New Energy Externalities Development for Sustainability

Policy use of the NEEDS results

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1 Introduction

1.1 Background and rationale

NEEDS is a research project funded within the European Commission 6th FP of RTD. As such, its primary objective is to develop innovative research, and accordingly generate original scientific knowledge. The scope and scale of the targeted scientific progress is clearly described in the project workplan and further illustrated in detail in the list and through the contents of the project Deliverables.

The ambition of NEEDS however extends beyond the purely scientific realm, as the project is intended to provide direct, usable inputs to the formulation and evaluation of energy policies in the overall framework of sustainability, therefore notably taking account of the economic, environmental and social dimensions of energy policies.

Policy formulation is an intrinsically multidisciplinary affair, and NEEDS is a highly multidisciplinary endeavour, both in terms of the sectorial competencies it can rely upon (energy technologies, environmental assessment, social assessments, economics) and for what concerns the methodological approaches and disciplines on which it draws (LCA, database development and mathematical modelling, quali-quantitative methods and tools such as multicriteria analysis, etc.)

Making the most of such multidisciplinary context requires a major integration effort. The various dimensions (managerial, technical, geographical, etc.) of such integration effort have been identified at the outset1 [1] , and the project has accordingly been structured and organised so as to maximise the benefits of multidisciplinarity, both for what concerns its effectiveness (actually achieving the expected results) and its efficiency (optimal use of the available resources, including funds, data, skills etc.).

NEEDS is an Integrated Project, and its integration dimension must be reflected not only in the implementation process but also, at least as importantly, in the nature and characteristics of its products, where the main challenge is to ensure their relevance and usability by a community of non-researchers (policy and decision makers, public and private, including civil society). This ambition has prompted the design of the Guidelines for the policy use of the NEEDS results[2] .

This third and Final Integrated Report illustrates the main results achieved by NEEDS in integrating a wide range of multidisciplinary competencies, analytical methods, tools and datasets, for the generation of outputs that, in addition to their scientific value, provide usable evidence for policy and decision making. Accordingly, this Report incorporates and supplements the basic contents of the above mentioned Guidelines.

1 See in particular [Ricci 2006] - Andrea Ricci et al. First Integrated Report – NEEDS Deliverable RS Int D5.1

2 See [Ricci 2007]- Andrea Ricci – Guidelines to the policy use of the NEEDS results – NEEDS Deliverable RS Int D5.2

The emphasis is therefore on the policy relevance of results, whereas the scientific value of the project achievements is presented in the long series of Deliverables and Technical Papers (more than 200 in total) produced by individual Workpackages within the 7 Research Streams featured by NEEDS.

1.2 A Policy Oriented Integrated Project

When it comes to providing inputs that are directly useful to policy makers, a series of requirements must be considered.

Policy relevance

Despite the explicit reference to policies in the NEEDS objectives and workplan, research tends to be primarily driven by the desire to increase and improve scientific knowledge. Moreover, policy formulation requirements often evolve over time, reflecting shifts in priorities or/and the dynamics of the reference context (e.g. unexpected increase in energy prices, changes in the geopolitical context, technological breakthroughs, etc.). A realistic appraisal of the actual policy relevance of such knowledge increase therefore requires a dedicated and continuous effort, with the direct involvement of policy makers and, in general, of stakeholders outside the research community.

Ability to communicate with the policy community.

An effective interaction with the policy community in turn requires the establishment of a common language or, better said, the adaptation of the RTD language to that of the policy makers. This is the well known challenge of finding the optimal trade off between simplification and scientific integrity.

Accessibility of project results.

Immediate fruition of the project results is ensured by the abundant set of Deliverables, which provide an exhaustive account of all findings. However, use of results by policy makers - and, in general, beyond the strict framework of the project - require, in addition to language adaptation as mentioned above, that easy and direct access is provided not only to the results but also to the tools and methods to elaborate and interpret them.

Transferability and generalisation of project results.

NEEDS has developed new methods and instruments, and applied them to a wide range of configurations (different countries, different scenarios, etc.). However, in particular for what concerns the monetary evaluation of externalities associated to the energy cycle, the numerical values provided by the project clearly cannot ensure full coverage of the (virtually infinite) configurations. Stakeholders and policy makers are, on the other hand, usually concerned with the formulation of policies and measures that must address the specific characteristics of a given sectorial, geographical and socio-economic context. A correct use of the NEEDS results by policy makers therefore requires an adaptation process to ensure that the evidence made available by the project is exploited within the limits of its scientific validity.

The NEEDS approach

All the above concerns have been explicitly addressed by NEEDS, notably through:

- The establishment of a Policy Advisory Group, with the participation of a varied set of stakeholders. The PAG has met regularly to discuss policy relevance (e.g. the choice of scenarios) and provide feedback to the project advancements.

- An ambitious communication and dissemination plan, which notably encompasses
  - the organisation of a series of Fora, where large audiences of stakeholders have gathered to discuss in detail specific priority issues addressed by NEEDS, that are relevant to policy formulation and appraisal
  - the publication of summaries of the project activities, designed to ensure a higher readability than the scientific Deliverables possibly do, and therefore facilitate the circulation, understanding and use of the project results beyond the specialised RTD community
  - the maintenance and promotion of the project website, which has been designed and continuously upgraded so as to serve not only as a specialised platform but also as an open window to the outside world

- A clear open source policy, which commits the NEEDS partners, individually and collectively, to deploy their best efforts to ensure that access - not only to the results but also to the tools and methods developed within the project - is ensured at no cost and with the highest possible degree of user friendliness (e.g. on line databases), within the limits dictated by pre-existing proprietary knowledge protection and by cost coverage constraints

- A dedicated research stream that has specifically dealt with the issues associated to generalisation and transferability of results, and the uncertainties thereof. Also, systematic use has been made within NEEDS of sensitivity analysis, precisely to ensure that the inevitable existence of uncertainties does not overly hinder the usability of results by policy makers.

Over and above such built-in features, NEEDS has devised an integrated approach to maximise the policy relevance and usability of its results. As described in more detail in [Ricci 2007], this approach was built to address the following basic aspects:

- Who are the target users that might be interested in using the results of NEEDS?
- Which are the questions that can be answered by NEEDS?
- In which format and with what functionalities will the NEEDS results be provided to the users? And how will it practically be possible to access and exploit the NEEDS products?
- What will happen in the future (i.e. once the NEEDS project is over)?

2 Target users

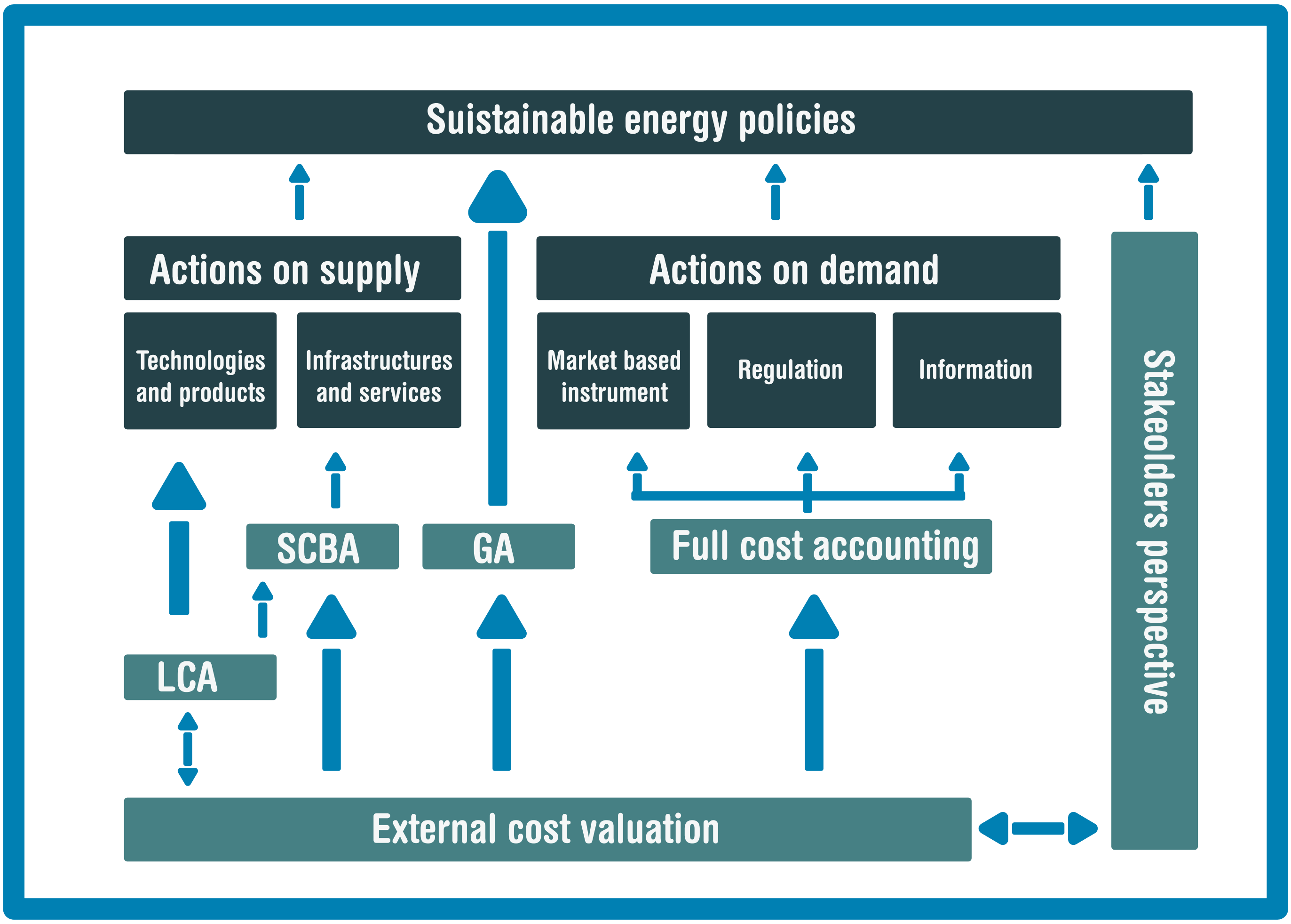
The main distinction here is between science/research users on one hand, other stakeholders (including policy makers) on the other.
Accordingly, a basic classification of NEEDS target users is presented below.

