the 1970s to the 1990s, after which production levelled off. Despite growing aluminium production, total consumption already exceeded domestic production in the 1970s. The resulting demand for bauxite and also for processed alumina and aluminium is met by increased imports from other world regions. Aluminium imports to the EU-15 come mostly from Africa and to some extent Australia and New Zealand.

The following conclusions can be drawn from analysing the data:

1. Absolute material use: There is no decrease in use of aluminium or copper, either on the global scale or in the EU.
2. Recycling: The recycling shares are growing and thus relieving uses of natural stocks. However, recycling rates are growing slower than overall consumption.
3. Sourcing: There is a clear trend towards decreasing raw material extraction and concurrent increasing imports of higher manufactured products in the EU.
4. Total waste generation: Few major technological innovations were developed over the period covered by our analysis to provide for a reduction of related waste flows. Continuing depletion of natural stocks is resulting in the mining of ores of increasingly lower grade with higher amounts of waste flows.

Main findings from the statistical analysis are given here for the example of copper. This analysis focused on the relation between copper use, developmental stage and economic dynamics. A cross-country correlation analysis was performed for all countries and each year on the relation between copper consumption levels and income levels. There are three clear groups of countries:

1. Countries where copper consumption levels strongly correlate with income levels.
2. Countries that maintained a persistent low copper consumption level at various levels of income.
3. Low income countries that had a large range of copper consumption levels.

Over the years only a few countries changed group; for the vast majority the pattern remained stable for more than 30 years.

A stakeholder meeting with the international copper association was held, where our findings regarding copper were presented and discussed in terms of the implications for future sustainable use of metals.

European level

The European strategy on a sustainable use of resources aims at a double decoupling; a decoupling of economic growth from resource use and a decoupling of resource use from its environmental impacts. At present DG Environment envisages developing targets and indicators for both resource productivity and environmental impacts of resource use. Whereas an indicator for aggregated environmental impacts of resource use still has to be developed, indicators for resource use itself are established and available. The challenge for scenario analysis lies in integrating parameters for resource use into appropriate econometric models (see also p. 35-38).

What was done?

Together with colleagues from Cambridge Econometrics we integrated material flow data for all European countries in their E3ME model, which basically involved a sectoral disaggregation of domestic extraction and physical imports.

The following four scenarios (up to 2030) will be modelled and analysed with respect to their impact on material use, energy use and CO_2 emissions:

1. *Ecological tax reform:* increasing taxes on resources and CO_2 emissions, decreasing taxes on labour (see also page 14).
2. *Time instead of money:* Gains in labour productivity are paid back to the labour forcepartly in money, partly in time.
3. *Lifestyle changes:* Different exogenously introduced changes in lifestyle (expressed in different private consumption patterns) are analysed with respect to their effects on resource use.
4. *Means and feasibility to achieve dematerialisation targets:* The fourth scenario combines the previous ones and will investigate if, under which conditions, and by which combinatio of instruments, specific dematerialisation goals (e.g. Factor 4) can be achieved.

Overall these scenarios aim at identifying promising points of intervention that could have a significant impact on future resource use levels.

National Level

Within this case study there was a focus on the Czech Republic. In collaboration with the case study on environmental technology the extraction and consumption patterns of this new EU Member State were analysed. The results were discussed with stakeholders and used the modelling of the case study (see pages 35-38).
The experimental stage of this sub-case study focused on quantification of direct and up-stream energy requirements and carbon emissions related to the production system in the Czech Republic. These flows were then linked to domestic final demand for commodities, as well as to their exports and to imports. The quantification of total energy requirements and carbon

emission flows was carried out for 1999 and 2003.

Results show that while total energy requirements for domestic final demand remained stable between 1999 and 2003, there was an increase in energy requirements for exports by approximately 9 percent. An increase in energy requirements for total final demand, which amounted to 4 percent between 1999 and 2003, was therefore driven by consumption abroad rather than by consumption in the Czech Republic.

Total energy requirements of imports went up by 6 percent. This suggested an increase in pressure exerted abroad by the consumption in the Czech Republic between 1999 and 2003. As total energy requirements for exports also went up, there was a simultaneous increase in pressure exerted on the environment in the Czech Republic by the consumption of other economies. The balance between energy imports and exports remains positive and on the same level for both years. This means that, with respect to its foreign trade and energy requirements, the Czech Republic exerts pressure on the environment abroad rather than other economies exert pressure on its environment. Total carbon emissions related to domestic final demand went up by 12 percent. As there was only a very slight increase in total energy requirements for domestic final demand, this increase indicated that more carbon-intensive energy carriers were burnt when producing commodities for domestic final demand in 2003 compared to 1999. The opposite seems to be true for exports and imports, as in spite of an increase in energy requirements, total carbon emissions went down by 7 percent for exports and almost 40 percent for imports.

Prospects for ISA

The results of this study provide the background for the scoping stage of a full-scale ISA. It provides the basis for scoping the unsustainability problem and paving the way to identify possible solution options to explore with stake-holders, concerning how the key relationships in this area might be manipulated, for example through substituting for some metals, reducing their use in some applications, improving recovery rates and recycling rates and reducing demand by selling services rather than selling products.

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ISA of Water: The Ebro River Basin

The Ebro River Basin is located in the North-Eastern part of the Iberian Peninsula. It is the largest hydrological basin of Spain and flows into a delta that represents one of the richest wetland areas in the Mediterranean basin in terms of biodiversity. This case study studied this basin within the context of changes occurring in Spanish water policy mainly during the last two decades.

One of the most outstanding conflicts regarding Spanish water policy was related to the National Water Plan (NWP, presented in the year 2000 and approved in 2001), which proposed a water transfer from the Ebro river basin mostly to the South for intensive agriculture and coastal tourism. The NWP was highly criticised in Spain for not taking the social and ecological impacts sufficiently into account, and because it framed the issue merely as an economic demand/supply optimisation question rather than considering systemic aspects of the river basin and landscape management. It was seen by a large sector of the Spanish population as a continuation of the 'old hydraulic paradigm' or 'culture', based on an endless increase of water supply, rather than for meeting local populations' needs. The NWP caused a wide social upheaval, manifested, for example, in the largest demonstrations on socio-environmental issues taking place in Spain for over two decades. A wide range of stakeholders built a new cross-cutting social movement and coordinated pressure group, named the 'New Water Culture' (NWC), which was intended to change the main water management orientation that had dominated water policy in Spain during the 20th century. This traditional approach was characterised by building large infrastructures (some 400 dams during Franco's period) and increasing water supply, as well as by a perception of water policy as a sectoral and centralised matter. In contrast, the NWC movement emphasised the need to manage water demand and allocation and thus adapt uses and users to existing water availability, e.g. through pricing and reuse, integration of water into landscape planning and promoting the engagement of stakeholders in the management of river basin resources. After a successful campaign by pressure groups working in concert at local, national but also at European level, the National Water Plan was finally withdrawn in 2004. This has been widely understood as the beginning of a transition in water policy not only in Spain but also elsewhere.

Monument to the People in Defence of the Ebro

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What was done?

The study examined the New Water Culture movement within the transition theory framework (see pages 40-42) and in particular, the role played by culture and/or by biophysical constraints in triggering transitional changes in the water domain. The focus was on the review of a selection of available assessment tools and methods and the development of both a World Cellular (WC) model and a new Integrated Sustainability Framework (ISF) to represent and support niche sustainability developments within the domain of water in a social learning mode. The World Cellular Model and Framework aimed not only to represent the complexity of social-ecological relationships of the Ebro river basin, but also to contribute to the empowerment of relevant pro-sustainability agents.

The WC model and ISF are structured in a way that provides a total system perspective of water uses and of the stocks and flows of water using a linked agent-based model. Policy trade-offs and alternatives are assessed with regard to the impacts (both positive and negative) on other agents rather than between abstract economic, social and economic domains. So the main focus is not so much on defining 'what' the problem is, but rather on 'who' has agency and responsibility for its resolution. The WC framework also includes a user-friendly interface in the form of a 'water game' to facilitate a structured dialogue among stakeholders and to support reflexive learning. The game contributes to the understanding of agents' motives and to help stakeholders to become aware of the social-ecological constraints of their actions and wants. It also contributes to agent engagement and to the reframing of perspectives on the unsustainability problem; it can be used in the experimenting stage of the ISA cycle to simulate situations that cannot be carried out in real time. In short, the WC Model and the game aim at empowering sustainability-related agents, illustrating differences in the agents' competences, and uncovering issues regarding the fairness in power and resource distribution (see page 30 for a screen-shot of the game).