	Prevailing interest in NEEDS results	
	Science/research	Policy making
Research institutions		
▢ Energy technologies	■■■	
▢ Energy economics		■
▢ General economics and social sciences	■■■	■
▢ Environmental sciences		
Specialised consultancies (e.g. EMAS, emission trading)	■■■	■
Engineering		
Industry active in energy research	■■■	■■
Industry other	■	■
Energy utilities	■■	■■■
Service providers (e.g. ESCO)	■■	■■
European Commission		
▢ Research	■■■	
▢ Policy		■■■
EU National and local governments	■	■■■
Developing countries (e.g. re. CDM)	■	■■■
Energy agencies	■■	■■
Interest groups	■	■■■
NGOs	■	■■■
Individual citizens	■	■

■■■ Very high interest ■■ high interest ■ moderate interest

3 Policy issues addressed

The overall policy framework served by NEEDS is schematically illustrated in the diagram below.



- Sustainable Energy Policies combine actions on the supply side with actions on the demand side.
- On the supply side, decisions on technologies and products are supported by Life Cycle Assessments (LCA) and by the External Cost Valuation derived from LCA, while decisions on infrastructure and services require Social Cost Benefit Analyses (SCBA), which also receive inputs from LCA and External Cost Valuation
- On the demand side, the identification of policy instruments (whether economic, regulatory or information based) requires the knowledge of the full (internal+external) costs of energy options.
- The perspective of stakeholders can influence the valuation of external costs (especially for those externalities, e.g. of a social nature, that are admittedly difficult to quantify), and ultimately contributes directly to policy decisions.
- Green accounting (GA) practices, which allow to quantify the macroeconomic impacts of the structure and quality of energy systems, provide policy makers with aggregate monitoring tools
- Finally, Integrated Energy Models (not represented in the diagram) allow to model the complex interactions between the various components

Accordingly, NEEDS allows to answer a wide range of policy queries that have a varied degree of complexity. A detailed classification of such queries can be found in [Ricci 2007]. At a more aggregated level, these queries can be classified in three main groups:
- Assessment of Energy technologies (based on foresight techniques, LCA, externalities valuation, stakeholders' perception and acceptance)
- Formulation, optimisation and impact assessment of Energy policies (through e.g. scenario building, modelling, Multicriteria Analysis), and their monitoring and evaluation (based on e.g. sustainability indicators, Green Accounting)
- Investment decisions, primarily based on Social Cost Benefit Analyses (SCBA)

The present document illustrates results for a wide selection of these queries. For each query addressed, it
- presents the nature of the policy issue in focus ("the query")
- highlights the innovative contribution of NEEDS to addressing the issue ("improvements")
- exemplifies concrete answers provided by NEEDS ("selected results")

3.1 Technology assessment queries

3.1.1 What are the real, full costs of the different energy sources and technologies?

The query

A good knowledge of the full cost values is obviously directly instrumental to providing basic input to policy formulation and investment decisions, and calculating the full (i.e. internal + external) costs of energy technologies is in fact the most explicit and fundamental goal of the entire NEEDS project.

At a more direct, primary level, cost values allow to answering policy questions such as "how do energy options compare?", or "how important is it to include external costs in technology and policy assessments? (i.e. how far are we off the mark if external costs are not properly included?".

Major improvements from NEEDS

- Full and detailed coverage of the life cycle (including material supply, component manufacturing, construction, operation and dismantling) of a number of new and emerging electricity generation technologies that were previously not (or poorly) documented,

- Time- and scenario- dependent LCA based on energy foresight techniques, which allows to estimate the future dynamics of energy technologies performance at the time horizons required by long term energy modelling (e.g. 2030 – 2050)

- Inclusion in the external costs accounting framework of new impacts (e.g. biodiversity) and improved accuracy in the valuation of most other impacts (with particular regard to mortality, which often dominates total external costs)

Selected results

Results shown hereafter are drawn from the NEEDS Research Stream RS1b (External costs valuation).

Figure 1 (respectively Figure 2) show the values of external costs (social costs) for selected Electricity Generation Technologies (EGT), at 2009. More and more detailed such results are available in the NEEDS deliverables (see below), particularly concerning the future expected dynamics of these cost values until 2050.

As explicitly stated in these two Figures, risk aversion and potential damages from terrorism are not included here, which has raised a heated debate within and outside the NEEDS community owing to the uneven underestimation of total costs that this omission entails across technologies. A full account of the debate that took place in the late stages of NEEDS - on this and other controversial issues - is presented in ANNEX.