What ISA can contribute to current European water policies

ISA provides a structured framework that permits the integration of different sources of knowledge in the process of framing, envisioning and elucidating socially and ecologically robust strategies, pathways and system interventions toward sustainability regime transformation. ISA could potentially be very useful for European water policies, which are not yet taking a fully integrated systems-based approach to sustainability for various reasons. The use of ISA within the water policy domain can provide agents and policy makers with a new vision, derived from a structured process for regime change. It can also contribute to the setting of voluntary limits to social-ecological growth and to redirecting patterns of development, and, thus, to increasing the long-term opportunities for improving water security and human welfare. ISA provides opportunities to make coherent narratives that integrate multiple domains, scales, problems, languages, and institutional arrangements. The application of ISA creates opportunities to help coordinate the actions of different agents to achieve patterns of development that are compatible with the long-term changes occurring in the social-

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ecological system as a whole. In the context of the Ebro river basin and other river basins in Spain, a transition was underway before the start of the MATISSE project. However, by deploying ISA it becomes easier to identify the current status of the transition process and provide appropriate support that may empower relevant agents and catalyse the process. Importantly, there are clear opportunities for ISA to play similar roles in identifying, structuring and supporting other niche developments in the domain of water management.

What was learned?

An important insight from the first iteration of the ISA cycle was a vision from stakeholders of sustainability as a situation in which relevant agents continuously learn to collaborate for the common good. This does not mean that all actors have the same set of goals and interests that drive their actions, or that all of them share the same world-views and ideas about the future. Rather, it means that the different perspectives of the future are not necessarily completely at odds with each other and that a certain degree of complementary and positive synergies can be found among them.

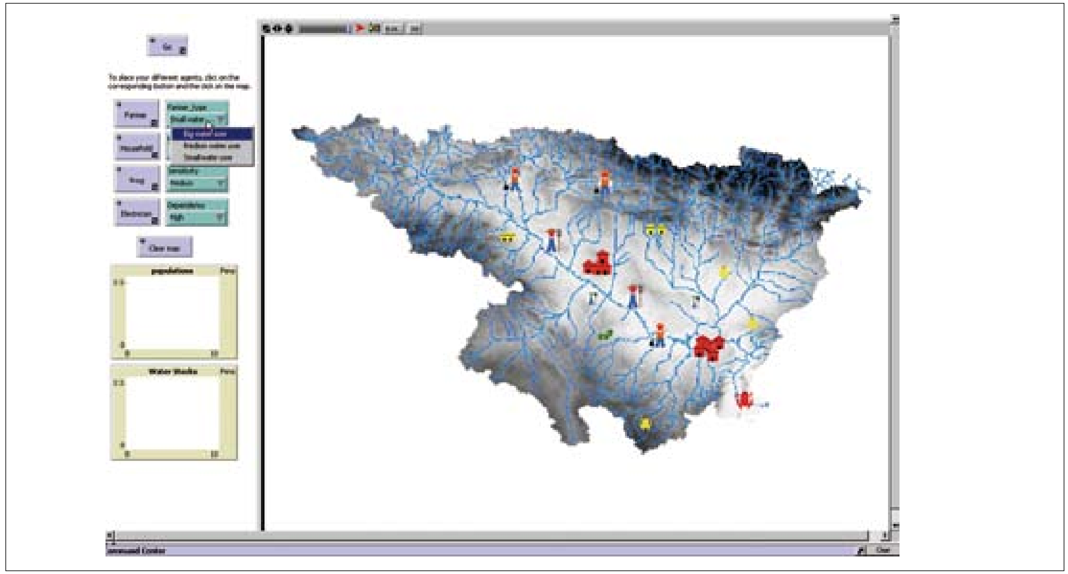
However, the second ISA iteration showed that in order to achieve substantive sustainability outcomes, collaboration among agents is not enough; agents also need to transform their practices. This result was obtained mainly by the application of an extended version of the game called the Water Transition Play. Transforming agents' behaviours and actions depends on building strategies that can appeal to the various agents and on building trust between agents. This is not something that can be achieved easily or in a short time frame, but depends on securing agents' commitment to the search process.

Our application of ISA for the case of water has allowed us to better identify the key elements that drive current unsustainability in the domain of water and beyond, not only from an 'expert' perspective but, more importantly, from the perspective of the 'people of the context'. The ISA deliberative processes can open up new debates and improve the capacities for greater awareness and control over the negative consequences of different policy alternatives and measures. Our procedure contributed to the identification of policy options. However, further research is needed to understand and assess to what extent these options can be implemented in the policy process.

ISA water models and tools can help to improve the understanding of the total system under consideration thus to assess the conditions under which transitions occur. However, the roles of ISA models and tools go beyond simple systems' representation and include agent empowerment

for transformation. In order to achieve this, and to support transitions, current models should provide easy interfaces, be more malleable and interactive, and better integrate the social dynamics and stakeholder concerns. The water case study has explored this new modelling approach with the development of the World Cellular Framework and gaming interface.

This case study also showed that language is a key element in overcoming the persistent problems of unsustainability, and in particular there is a need to develop a shared language among experts from different specialisms and among stakeholders that is able to bridge the divides between economics, natural sciences, and ethics. Hence, together with the World Cellular Model, we developed and implemented an original conceptual framework to support the making of a sustainability narrative. We developed and used a framework called SEIC (Structure and institutions – Energy and resources – Information and knowledge – system Change) to integrate languages from different sources and backgrounds. Key elements included in this conceptual and linguistic framework concern time and scale, which we use as cross-cutting themes. We aimed at developing a relational framework to explore sustainability and its meaning, which could be made operational as an easy-to-use model able to support the development of systemic narratives about transition processes.
In this project, ISA has been performed as a basic research experiment. But at the same time, the integration of different sources of knowledge has broadened our understanding of the essential components of sustainable development and has enormously enriched our assessment and depiction of the whole system dynamics. We conclude that a precondition for the successful use of ISA is a common agreement by those engaged in policy making that strategic structural change is needed. The success of ISA for a certain project does depend less on the environmental or sustainability problems encountered and more on the sincere willingness of agents to engage in a process of system transformation.



Screenshot of the Water Transition Play

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Sustainable Transport: The Hydrogen Case Study

The use of hydrogen as an energy carrier for the transport system has been discussed and tested in research niches for many years. High oil prices, the growing awareness that this will not be a temporary situation and the strong dependency of the European transport system on fossil fuels (more than 97 percent), which raises the issue of the security of energy supply for transport, provokes the search for alternative primary energy sources, new fuels and new technologies for the transport system. In addition, today's transport system causes other adverse impacts like greenhouse gas emissions, other forms of air pollution, transport noise, and accidents.

One of the alternative energy carriers for transport is hydrogen. It can be generated from a number of different primary energy sources, both fossil and non-fossil. These would improve the security of energy supply for transport by increasing the diversity of potential feedstocks and widening the range of geographical sources. Depending on the production pathway of hydrogen, the emission of greenhouse gases can be reduced or completely eliminated. Using hydrogen in fuel cells would solve the problem of air pollution, at least at the point of use, but potentially also at the point of production. Road transport noise in urban areas would be significantly reduced.

Of course, not all (environmental) problems of transport could be solved by hydrogen. For example, the land-take for transport infrastructure, the maintenance of a large and ageing infrastructure network and the congestion issue will not be influenced by changing the energy carrier driving the transport system.

What was done?