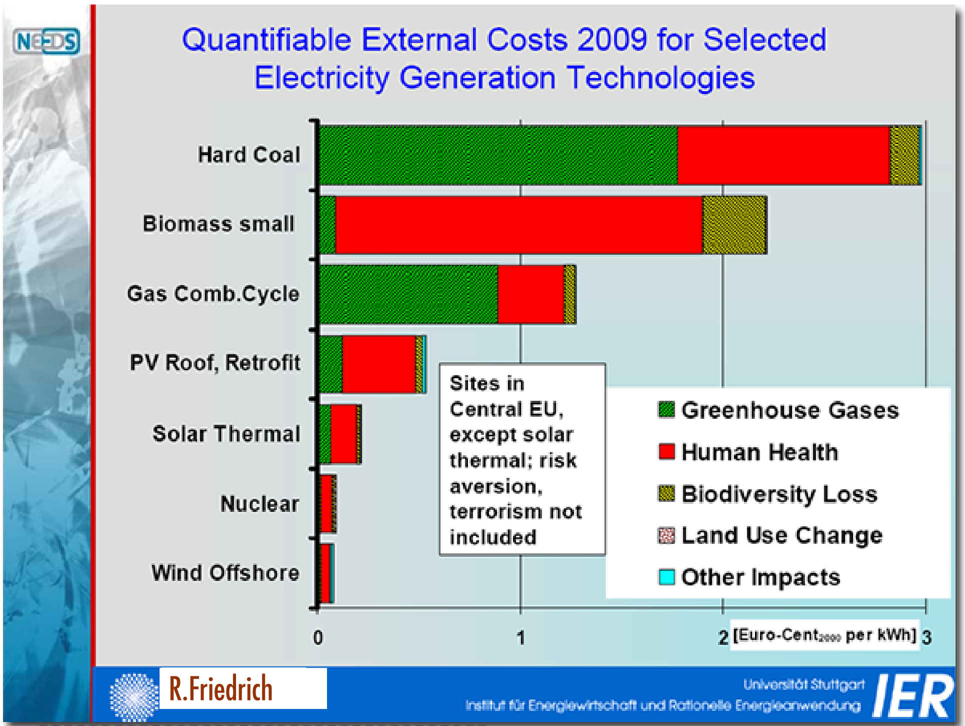


Figure 1 – External costs (2009) for selected EGT

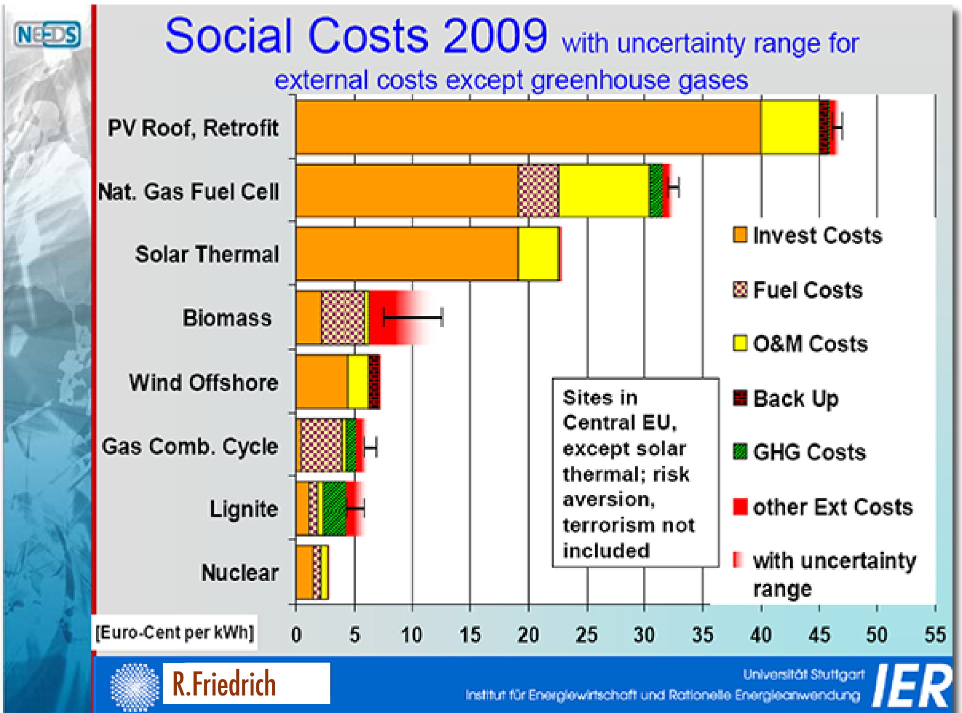


Figure 2 – Social costs (2009) for selected EGT

Figure 3 presents the expected values of private costs at 2050 for a selection of EGT. It notably compares Nuclear (both PWR and EPR) with Biomass and a wide variety of Fossil Fuel technologies, with and without CCS.

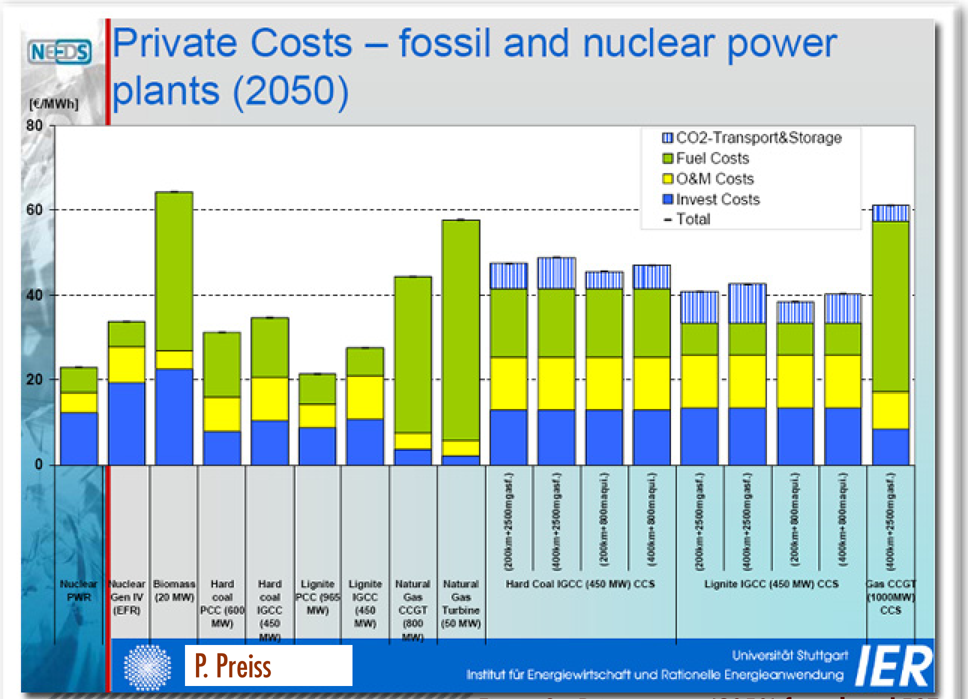


Figure 3 - Private costs (2050) for selected EGT

3.1.2 How to put economic values on externalities that are difficult to quantify?

The query

It often happens that the (real or apparent) incompleteness or/and the perceived inaccuracy of the available scientific knowledge generates a lack of trust on behalf of policy makers, and subsequently their reticence in using results that are otherwise robust and trustworthy. Completeness of the cost accounting framework is therefore of the essence (if only to convey the message to policy makers that sufficient data are available to feed into decision making processes). Despite the considerable research efforts over the past two decades, it is recognised that some gaps can still be found for what concerns externality valuation, owing to (i) the objective difficulty of quantifying and valuing specific externalities and to (ii) the emergence of impacts categories that were not known, or recognised as relevant, until recently.

Major improvements from NEEDS

NEEDS has made significant progress in this area, notably by

- pioneering the valuation of **biodiversity**, with the experimental development and application of what is considered to be the most promising approach, based on the valuation of the PDF (Potentially Disappearing Fraction)

- increasing the robustness of the state-of-the-art knowledge for what concerns one of the most controversial and difficult topics in externality valuation, i.e. **climate change**

- generating new knowledge and data for one of the critical external costs, i.e. human **mortality**: although datasets were already available before NEEDS, they were largely obsolete and their accuracy in need of improvement. NEEDS has produced new datasets based on original WTP surveys, based on improved questionnaires.

Further significant innovation was achieved in NEEDS for what concerns, among others, the **soil pollution pathways** and the detailed valuation of externalities arising from the **extraction and transport of energy sources** (including emerging energy sources such as hydrogen)

Selected results

Aggregated results incorporate, in fact, a wealth of detailed figures calculated in NEEDS, many of which have a policy support value in their own right. For instance

- Biodiversity externalities have been estimated by NEEDS at 2.66 €/m2, corresponding to the costs that must be faced to restore the so-called PDF
- The new surveys carried out in NEEDS have allowed to generate better and updated values of VOLY (Value Of Life Year), and to differentiate these values geographically, which are in the order of 40 k€for EU(15) Member States and in the order of 33 k€for NMS (New Member States)
- Stream RS1c has produced disaggregated estimations of the externalities arising for the extraction and transport of energy sources, which were previously unavailable, and found that even including the probabilistic externalities associated to oil spills, the incidence of external costs on the total costs of bringing oil to Europe is relatively low, in the order of 2.5 €per ton of transported oil, representing less than 5% of direct (private) costs, and aproximately 1% of current oil prices.

As for CO2 costs, they admittedly vary, even considerably, according to specific assumptions (e.g. discount rates), and depending on the nature of the long-term scenario considered. Although full consensus[3] cannot be reached given the objective uncertainties characterising this issue, NEEDS has however produced robust ranges that are broadly accepted by the scientific community (Figure 4 below).