This case study analysed the sustainability of a possible shift of the European transport system towards the use of hydrogen as an energy carrier from a stakeholder perspective and a model-based perspective. The first iteration of the ISA-cycle included stakeholder engagement to obtain different perspectives on sustainable transport, modelling scenarios with the ASTRA model and learning from the experiences for the second iteration. ASTRA (Assessment of Transport Strategies) is a system dynamics model generating time profiles of variables and indicators needed for policy assessment. ASTRA runs scenarios for the period 1990 until 2030 using the first twelve years for calibration of the model. The ASTRA model consists of eight modules, covering population, macroeconomics, regional economics, foreign trade, transport, environment, vehicle fleet and welfare. The model region is EU-25. The first ISA cycle showed that ASTRA is well suited for the analysis of sustainability impacts, but that extra tools would be needed to explore the relationships and processes that will be important for analysing transition dynamics.

For the second iteration ASTRA was extended to assess the prospects for – and environmental and economic impacts of – a transition to alternative fuel vehicles (including hydrogen fuel cell vehicles). Furthermore a new system dynamics ISA-tool was developed to assess the prospects for a hydrogen transition within transport, with a focus on economic policy analysis and exploring the co-evolution of fuel infrastructure build-up and vehicle development. Also a transport technology application of the

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generic transition model (see pages 40-42) was developed for an assessment of a hydrogen transition within transport in the context of broader technological change in the system. The new system dynamic model and the transition model were applied in a case study for Germany.

Another important step of the second cycle was the link to other case studies and model activities. This included the modelling of platinum use in hydrogen vehicles (see pages 19 - 22) and possible competition in the use of biomass (see pages 39 - 40).

Model results

The ASTRA results for the EU-25 show that a transition to hydrogen transport fuels would have positive economic and environmental impacts: an increase in GDP, employment and investment and growth in a number of sectors (electronic, chemical, mechanical, automotive) associated with fuel cell vehicle (FCV) technology. Other sectors are negatively impacted, however, due to expenditure diverted away from other consumer goods (e.g., food, textiles, paper, plastics and catering) towards transport consumption. CO_2 emissions from driving activity decline by -4.6 percent by 2030; and there are lower levels of fossil fuel imports (see table below).

Using ASTRA to model vehicle sales, the prospects for — and economic and environmental impacts of — a transition to low-carbon vehicles were assessed. The results indicate that a carbon policy would lead to reduced support for conventionally powered vehicles (Internal Combustion Engine – (ICE) vehicles) both petrol and diesel, and enable a take-off of hydrogen vehicles by 2030. By 2050, hydrogen vehicle sales would account for 20 percent of the total European market. Under baseline and carbon tax scenarios, hybrid and LPG (liquified petroleum gas) cars see initial, limited support around 2000, but do not take off. Under both scenarios, other biofuelled cars (fuelled with bio-ethanol) and Compressed Natural Gas cars take off around 2010, but begin to decline after 2020. Overall, we conclude that due to the policies changes of the vehicle fleet composition as well as the types of fuel consumed are substantial. The carbon tax would have little impact on the economy (up to +0.3 percent of GDP in 2050), but would lead to substantial reductions of CO_2 emissions from transport.

Economy	GDP	Employment	Investment	
Impact of H_2 cars	↓	↑	↑↑	
Resources	Gasoline	Diesel	Import of natural gas	Platinum
Impact of H_2 cars	↓↓	↓	↑	↑↑
Transport emissions	CO_2 driving	CO_2 upstream	CO_2 total	NO_x emissions
Impact of H_2 cars	↓	↑	↓	↓

Source: ASTRA scenario results

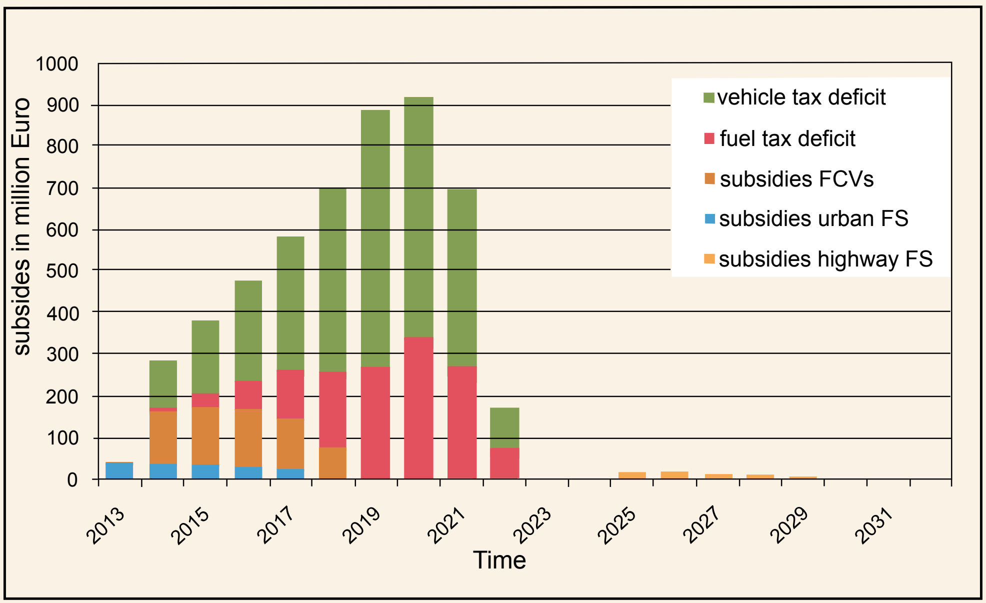
Summary of major quantified impacts of introducing H_2 vehicles in the EU-25 with an exogenously given market penetration of H_2 vehicles

The **hydrogen diffusion model** shows for Germany that, since a transition to hydrogen as an energy fuel in the transport sector is a disruptive innovation, relevant support is needed in different areas for a limited time period; in an optimistic case, for around eight to ten years. In particular, support is needed in three areas:

- Subsidies for vehicles (highest support necessary)
- Subsidies for at least 500 filling stations (in urban areas and at highways)
- No VAT and no taxes for hydrogen in the introduction phase(first one million FCVs)

The figure on the right shows model results regarding the levels of support needed for fuel cell vehicles and filling stations for one of the scenarios that was modelled. After a period of support, the hydrogen vehicles have a lower total cost than conventional vehicles. This assumes that the cost reduction targets of hydrogen vehicles are reached, which depends on learning curves. It is important to reach a certain level of market penetration of hydrogen vehicles and infrastructure build-up very fast; otherwise hydrogen would fail. The overall financial support is much lower in the case of fast market penetration than with slow market penetration. However, even with massive financial support, only one-third of all vehicles would be FCVs by 2040.

The Transport Technology Transition modelling for Germany shows biofuels-based and hybrid-electric technologies dominating in the medium term, before hydrogen takes off in the longer term (see also pages 41-42). This is consistent with the literature on technological development within the transport sector.[1, 2] Crucially, the scenario assumed no restrictions on the use of biofuels (unlike in the ASTRA model), which is why we see an overly optimistic (unrealistic) growth of this niche. It is also noteworthy that we do not include battery electric vehicles (BEVs). ASTRA results suggest little prospect (under current trends) for BEVs to take off.



Simulation results of the so-called Lead Scenario where the state assumes all financial burdens and the fuel cell vehicles are seen as perfect substitutes for conventional vehicles and the support strategy is optimized (FCVs: fuel cell vehicles, FS: Filling station).

Inputs from stakeholder involvement

Stakeholder engagement is relevant to the issue of shifting transport to hydrogen use given the complexity, ambiguity and subjectivity of persistent problems of unsustainability, such as those of transport. In this case study, two European-scale and two national-level stakeholder workshops were organised (see also pages 43-46).

The aims were to elicit stakeholders' visions of sustainability in relation to both hydrogen transport technology and transport itself and their views on viable pathways and any barriers to sustainable hydrogen-based transport. Stakeholders' input led to the reframing of the case study from a focus on a hydrogen transition to that of a wider mobility transition, as well as the definition of sustainability criteria for sustainable transport/mobility and pathways to sustainable hydrogen-based transport. Feedback on model design and experiments was also provided.

Results reveal a wide consensus that sustainable transport requires diversified and renewable primary energy supplies and diversified delivery of mobility solutions. International competitiveness is a serious economic, social and political concern. Hydrogen fuels and electrochemical conversion technologies could contribute to sustainability, but outcomes depend on how and where hydrogen is produced, the cost and technical performances of technologies, how these are improved, and whether the technologies induce new resource or sustainability constraints.