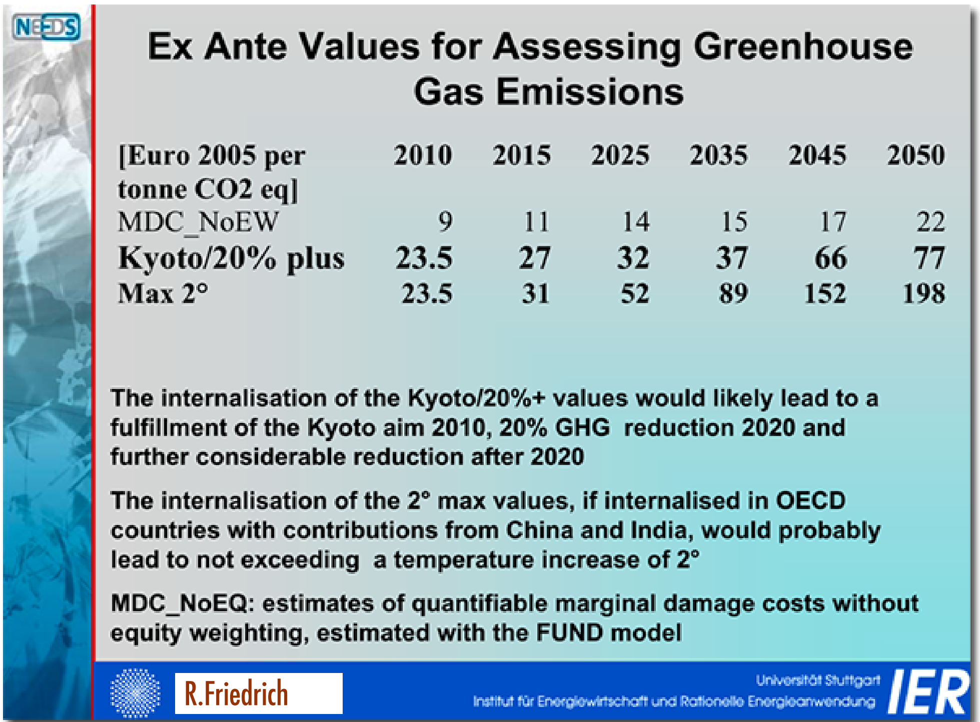


Figure 4 – Ranges of CO2 values

3 see also ANNEX

3.1.3 Are external cost values equally available across different countries?

The query

Extensive geographical coverage is obviously desirable to ensure that policy and decision making at the individual country level can draw upon reliable, country specific evidence. It is however even more important when considering that policy and investment decisions at the level of an individual country bear direct consequences on the sustainability of other countries, notably owing to the regional and global nature of the impacts associated to airborne pollutants, and more generally to the transborder nature of environmental phenomena.
Thanks to the ExternE project series, abundant datasets were made available that primarily cover EU Member States, but many countries outside the EU must also be included in the perspective of a complete assessment of the impacts of energy systems and policies.
On the other hand, the generation of high quality datasets on additional countries is very demanding, in terms of (i) financial resources (bottom-up calculations are expensive) and of (ii) required data and technical skills, that might not be available at the outset.

Major improvements from NEEDS

NEEDS has contributed to the advancement in this area in two complementary directions: on the one hand, it has carried out a number of country specific studies, notably in Eastern and Mediterranean countries, to generate fresh datasets while at the same time building technical capacity in those countries; on the other hand, it has developed a robust methodology for value transfer, and experimented it within the project itself so as to pave the way for its generalised adoption, beyond NEEDS.

Selected results

Figures 5 and 6 below illustrate examples of results where critical values (e.g. damages from CO2 emissions and from Air Pollutants) are consistently shown across EU Member States.

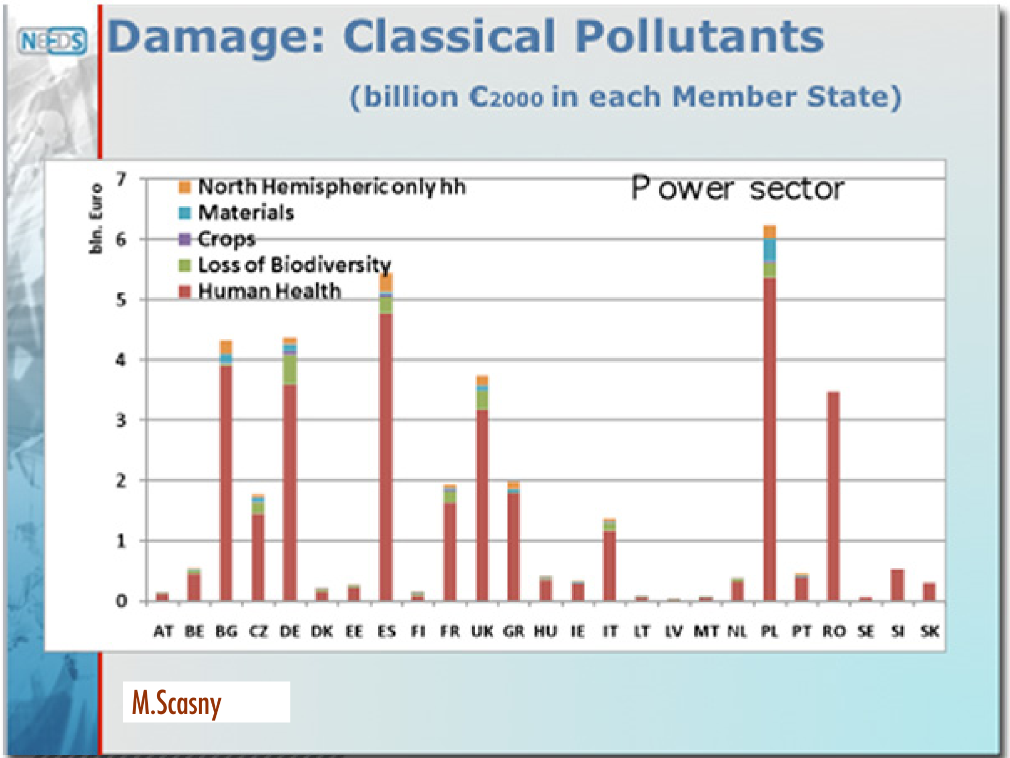


Figure 5 – Air pollution damages from the power sector across the EU

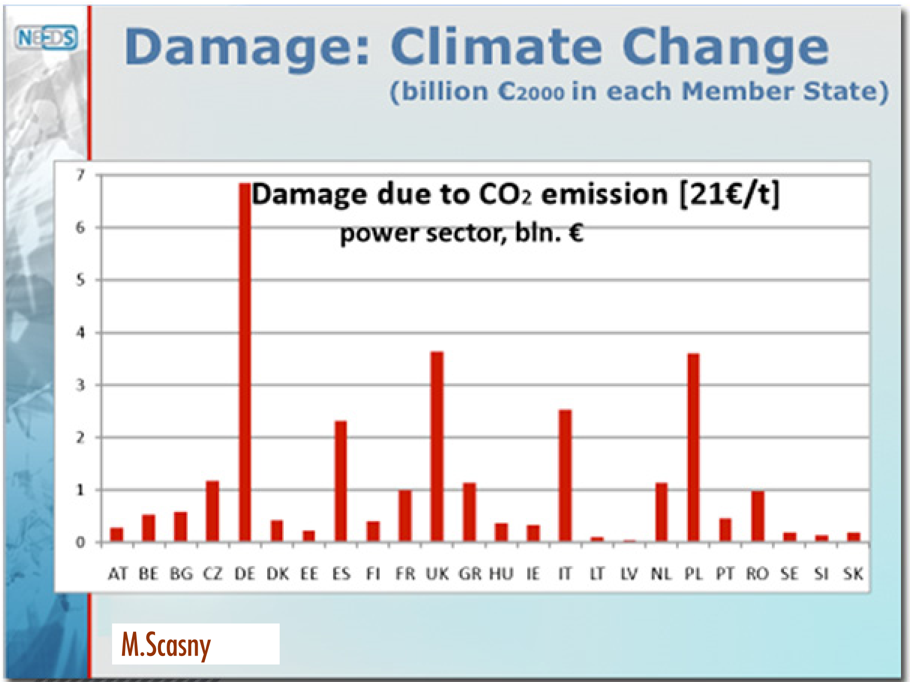


Figure 6 – Climate change damage from the power sector across the EU

3.1.4 How do Energy technologies compare along their full life cycle? And how will they evolve in terms of performances, costs, market share?

The query

Policy makers are usually fond of information that immediately allows them to rank alternative options, possibly according to a one-dimensional criterion. While such requests are legitimate and understandable, technology ranking is a very complex affair, and if treated unappropriately it can generate major misunderstandings and mislead important decisions. Full costs analysis is certainly getting as close as possible to providing a robust input to the ranking of energy technologies, and is indeed at the core of the NEEDS achievements. A meaningful comparison between technologies must however consider several dimensions, which typically include (i) private and external costs, both individually and cumulatively, (ii) current performances of individual technologies (energy and economic efficiency, resource consumption etc.) and their expected evolution over time (particularly considering the different level of maturity of currently available technologies, and therefore the fact that their improvement rates in the medium/long term could be highly differentiated), and (iii) expected market shares (which are strongly related to costs and performances, but also to the existence of targeted policies).

Major improvements from NEEDS

NEEDS has produced a considerable amount of results that feed directly into the general issue of technology comparison. As previously highlighted, major innovations can be found in terms of the choice of technologies analysed (new and emerging electricity generation technologies that were previously under-documented), and of the time perspective of the LCA, for which NEEDS has pioneered a dynamic approach to LCA, based on the adoption of alternative scenarios that recognise the intrinsic uncertainty associated to technological foresight.