The views of the experts highlighted a need for both technological and non-technological measures to tackle rising transport demand. Citizen stakeholders supported the view of experts that transport in its current form and ongoing trends in the sector are unsustainable and that a 'business-as-usual' approach should be rejected. They identified similar environmental, social and economic criteria for sustainable transport and located responsibility for fostering sustain-able transport primarily with governments. In contrast to experts, citizens tended to place more emphasis on behavioural change policies than on transport technologies. Moreover, citizens considered amenity aspects of transport to be most important, while experts stressed the technological issues.

Conclusion

A sustainable solution for the transport sector is becoming increasingly linked to a sustainable solution for the energy system. Both depend on a diversification of energy sources and modes of delivery of final energy services. Both also require sustainable sourcing of fuels. Although hydrogen used in fuel cells producing electricity to propel electric engines appears to provide a promising option for a sustainable transport system, it still has to overcome significant technological barriers and it must compete with other plausible solutions. The barriers also apply to competing technologies and it is unclear yet which technology will break through its barriers faster and how competition between technologies will play out. There is also international competition to consider. An important aspect from a European perspective concerns the economic and trading implications of being (or not being) in the forefront of hydrogen technology development. For these reasons, investing in hydrogen research, technology development and demonstration projects may also be justifiable as a hedging strategy in the event that breakthroughs are achieved in hydrogen energy chains and mobile fuel cell technologies that lead to hydrogen emerging as a dominant technology in the future.

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Environmental Technological Change: The Czech Republic

R&D and fast market diffusion of resource-efficient technologies will be important contributors to sustainable development transitions. This MATISSE case study focused on the transition of economies in connection with the adoption of technology. Starting from a more general development pathway examined in the first iteration of this ISA case study, a possible introduction of environmental tax reform was the focus of the second iteration. Besides analysis on the European scale, the case study focused in particular on the Czech Republic.

The use of fiscal measures to stimulate change away from environmentally-damaging behaviour is already well-established. In contrast to environmental taxes the practice of environmental tax reform (ETR), in which the overall tax burden remains unchanged but taxes are restructured (for example to be higher on resource use and waste generation and to be lower on employment and income), is less widespread. To date the focus of implementing environmental taxes has been most common in the areas of energy and transport followed by waste and water. Taxes are applied in some countries in other limited areas, such as pesticides and fertilisers, packaging, resources, and chemical waste.

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What was done?

Although starting the analysis on the scale of EU-25, this case study focused on the Czech Republic and the process involved several meetings with stakeholders in this country. Initial work and discussions aimed at providing stakeholders with information on underlying trends and indicative impacts that technology might be able to achieve in relation to sustainable development. An alternative development scenario was designed and implemented in E3ME, a multinational dynamic model of the EU-25 (further information on E3ME can be found at: www.e3me.com). Comparing the outcome of the scenario with that of the MATISSE baseline provided an initial indication to the stakeholders of the extent to which investment in technology (in a broad sense) can contribute to their vision of a sustainable future.

The scenario developed fulfilled an important role in providing an initial quantification of underlying trends and possible impacts, which helped to focus areas of concern and possible development paths. The discussions with stakeholders reinforced their emphasis on material use (and the potential to produce absolute dematerialisation in the future) and social sustainability (especially reducing, rather than increasing, the well-being differential between the urban and rural areas), as important for sustainable development.

To provide more focus on potential drivers of change the discussions with stakeholders suggested that a scenario exploring the effects of an ecological tax reform (ETR) would be of interest. This coincided with the topic of ETR returning to the centre of the political debate in the Czech Republic.

The impact of the proposed development pathway was modelled through a series of sequential scenarios, each of which examined the effects of a particular driver for change in the context of other changes that have been modelled. The scenario analysis used E3ME.

In summary these scenarios involved

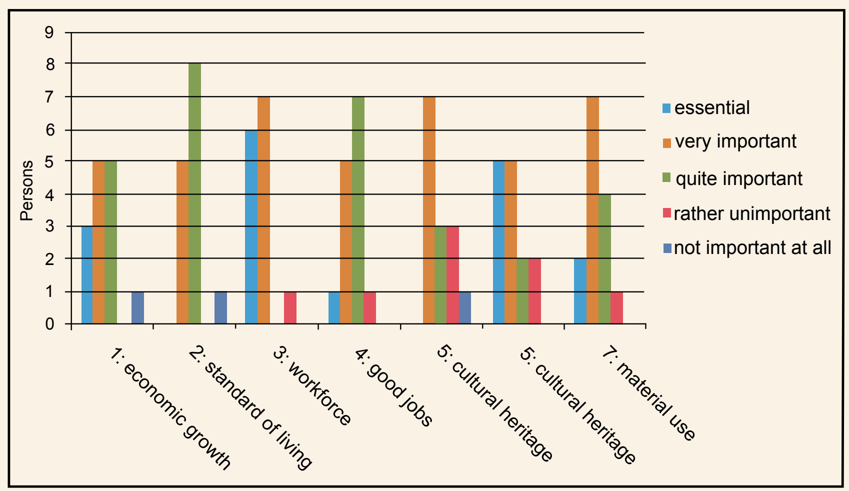
- the introduction of a revenue-neutral carbon levy on energy throughout the EU-25;
- increases in business R&D (stimulated by the increased cost of energy); and
- improved material use efficiency.

A Vision for the Czech Republic

The pathway for the Czech Republic is built on the assumption that it actively embraces environmental tax reform as a means to limit the potential environmental impact of future economic growth. It is keen to achieve far-reaching efficiencies in resource use and for efficiencies to be improved in many economic sectors. The push for more active policies in this area results from the desire to encourage competitive businesses and environmental responsibility, but also from a belief that more far-reaching environmental tax reform will, in time, become the norm within the EU and that by being at the forefront of the movement, the Czech Republic will achieve longer-term benefits for the economy.

Specifically, the vision for the Czech Republic focuses on reduced demand both for non-renewable raw materials (from all sources), and for commodities that have high environmental costs (whether associated with their production or use).

Therefore, in addition to implementing taxes on energy in an attempt to reduce demand and promote the uptake of energy-efficient production techniques, the Czech Republic also introduces a materials input tax on the use of certain raw materials and a materials tax on the use of key manufactured commodities by certain sectors that are environmentally-damaging, where the environmental burden relates to more than the sourcing of its material inputs or the (potentially) high use of energy in its manufacture.



The participants of the third workshop in Prague were asked to rank seven elements of the Czech sustainability vision according to how important they seem to them. The results are shown in this figure.

The issues relating to the introduction of ETR to areas other than energy are expanded on in more detail below.

Results of ETR Scenario Modelling

The first scenario included a levy from 2008 as a flat rate charge on the carbon content of fuels. The levy is set at 200 euros per tonne of carbon (55 euros per tonne of CO_2). The purpose of the levy is twofold: to raise the price of energy and thereby encourage improved efficiency in its use, and to encourage users to switch to less carbon-intensive sources of energy. The levy is assumed to be revenue-neutral for each country, with the revenues raised matched by an offsetting reduction on social security payments by employers.

The impact of the levy and revenue recycling is to raise GDP in the EU-25, though the overall impact is relatively small (by 2030 GDP is around 0.5 percent higher than in the baseline projection). The impact is greater within the EU-10 than EU-15. The overall impact on employment is positive, though as with the impact on GDP it is relatively small (0.5 percent, 1.2m people in EU-25 by 2030), and the largest relative impact is within the EU-10. All countries (with the exception of a couple of the smaller EU-10) see positive employment effects. The overall demand for energy in EU-25 is almost 10 percent lower in 2020 and 15 percent lower in 2030.

The reductions are slightly stronger in the EU-10 than the EU-15.