Selected results

Sample results shown below are drawn from Stream RS1a (LCA).
Figures 7, 8 and 9 illustrate how future developments of PV technologies are excepted to reflect on, respectively, the market share of the most relevant PV technology options, the dynamics of production costs, and the corresponding performances for what concerns total lifecycle CO2 emissions.

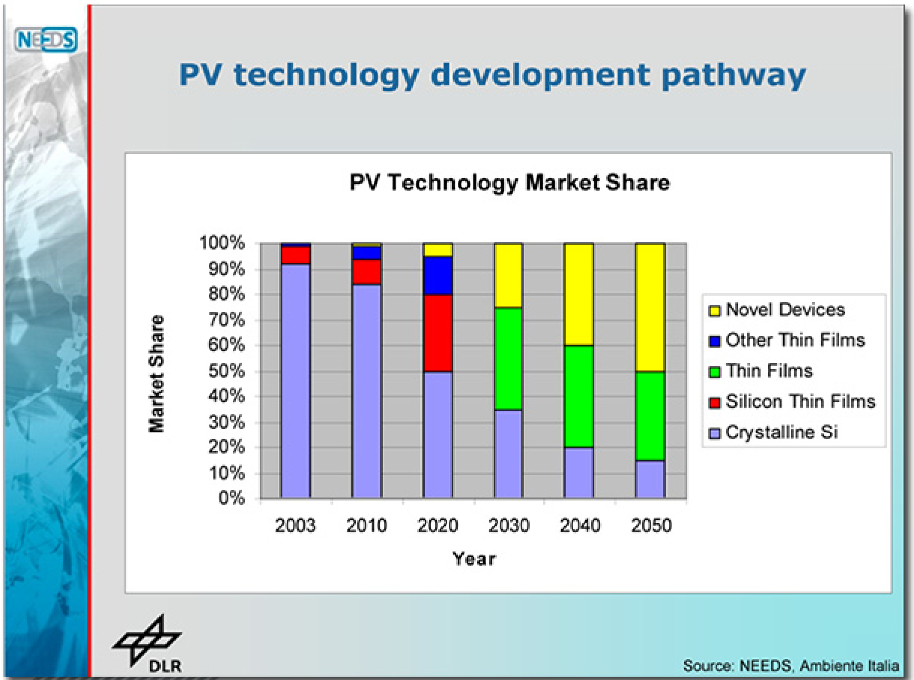


Figure 7 - Market share of PV at the 2050 horizon

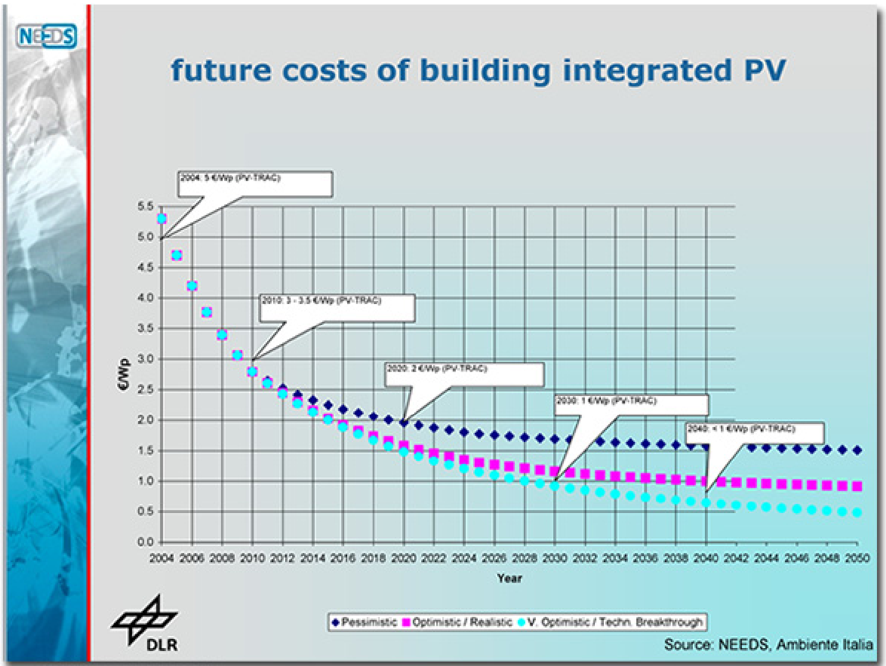


Figure 8 – Future costs of PV at the 2050 horizon

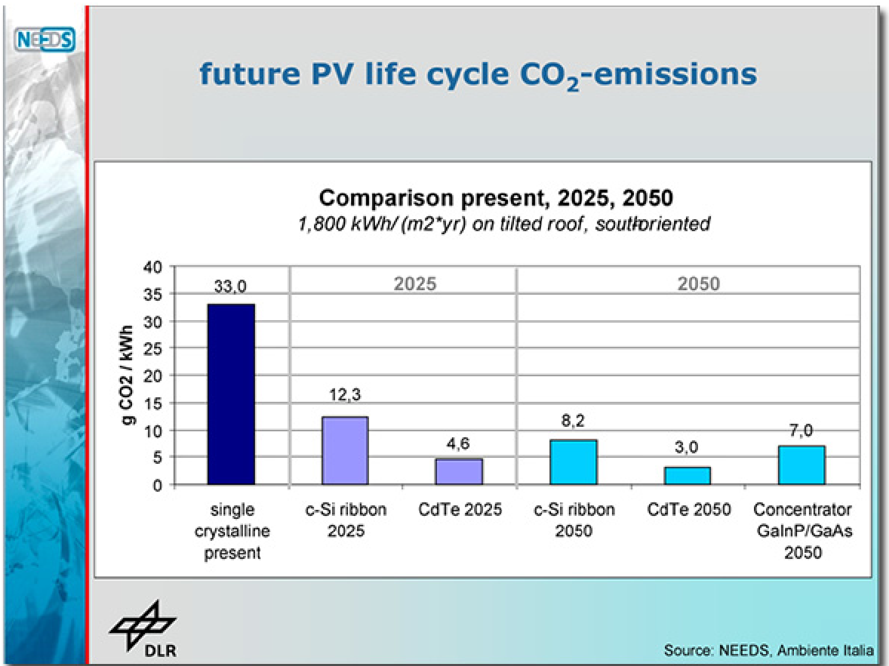


Figure 9 – CO2 emissions of PV at the 2050 horizon

Figure 10 shows the expected progress of major EGT between now and 2050 for what concerns CO2 lifecycle emissions.

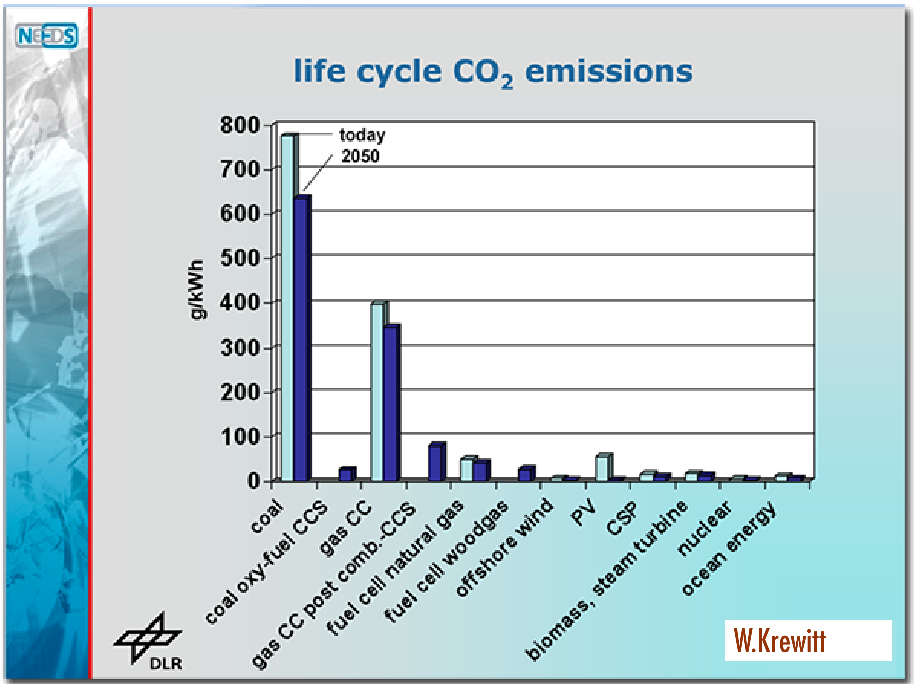


Figure 10 – Expected reduction of lifecycle CO2 emissions for selected EGT at 2050

Figure 11 shows the influence of different scenarios on the future CO2 performance of selected RES (Renewable Energy Sources). Scenarios are differentiated both

- at the technology level[4] (BAU = Business as Usual, PE = Pessimistic, RO = Realistic-Optimistic, VO = Very Optimistic)
- at the policy level[5] (440 ppm Vs Renewables)

4 for a full description of the approach to technology scenarios, see for instance Deliverable RS1a D2.2
5 for a full description of the policy scenarios, see Section 3.2.1 below

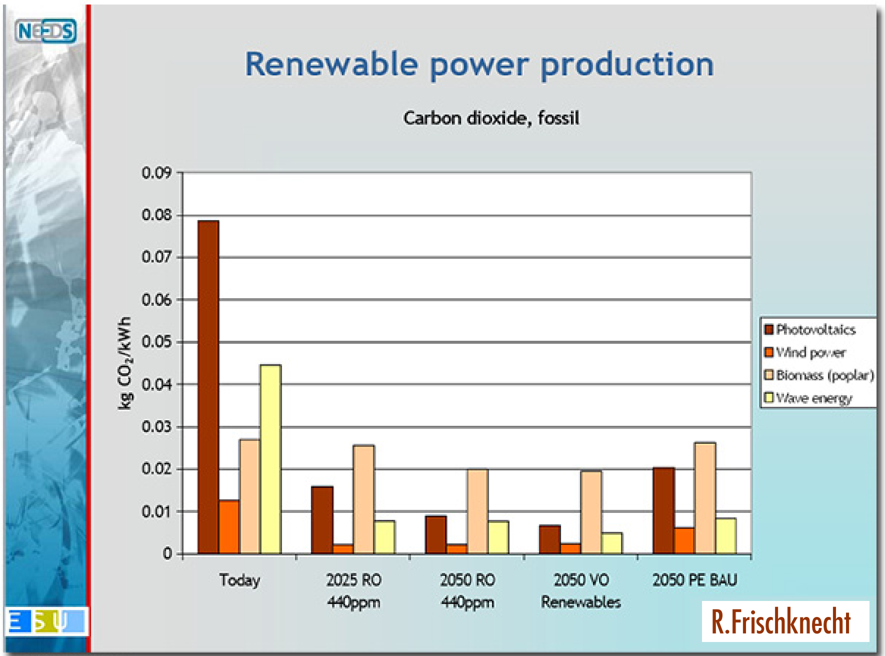


Figure 11 – CO2 lifecycle emissions for selected renewables in different scenarios

Similarly, Figures 12 and 13 illustrate the expected progress of, respectively, Offshore wind and Wave energy for what concerns CO2, PM10, Carbon-14 and Landtake

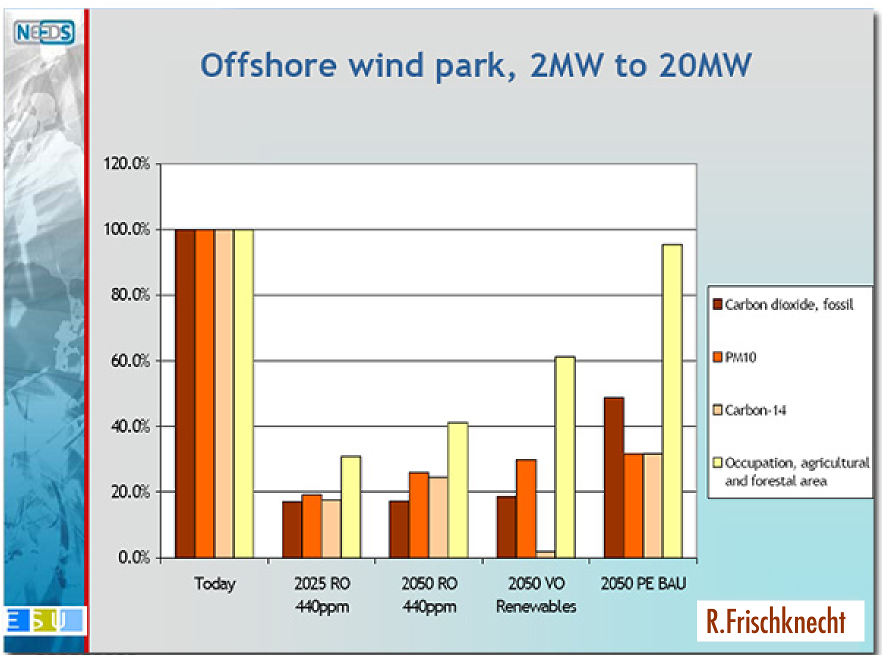


Figure 12 – Off shore wind at the 2050 horizon

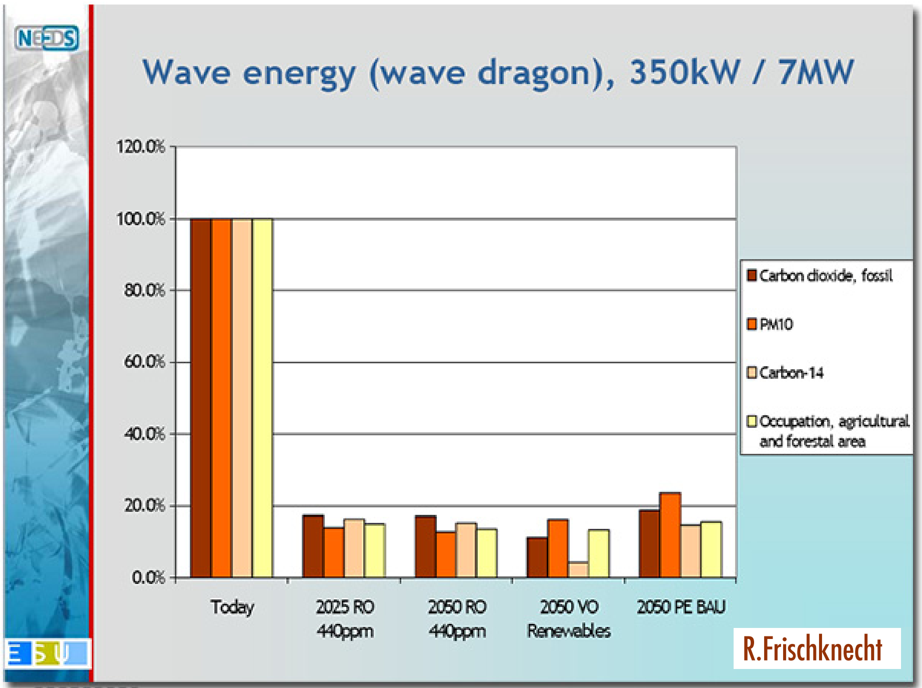


Figure 13 – Wave energy at the 2050 horizon

3.1.5 Is the principle of monetary valuation of energy externalities accepted by citizens and by policy makers? What can be done to improve acceptability and therefore foster a more extensive use of externality valuation?

The query

Policy use of externalities data materialises through instruments (e.g. taxation, pricing and incentives, etc.) that bear immediate consequences on citizens and economic players. In turn, policy makers responsible for the design and enforcement of such instruments are (and/or should be) directly concerned about their acceptability. Although the concept of externalities is gaining increasing visibility, even in public debates, much remains to be done to ensure that it is properly understood and accepted.

Major improvements from NEEDS

NEEDS has conducted various surveys and country specific case studies to elicit novel information from a wide audience of stakeholders and representatives of the civil society to ascertain their awareness of the concept of energy externalities and its implications, the related levels of acceptability and the areas where understanding of the concept seems inadequate.

Selected results

As illustrated in Figures 14 and 15 below, the responses to the survey expressed a very strong acceptance of the concept of externalities, of the internalisation of external costs as well as of the policy use of the results (with the exception of supporting subsidies and penalties for which the acceptance rate was less pronounced). As for the Impact Pathway Approach (IPA), the responses reflected a mixed level of awareness, despite the typically high education level of the respondents. In spite of awareness about the limitations of the approach the results obtained within the ExternE projects for specific energy technologies are mostly accepted. There are, however, large differences what concerns the views on the estimates for nuclear energy.