	Energy tax	Increased R&D	Material efficiency	Total
GDP	1.0	7.0	-0.6	-7.5
Employment	7.0	2.0	-3.9	-1.3
Energy	-10.7	-5.7	-2.9	-28.8
GHGs	-16.7	-7.1	-3.2	-25.6
Material use (TMR)	-0.9	1.5	-6.6	-6.1

Summary of scenario impacts: Czech Republic, in % of baseline in 2020

The second scenario assumed that introducing a carbon levy indirectly makes businesses raise the level of their R&D efforts. This would be in an attempt to lower their own costs by improving their processes, as well as to improve the energy-efficiency characteristics of the products they produce. For the EU as a whole it means that business R&D spending would represent around 2.5 percent of GDP. As a result, R&D is some 40 percent higher than in the baseline scenario in both 2020 and 2030.

The overall impact of the additional R&D is to raise GDP in EU-25 by 2.5 percent by 2030. The largest relative impact is in the EU-10, where GDP is around 5-5.5 percent higher. The employment impact amounts to 1 percent (some 2.7 m jobs) by 2030. Most of these net additional jobs are created in the EU-15. There is a relatively quick impact on energy use, with energy use in the EU-25 10 percent lower by 2010 as a result of the additional R&D.

The earlier scenarios have shown that while a focus on raising the cost of energy, or on improving the energy efficiency of production can have a favourable impact on the material intensity of an economy, it does so in a limited way. This is typically either by reducing the extraction/use of energy products (coal, oil) or by focusing additional growth on the less resource-intensive parts of the economy. There is little impact on the more general resource use and requirements of the economy.

In the third scenario it is assumed that an additional indirect benefit from the introduction of the carbon levy, and the focus this gives to using the energy resource effectively, is that it focuses attention on the efficient use of all resources. This results in a variant on the so-called 'Aachen scenario' occurring, where manufacturing and construction sectors achieve a 20 percent reduction in material input costs through the widespread implementation of currently-known technologies and best practices by 2015 (i.e. achieving efficiency improvements of 2.2 percent per year).

In this scenario, GDP in the EU-25 is lower than in the absence of the stronger resource efficiency trends, by around 3 percent by 2015 (the year in which the main additional resource savings are achieved) and by around 2.25 percent in the long term. In the short term, the impact is mainly felt in the EU-15, the economies that will be supplying most of the manufactured inputs for which demand is being reduced as a consequence of the improvements in resource efficiency. There are important differences in the impact that the scenario has on different indicators of economic output. While the impact on GDP is negative there is a positive impact on value-added. The impact on GDP varies greatly by industry and thus by country. Many countries in the EU-10 see a positive GDP impact. As a result of the lower levels of economic output (as against value-added) in the EU-25 in the scenario, the use of energy is lowered by 5-6 percent from 2015.

The table on the previous page summarises the impact of the scenarios on the Czech Republic in terms of several 'headline' indicators of sus-tainable development. Together, the measures result in a higher level of economic output, though slightly lower employment, and re-duced levels of energy demand, GHG emissions and resource use.

Tensions

There are important issues and potential tensions for sustainable development raised by each of the scenarios considered. Concerning material use, it was shown, for example, that improved resource efficiency can result in lower output but higher value-added, that the scale of impact on material use can reduce over time, and that higher R&D will not necessarily lower over-all material use. The distribution of impacts var-ies within the economy (for example, between sectors) and between economies, which may lead to difficulties in getting such policies as have been considered widely accepted unless they are a part of a broader policy package. For example, economies are significantly affected if they have a dominance of manufacturing, while there is generally limited impact on pub-lic services. Equally the impact on an industry can vary between countries as policies have an impact on the relative competitive position of sectors between countries. Specific focus may be needed to increase the likelihood that such policies will lead to socially sustainable growth. Overall, a net increase in employment is not guaranteed. This, also, suggests that a broader package of measures may be needed.

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Available at: www.matisse-project.net

Developing and Linking Tools for ISA

Within an ISA cycle, combinations of tools are used to develop and test the visions in terms of con-sistency, adequacy, robustness and feasibility. Further, they are used to explore the implications of policy options and trade-offs between different pathways.

In the MATISSE project the work on tools had two distinct foci. The first is a focus on scenarios, which are covered elsewhere in this brochure (pages 11-14). The other is on models, in particular on simulation and conceptual models, both existing and new: *Interlinking and improving existing modelling tools*. This involves the use of a portfolio of existing Integrated Assessment (IA)-models and other models in a more creative and coherent manner, while also linking, adjusting and improving them. *Developing prototypes of new ISA-modelling tools*. This involves the development of new conceptual models and modules that are based on a new paradigm that is rooted in complex systems theory, evolutionary economics and multi-agent modelling. The aim is to develop stakeholder-oriented, explorative, and more integrated ISA-tools.

Existing modelling tools

Computer modelling tools are simplified representations of complex real-world phenomena. They are based on scientific theory and have a formal, mathematical structure. Existing modelling tools have been applied to a wide range of sustainability issues and have been used for policy-relevant sustainability assessments. These include biophysical models, socio-economic models and integrated modelling approaches[1].

Within the ISA cycle of scoping, envisioning, experimenting and learning, computer simulation models are especially useful in three stages:

- Applications of certain models in previous ISA-type assessments can help in the scoping stage of a sustainability assessment to define the problem, pinpoint its key drivers and causal chains and identify potential trade-offs and synergies to provide guidance on which measures could be appropriate to tackle the problem.
- Extensive scenario development and analysis with existing and/or improved models are useful in the envisioning stage to map alternative futures.
- In the experimental stage, models are used to explore the potential of a range of policy options and transition pathways to solve the sustainability issues at hand. If models from different schools can be coupled, they may provide a comprehensive and consistent framework for understanding the potential interactions between social, economic and environmental processes.
- In the learning stage, the models can be updated based on past experiences, in preparation for the next ISA cycle.

The focus is, however, on the experimental stage in which models are of crucial importance.

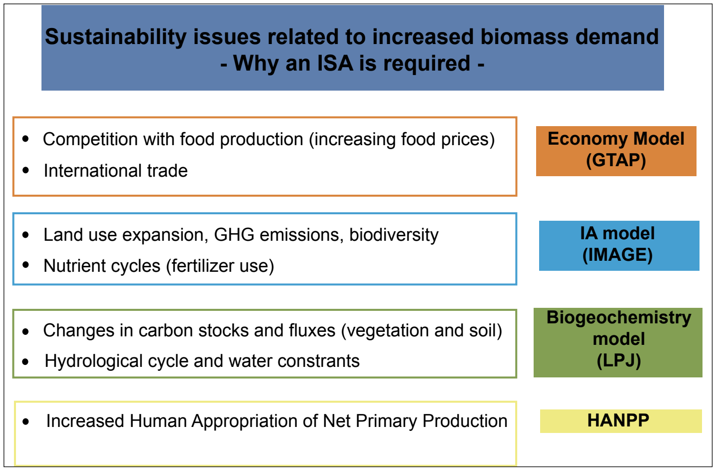
Linking existing modelling tools

An example of linking models is provided by the MATISSE efforts to define possible limits to sustainable biomass demand and supply for Europe until 2050, including global trade linkages and an array of policy options. Since increased biomass demand would have implications for biogeochemical cycles, water systems, material and energy flows, a variety of models is required and these must be linked (see next page). Four models have been linked within the MATISSE project. The results of linking the models and defining possible limits to sustainable biomass demand are relevant for the case studies on dematerialisation and sustainable mobility.

Improving existing tools

A number of improvements have been made to the E3ME within MATISSE. These include extending the model to incorporate the cost of damaging externalities from air pollution and implementing a new module that links economic activity and demand for physical materials.

The case study on Agriculture, Forestry and Land Use (AFLU) has also developed and extended models to enable them to ade-



quately represent the critical relationships linking the policy instruments designed to promote sustainability in the AFLU sector with a host of widely disparate sustainable development concerns. This has included development of a stochastic model to provide the joint distributions of the policy impacts using the expected impacts given by the deterministic models as a reference. Methodologies have been developed for measuring costs of application of policy measures. Finally an Integrated Policy Assessment tool will provide the synthesis, albeit in a reduced form, of the modelling work undertaken.

New tools for ISA

A major goal of the MATISSE project was to develop prototypes of a new generation of modelling tools for use in ISA. This is a huge task that will likely take many years to complete! In this project we decided to focus our work in particular on developing a new modelling tool that can simulate socio-technical 'transitions' in the context of pathways towards a more sustainable future. By 'transition' we refer to a fundamental change in the structure and functioning of a whole system rather than incremental changes within a current system. So the switch from sailing ships to steam ships in the 19th century might be an example of a transition, whereas gradual incremental improvements in the technology of sailing ships would not be.