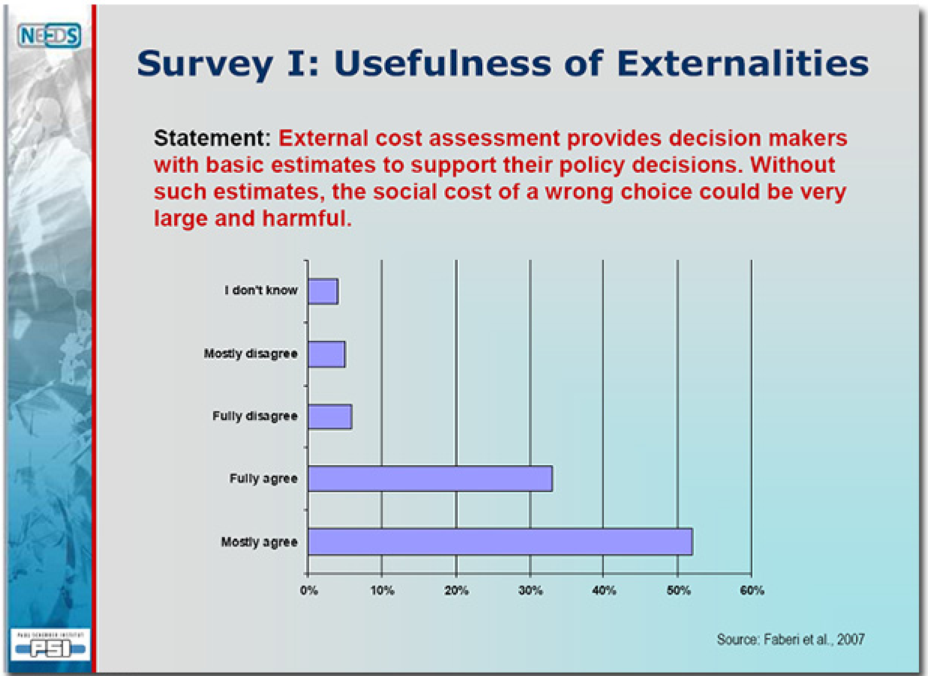


Figure 14 – Are externalities perceived as useful information?

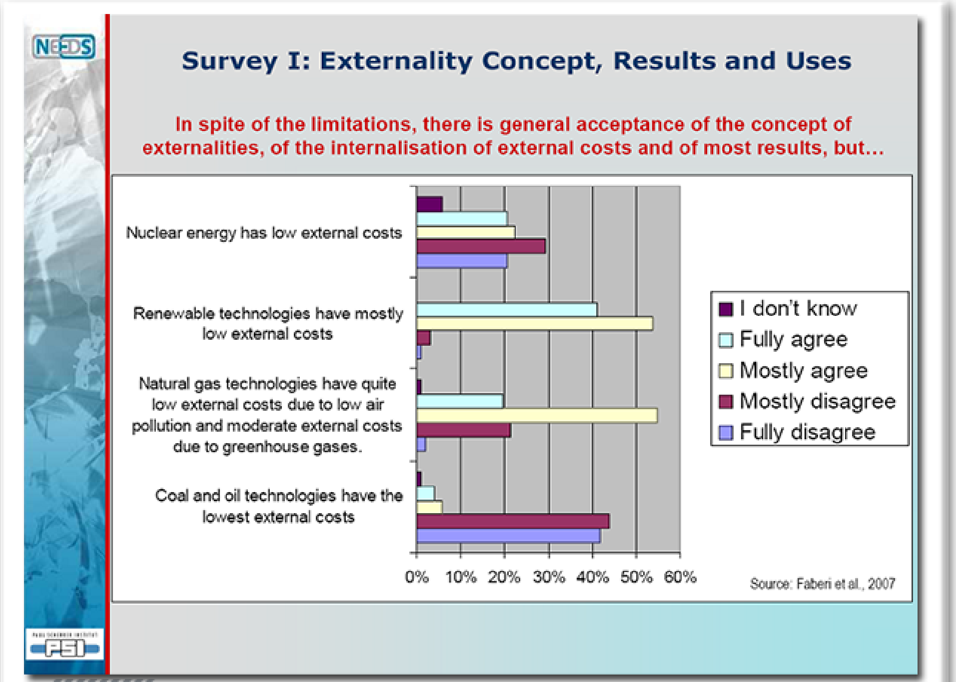


Figure 15 – General acceptance of externalities results

3.1.6 Is it possible to differentiate Energy technologies based on their sustainability performance? How sustainable are the various technologies when performance indicators are combined with stakeholders preferences? Which technologies exhibit the most robust behaviour in an overall sustainability perspective?

The query

Energy technologies, as previously highlighted, can be compared by recurring to a variety of criteria. Although the concept of generalised cost is commonly accepted as sound and providing inputs that are directly policy relevant, the question arises of whether it fully succeeds in capturing the many facets of sustainability appraisal. Policy makers (as well as representatives of the civil society) at times contend that a purely monetary quantification of all costs and benefits fails to reliably capture selected specific phenomena and their real significance. This may be due to the nature of these phenomena that intrinsically do not lend themselves to quantification/monetisation, or/and to the objective difficulty in calculating the corresponding values.

Complementary approaches, notably based on well thought systems of sustainability indicators, can be included in the sustainability assessment framework, to generate a more comprehensive (and acceptable) picture of the overall compared performance of individual technologies.

Major improvements from NEEDS

This is another area where NEEDS has decisively pioneered, notably through:

- The establishment of an original set of energy-specific sustainability indicators, developed in consultation with stakeholders and representatives of the civil society, and equally covering the three dimensions of sustainability

- Using these indicators (and the relative value that stakeholders assign them within a MCDA) in combination with full cost accounting to identify discrepancies between "objective" measurements and the "subjective" valuation of stakeholders.

The interpretation of results is not always straightforward, but it certainly allows to identify critical issues and suggest future actions to reduce the gaps.

Selected results

In general, the proposed sustainability criteria found wide acceptance both in terms of content as well as hierarchical structure.

	Criterion	
ENVIRONMENTAL DIMENSION	RESOURCES	
		Energy Resources
		Mineral Resources (Ores)
	CLIMATE CHANGE	
	IMPACT ON ECOSYSTEMS	
		Impacts from Normal Operation
		Impacts from Severe Accidents
	WASTES	
		Special Chemical Wastes stored in Underground Depositories
		Medium and High Level Radioactive Wastes to be stored in Geological Repositories
ECONOMIC DIMENSION	IMPACTS ON COSTUMERS	
		Price of Electricity
	IMPACTS ON OVERALL ECONOMY	
		Employment
		Autonomy of Electricity Generation
	IMPACTS ON UTILITY	
		Financial Risks
		Operation
SOCIAL DIMENSION	SECURITY/RELIABILITY OF ENERGY PROVISION	
		Political Threats to Continuity of Energy Service
		Flexibility and Adaptation
	POLITICAL STABILITY AND LEGITIMACY	
		Potential of Conflicts induced by Energy Systems.
		Necessity of Participative Decision-making processes
	SOCIAL AND INDIVIDUAL RISKS	
		Expert-based Risk Estimates for Normal Operation
		Expert-based Risk Estimates for Accidents
		Perceived Risks
		Terrorist Threat
	QUALITY OF RESIDENTIAL ENVIRONMENT	
		Effects on the Quality of Landscape
		Noise Exposure

Figure 16 below provides an aggregated summary picture of the results of the MCDA.

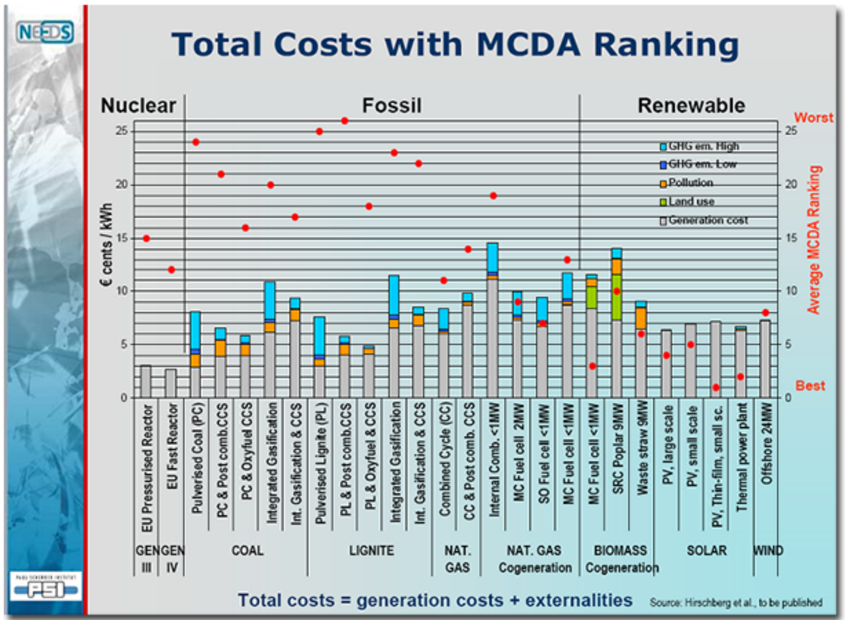


Figure 16 – Consistency between total costs and MCDA ranking

While within the external cost estimation framework applied in NEEDS nuclear energy exhibits the lowest total costs, its ranking in the MCDA-framework tends to be lower, mainly due to consideration of a variety of social aspects not reflected in external costs. Thus, nuclear energy ranks mostly lower than renewables, which benefit from much improved economic performance. Renewables show the most robust behaviour, i.e. in comparison to fossil and nuclear options a lower dependence of ranking on the differences in preference profiles; this applies especially to solar technologies. Coal technologies perform worse than centralized natural gas options; the latter are in the midfield and have thus ranking comparable to nuclear. The performance of CCS is mixed, i.e. fossil technologies with CCS may rank better or worse than the corresponding technologies without CCS, depending on which specific CCS option is used.