We set out to develop protypes of a tool that would be able to capture the type of fundamental structural change that we postulate will be necessary to achieve sustainability (in Europe and elsewhere) during the course of this Century. To do this we first developed a guiding conceptual framework for transition modelling that provided a synthesis of available empirical evidence about previous transitions, on the one hand, and the emerging body of theory on socio-technical transitions on the other hand.

Concepts from the literature on socio-technical transitions were used to develop a structured narrative about the kinds of process involved in producing a transition. We conceptualised a transition as arising out of a dynamic interplay between a dominant (or 'incumbent') regime and set of competing niches. By the 'regime' we refer to a dominant set of practices, and also the actors and structures associated with that dominant set of practices. Thus the behaviour of many individual actors is aggregated using the concept of a 'regime'. Similarly 'niches' represents constellations of actors (and associated structures) grouped around new, novel or emerging practices.

The key dynamical patterns underlying a transition were then described by defining a minimal set of 'mechanisms' that could, in principle, reproduce the dynamical features of observed transitions. Examples of such mechanisms include that of the clustering of niches into one larger niche or the absorption of a niche by the regime in order to remove competition or gain new practices. We then developed the prototype transition model by developing algorithms for each of the identified 'mechanisms' and then allowing them to determine the dynamics of the interactions between regime and niches. In addition a background 'landscape' was described that represents the underlying, but powerful, currents that inexorably change the context of opportunities, challenges and problems facing both the regime and niches. Through differentiated response 'mechanisms' it is possible to explore how landscape 'signals' can either favour the regime, and stability, or niches, and an eventual transition.

In contrast to other assessment tools, the transition modelling tool developed within the MATISSE project highlights the complexity of interactions between actors and structures and the non-linear dynamics within social systems. The modelling framework developed in MATISSE is highly suited to exploring simulations of radical alternative futures because it is inherently able to simulate systems innovation and deep structural change. By simply including a niche in the model that has radically novel practices (and hypothesising why these may lead to success) the model simulates the dynamics of the emergence of novel societal structures in the context of transitions to sustainability during the course of this Century.

An application to the assessment of mobility in Europe

The conceptual framework for transition modelling developed in the MATISSE project has been used in initial modelling of a mobility transition. For this purpose, the regime is defined as *private mobility using petrol/diesel internal combustion engine (ICE) technology*. At time point 0 (year 2000), public transport is identified as an empowered niche. Other niches are: *hybrid-electric vehicles, biofuel-powered vehicles, hydrogen fuel cell vehicles, urban ICT-centred lifestyles, car sharing,* and *slow modes*. The model also includes simple consumer/citizen agentswho provide 'support' (a broad concept that encompasses generation of resources and 'power' through market, political and cultural processes) to the regi me and the various niches.

The consumer/citizen agents are associated with a set of 'practices'. Practices are broadly defined and include technology production and consumption, transport service provision and use, and infrastructure provision and use. The least number of practices has been identified that can differentiate the various niches, empowered niches, and regime and that impact on the environmental, social and economic mobility criteria identified earlier.

These practices are: CO_2 emissions [gCO_2/pkm]; cost acceptance [€/y]; private mobility [pkm/y]; public mobility [pkm/y]; ICT use

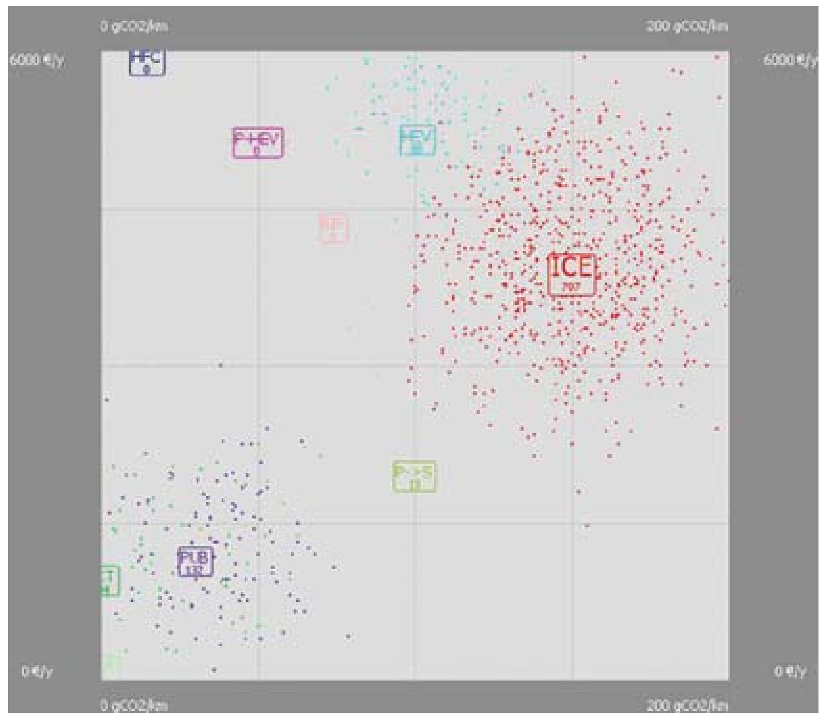


Figure 1. Screen-shot of the mobility transition model showing the 'practice space' – multidimensional axes, which represent the practices listed above; here, only cost and CO_2 emissions are shown. (Dots represent consumer/citizen;

ICE (Internal Combustion Engine) = private ICE mobility; PUB = public transport; BIF = biofuel vehicles; HEV = hybrid-electric vehicles; P>S = car sharing; HFC = hydrogen fuel cell vehicles; ICT (Information & Communication Technology) = urban ICT-centred lifestyles; SLW = slow modes).

[percent]; and built environment [mixed vs. single zone use; percent].

Figure 1 shows where consumer agents and the regime and niches are located in a chosen two dimensional subspace of the full 'practice space'. This indicates the (dis)similarity between agents according to their respective interests and activities; in this figure the difference is in respect of accepted cost and CO_2 emissions. In contrast to most economic models, consumer/citizen preferences and choices are not assumed to be static; rather they respond to changing landscape conditions and the changing power of agents. Runs of the transition model thus show how the distribution of consumers shifts across this practice space.

Landscape trends and policy interventions are considered as exogenous 'signals' which affect agents – both directly (via adaptation) and indirectly (via change in consumer/citizen practices which in turn affects support for agents). Landscape signals in the mobility application are:

- Growing consumer/citizen concerns about climate change and emissions;
- Increased use of ICT (intrinsic value of car-reduced);
- Rising fuel costs.

Figure 2 shows the dynamic output of a 'model experiment' using the initial distribution in the mobility system of consumer and niche/regime practices shown in Figure 1. This output shows system changes impacting on an indicator of the 'strength' or 'power' of the regime and niches. 'In this case, the prevailing private-ICE regime is replaced by a hybrid-electric regime; there is initial growth of the hydrogen niche after 2025. The results from this example run should not be considered a prediction, but rather an indicative simulation of radical social change processes using novel-modelling techniques. Initial tests show the model is capable of reproducing the transition patterns we expect to see, including slow development of niches, followed by a more rapid 'take-off' and then replacement of the regime, as well as failed transitions in which the regime adapts.

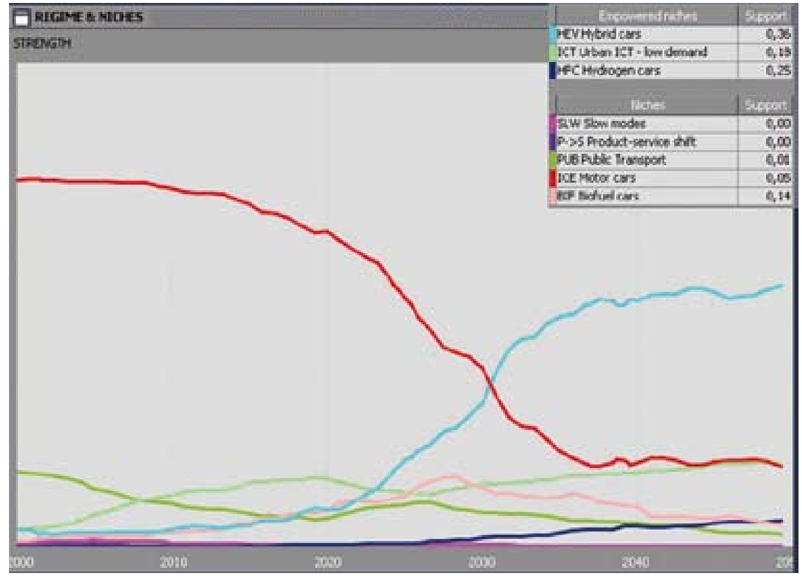


Figure 2. Screen-shot of a model run in which the prevailing mobility regime (of privately owned ICE vehicles) is replaced (by a hybrid-electric regime). The x-axis represents time (2000 to 2050); the yaxis represents the strength or power of the niches or regime (defined here as the support obtained from consumers; where support is distributed across all niches and the regime and always sums to 1).

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Stakeholder Engagement and Learning in ISA

Stakeholder Engagement

Integrated Sustainability Assessment (ISA) is a fundamentally participatory approach to sustainability assessment. Within the MATISSE project we have worked with stakeholders:

- To construct 'visions' of, and 'pathways' to, sustainable futures – that reflect the experiences, views and concerns of different stakeholders;
- To look at the different options (including options for transformation of and collaboration between stakeholders) and trade-offs between options that different pathways entail;
- To increase the mutual understanding of the science and policy and to improve the representation of the policy arena in the models we are developing;
- To test and improve participatory methods for policy assessment and social learning; and
- To disseminate our research and raise the profile of institutions involved in MATISSE.

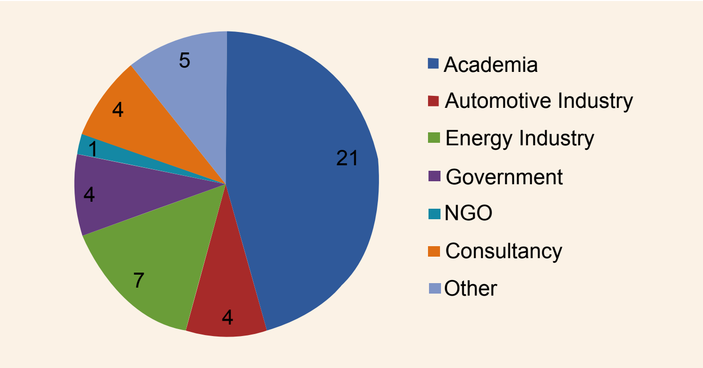
Stakeholders have been formally engaged through workshops, in-depth interviews and questionnaires. In addition we had informal contact (via email, phone and face-to-face meetings) with several relevant groups (academics, government agencies, and industry representatives) who also acted as advisors and data providers. Furthermore, a high-level advisory group, comprising senior academics, politicians and industry representatives, has given feedback on the project as a whole and advised on how findings could be applied to real-world sustainability challenges.

Topic	Activities
Dematerialisation	Workshop with stakeholders from the European Commission in October 2005. A second workshop within the framework of the EU-funded FORESCENE project in 2006.
Water	Stakeholder meetings in November 2005, March 2006 and March 2007. Final workshop is planned in February 2008. While the first workshop was only of an exploratory kind, the second and third meetings allowed carrying out several visioning and experimenting activities.
Agriculture, Forestry and Land Use	Workshop with stakeholders from the EU Commission and other relevant organisations in Brussels in October 2006.
Hydrogen/ Mobility	Two workshops were held in Frankfurt (February 2006, June 2007). MATISSE researchers conducted focus groups with and distributed self-completion questionnaires to stakeholders with interests and expertise in sustainable transport and hydrogen transport technology. Two citizens' workshops were organised in the UK as part of events to engage the public in science or environmental issues: the BA Festival of Science in September 2006, and the Norwich Forum Trust's Earth Event in March 2007.
Environmental Technology – the CzechRepublic	Two workshops were held in Prague in 2006 (April and September). A third workshop was held in November 2007 together with colleagues from the case study on dematerialisation.

Stakeholder Workshops in the MATISSE Project

As an example, the figure on the next page shows the backgrounds of participants in the first expert workshop held in the Hydrogen case study.

The questionnaires administered in several of the stakeholder workshops provided an opportunity to explore whether the stakeholder engagement methods had fostered social learning amongst stakeholders. For example, in the Hydrogen case study when asked what they had learned from the expert focus groups and citizens' workshops, in total three-quarters of stakeholders (rising to 83 percent of citizens) felt they had learnt something. The table on next page shows that in total,



Backgrounds of participants in the stakeholder workshop in Frankfurt (February 2006)

three out of ten stakeholders felt they had changed their views about the topics discussed in the groups. Responses often referred to learning about other participants' points of view, as well as technological aspects, transport in other countries, and the complexity of transport issues.

There has also, of course, been considerable learning within the project from the stakeholder activities. For example, the results of our stakeholder engagement work were vital for the scoping stage of the Hydrogen ISA. Rather than restricting the assessment to hydrogen-based transport as originally intended, it was broadened to encompass a range of technical and behavioural options for addressing 'unsustainable mobility'. We conclude that deliberative workshops provide valuable fora to co-construct knowledge and elicit informed views of citizens and experts. They can also empower these groups to participate in important social issues related to sustainability.

Learning to do ISA

In addition to reporting on learning by stakeholders, it is important to report on findings about learning by researchers in the MATISSE project. This is particularly so because ISA is in its infancy and the project was, first and foremost, a methodology development and testing project, which responds to a gap in sustainability assessment practice. ISA is intended to fill this gap and the project tested ways to implement the ISA process architecture and analytical dimensions. ISA is challenging, since it calls for capacities and features that are unconventional. Hence the most urgent task at this stage is to build awareness among scientists of these challenges and requirements.

The four steps of the ISA cycle were in principle useful in structuring the complex process of doing sustainability assessments. The scoping stage was an important step for all case studies to broaden the perspective of the issue and to put the case study into context. An important lesson seems to be that although the concept of ISA seems to be simple, logical and straightforward, it is not at all easy to apply to real life complex problems with multiple levels.

The degree and nature of stakeholder involvement varied in the case studies. Overall

Do you feel the break-out discussion has changed your views about any of the topics discussed?	Citizens (Sept06) N=14	Citizens (Mar07) N=15	Experts (Feb06) N=44	Experts (Jun07) N=24	**Total**
Yes	21%	33%	33%	29%	**29%**
No	29%	27%	56%	42%	**39%**
Don´t know	14%	-	12%	21%	**12%**
No answer	36%	40%	-	8%	**21%**
What, if anything, do you feel you have learned from the break-out discussion [workshop]?					**Total**
Total no. of responses indicating learning	79%	87%	73%	63%	**76%**

Stakeholder deliberation and learning outcomes from the workshops in the Hydrogen/Mobility case study it broadened the scope of the case studies and was an enriching experience. At the same time it was a major challenge for the case studies to engage stakeholders in the process and to keep them involved. An important lesson was that a lot of time and resources and professional skills are required to manage stakeholder processes. Also it has been a major challenge to include stakeholder input in the assessments in a consistent way.

Models and tools have played different roles in the various case studies. In some case studies models have been the central tool for analysis, in other cases prototypes of games and tools have been demonstrated to and even developed with potential users, or insights about stakeholder preferences have been used to tune new tools. An important insight gained by applying models in the case studies was that it helped the modelers to be explicit and think again about the underlying model assumptions. Team members have learned that it is not an easy task to adapt models for specific questions without challenging assumptions and model structures. And it is hard to change anything during a short-term process (in this case a research project): model development is a large investment which requires planning ahead. Finally, there was learning about needed improvements of methods and tools for ISA. This includes, for example, explicitly representing or managing trade-offs, uncertainty analysis, modelling social dynamics, linking intensive and extensive participatory methods.

Evaluation and Learning in ISA

Previous experience shows that learning in assessment processes can range from simple learning in which new knowledge is absorbed through error correction, through more advanced learning in which underlying objectives, values and norms are also modified as new knowledge becomes available, to more advanced 'learning to learn'.

Within the ISA concept, evaluation and learning are an explicit step in the assessment cycle. All sustainability assessment processes seek to generate and integrate information. The purpose of those forms of sustainability assessment most routinely used to support

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policy making is to develop evidence for immediate instrumental purposes, such as to screen policy alternatives for unintentional impacts. ISA distinguishes itself from those forms of assessment in its purpose to develop insights able to promote conceptual learning, reframing and other transformative outcomes.

ISA is designed as a participatory process through which participants gain insights, on the one hand, into the nature of contextspecific problems of sustainable development and how these are embedded in the broader social-ecological system. On the other hand it focuses on different perspectives on these problems, including how issues (and solution possibilities) are framed presently. Whereas other sustainability assessment processes focus on projecting the impacts of proposed undertakings, ISA is more concerned with improving understanding among all those engaged in the assessment process about

- key relationships in the social-ecological system and how they relate to sustainability (sustainability learning);
- how issues are framed by different stakeholders and how these framings relate to the possibilities to resolve persistent problems of unsustainable development (social learning); and
- designing pathways toward more sustainable futures (transition learning).

Of critical importance is that 'sustainability learning' takes place through a participatory process of social learning so that it includes learning about (and reflection on) one's own understanding, perspectives on and framing of the issues as well as others' understandings, perspectives and framings. This is needed in order to establish shared visions of desirable futures and to provoke a process of social capital building around the exploration of pathways toward these, which is needed for 'transition learning'.

However, there is another reason why learning and evaluation are essential in ISA. Perhaps one of the most important insights about ISA is that any specific ISA application will need to be tailored to its context of application. Both in the development of the general elements of the ISA approach and in customising ISA to the specifics of a particular application, ISA calls for a process of co-development of methods and tools involving mutual learning among those developing methods and tools and those using them. By implication the development of ISA methods and tools will have to be achieved through an adaptive 'learning-by-doing' approach involving interplay between tool developers and users supported by evaluation.

Evaluation will necessarily involve the stakeholders, since it is their experiences as users of the methods and tools and their insights into their 'fitness-for-purpose' that are needed to support adjustment and corrective action.

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Key Findings

Policy making within the European Union and in many other jurisdictions is characterised by the coexistence of several different policy agendas, which are reconciled at the operational level for each individual policy procy Impact Assessment (IA) process to highlight spill-over effects and policy conflicts. By contrast, ISA is a process that seeks ways of reconciling different agendas and concerns at a higher strategic level. This has the potential to reduce conflicts and open new development opportunities at all levels of policy-making. ISA at a strategic level and more routine institutionalised processes of sustainability assessment at operational levels are therefore potentially complementary processes.

ISA is a process for structuring dialogue and analysis about how to make progress towards sustainable development. It is appropriate for dealing with persistent problems, but not for all policy areas. Using an ISA process can help make policy interlinkages transparent and support the identification of win-win strategies.

The process can also stimulate actors from mainstream policy areas to consider **potential niche developments**. ISA enhances understanding of the complexity of (un)sustainability issues as well as the barriers to moving towards sustainability. ISA may not provide instant results in shifting policy onto a more sustainable track. But the broader, **exploratory approach of ISA**, the way the process is used and the context within which it is applied, are likely to find resonance in areas where there are persistent problems of unsustainability (e.g. energy, transport, agriculture). Following this approach, the ISA process adds to the pool of longer-term knowledge, builds relationships of trust among influential stakeholders, and potentially can create a fresh way of policy comprehension. The ISA approach also has the overall ambition to enhance **social learning**.

Achieving a greater shift towards sustainable development depends on establishing an interpretation or interpretations of sustainability in a given context using concepts such as **stocks, flows and thresholds**, including reflection on what to avoid as well as what to seek to attain. The relevant relationships, interdependencies and uncertainties can be revealed, explored and anticipated through an ISA process. These measures cover the environmental, social and economic domains.

The ISA process explores **development pathways and agency** and exposes synergies and trade-offs among multiple objectives, actions, stakeholders, time horizons and places. The process also supports the identification and mapping out of fundamentally conflicting worldviews on sustainable development. ISA can therefore be used to ensure that decision-


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making promotes viable, effective and acceptable measures, avoiding unnecessary policy conflicts and reducing problem shifting.

Integrated models exploring sustainability transitions and most economic models address different needs. Most macro-economic models are rooted in equilibrium approaches and rational actor thinking, while integrated sustainability models focus on interactions among agents and behaviours that reflect diverse and evolving rationales. It is important to understand the situations for which these different kinds of model may be used.

A transition is about radical, structural change achieved in incremental steps. Transitions can be represented by shifts of dominance among different socio-technical systems referred to as 'niches' (i.e., those systems not currently dominant) and the 'regime' the (i.e., currently dominant system), so integrated sustainability models must be able to represent agents' learning behaviours and processes of cooperation and competition between agents. Concepts and building blocks for new methods and tools have been developed and these provide insights into how transitions between equilibria might be supported and how inertias, such as path-dependent development and technology lock-in, might be overcome.

From the perspective of sustainability assessment, it appears that the **balance in investment in model development must be adjusted.** In particular, substantial investment is needed in the development of the next generation of integrated sustainability models and in capacity building for modelling the dynamics of transitions.

There is movement in the business and industry sectors as well as in civil society for a **more sustainable form of living and working.** This should open up new opportunities for ISA in the future. In turn, this should improve the longer term prospects for institutionalised (Sustainability) Impact Assessment procedures to become more effective.

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- Tyndall Centre & CSERGE, University of East Anglia (UEA), United Kingdom
- University of Durham (DUR), United Kingdom
- Wuppertal Institute for Climate, Environment and Energy (WI), Germany

Abbreviations

AFLU	Agriculture, Forestry and Land Use
ASTRA	Assessment of Transport Strategies (model)
BA	British Association for the Advancement of Science
BEV	Battery electric vehicles
BIF	Biofuel vehicles
CAP	Common Agricultural Policy (EU)
DMI	Direct Material Input
E3ME	Energy-Environment-Economy Model of Europe
EEA	European Environment Agency
ETR	Environmental Tax Reform
ETS	European Emission Trading Sheme
FCV	Fuel Cell Vehicle
FS	Filling Sation
GDP	Gross Domestic Product
GHG	Greenhouse Gases
GTAP	Global Trade Analysis Project (model)
HANPP	Human Appropriation of Net Primary Production
HEV	Hybrid-electric vehicles
HFC	Hydrogen fuel cell vehicles
IA	Integrated Assessment
ICE	Internal Combustion Engine
ICT	Information and Communication Technology
IFS	Integrated Framework for Sustainability
IMAGE	Integrated Model to Assess the Global Environment
IPA	Integrated Policy Assessment
ISA	Integrated Sustainability Assessment
LPG	Liquified Petroleum Gas
LPJ	Lund-Potsdam-Jena (model)
MFA	Material Flow Analysis
NWC	New Water Culture
NWP	National Water Plan (Spain)
PGM	Platinum Group Metals
PUB	Public transport
R&D	Research & Development
RIA	Regulatory Impact Assessment
SA	Sustainability Assessment
SIA	Sustainability Impact Assessment
SLW	Slow modes
TMR	Total Material Requirement
VAT	Value Added Tax
WCM	World Cellular Model
WTO	World Trade Organisation

MATISSE

Integrated Sustainability Assessment (ISA) is a cyclical, participatory process of scoping, envisioning, experimenting, and learning through which a shared interpretation of sustainability for a specific context is developed and applied in an integrated manner, in order to explore solutions to persistent problems of unsustainable development. The core activity of the EU-project MATISSE was to improve the capacity for conducting ISA at the strategic level.

This brochure presents the results of the MATISSE project and addresses policy makers and stakeholders all over Europe who might be interested in implementing an ISA within their sphere of influence. It gives an overview of ISA, its tools, and how ISA is connected to related concepts. The EU-level scenarios developed within MATISSE and the case studies developed in order to test the ISA-concept are introduced as well.

SIXTH FRAMEWORK PROGRAMME

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