3.1.7 How do citizens and stakeholders perceive various types of risks associated with Energy systems? Do they trust official agencies concerning risk management?

The query

Although technically risk can be calculated by multiplying probability by damage value, the most common perception of risk is much softer and subjective. This is particularly true when probability is low and damage value is high (as for nuclear energy, but also e.g. hydro power). On the other hand, whatever the perception that stakeholders have, this will influence behaviour, decision making and ultimately policy effectiveness. It is therefore important to understand at best what is the actual perception of risk and possibly the factors that drive it. This will help decision makers in both assessing the acceptability of specific decisions and in deploying adequate information efforts.

Major improvements from NEEDS

The above mentioned surveys, combined with the detailed MCDA carried out in NEEDS are probably the first highly structured attempt to gauge risk perception for a wide array of energy options. Accordingly, the results – despite their experimental nature and their less than obvious interpretation - shed novel light on the issue of risk perception, not the least as they include and explicit representation of social concerns.

Selected results

Evaluation and perception of accident risks are known to be a highly sensitive and problematic issue. Based on the outcome of the surveys and of the MCDA carried out in RS2b (see Figure 17 below), estimated expected accident risks are by far lowest for nuclear and solar technologies while fossil fuel chains exhibit the highest risks. On the other hand the maximum credible consequences of severe accidents, which can be viewed as a measure of risk aversion, are by far highest for nuclear, very small for solar and wind, and in the middle range for fossil chains. The perceived accident risks based on interviews with experts are considered to be highest for nuclear followed by fossil chains, with solar and wind again perceived as having small risks.

An explicit comparison between "objective" and "perceived" risks can therefore be summarised as follows:

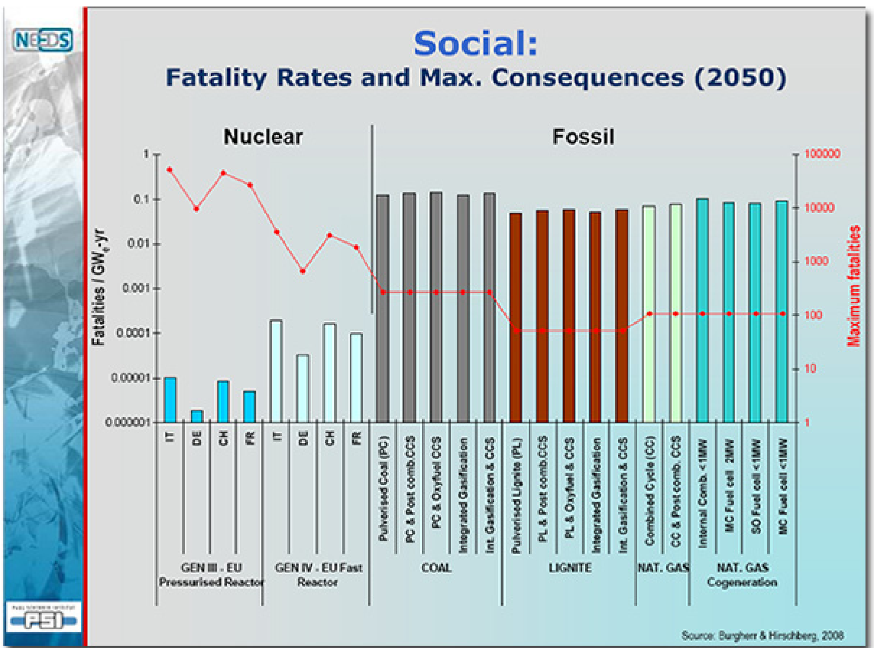


Figure 17 – Risk perception

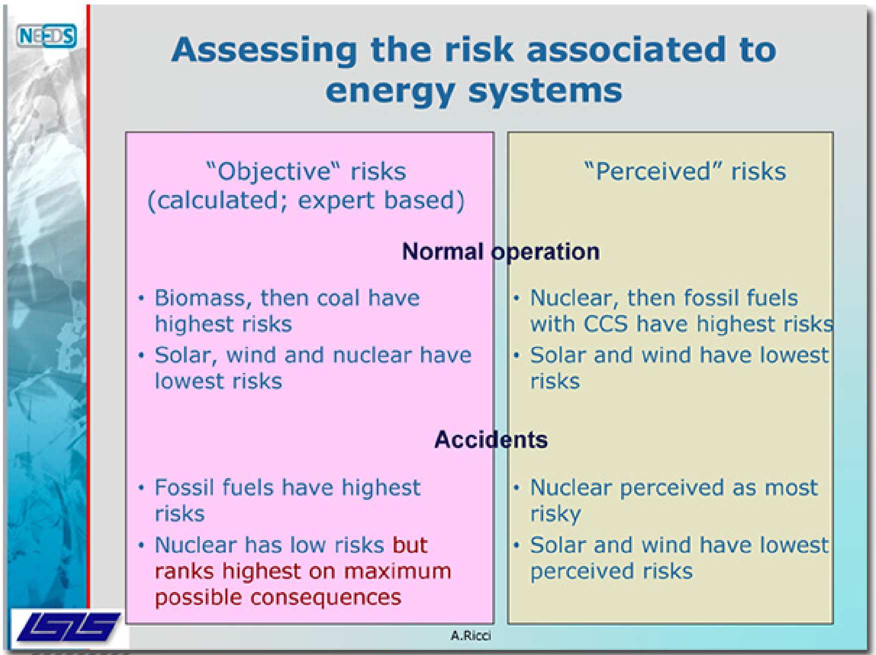


Figure 18 – Objective Vs Perceived risks

3.1.8 How to treat uncertainty and how to present it to policy and decision makers?

The query

Although it is unavoidable in any serious scientific debate, uncertainty is both the nightmare of policy makers and often used as an alibi to skirt difficult decisions. On the other hand, it is also obvious that decision risks can become unacceptable when uncertainty is too high.
It is therefore the duty of serious scientists to appraise ranges of uncertainty and, even more importantly, to present them in a way that will hopefully demonstrate that "being approximately right is better than being exactly wrong".

Major improvements from NEEDS

NEEDS has devoted a dedicated workpackage to uncertainty, and has produced a detailed, scientifically sound framework for its treatment, which, for the first time, systematically and consistently examines all steps of the Impact Pathway Approach from the uncertainty perspective.
It has also directly experimented and validated such framework in the context of the generalisation and transferability of external cost values across countries and sites.

Selected results

NEEDS results are systematically presented including the estimated range of uncertainty that characterises them. This was made possible by a systematic recourse to alternative sets of assumptions and scenarios (as shown in previous Figures) that have notably been used for sensitivity analysis, and by the development and adoption of a structured and detailed methodology to ensure the consistent treatment of uncertainty across cost categories and countries.

Ultimately, a "rule of thumb" can be enunciated, whereby uncertainty ranges for energy externalities are roughly in the order of a factor 0.3 €3.

For additional considerations on the consequences of uncertainty on the interpretation of the NEEDS results, see also ANNEX

3.1.9 Does external cost valuation take due account of the differences in preferences and purchasing power across countries?

The query

This is another issue where heated debates have been on-going for a long time: is it fair to assign different monetary values to e.g. human life in different countries? On the other hand, if the energy system in Country A inflicts damages also to Country B that has a lower purchasing power, PPP adjustment will reduce the burden of responsibility placed on the "damager".

Major improvements from NEEDS

NEEDS has strived to systematically account for the possible effect of using purchasing power adjustments, by presenting results that allow to assess the sensitivity to PPP.

Selected results

As an example, Figures 19 and 20 below illustrate how PPP influences the values of externalities generated by the power sector (as a % of GDP), and how country rankings can accordingly vary.

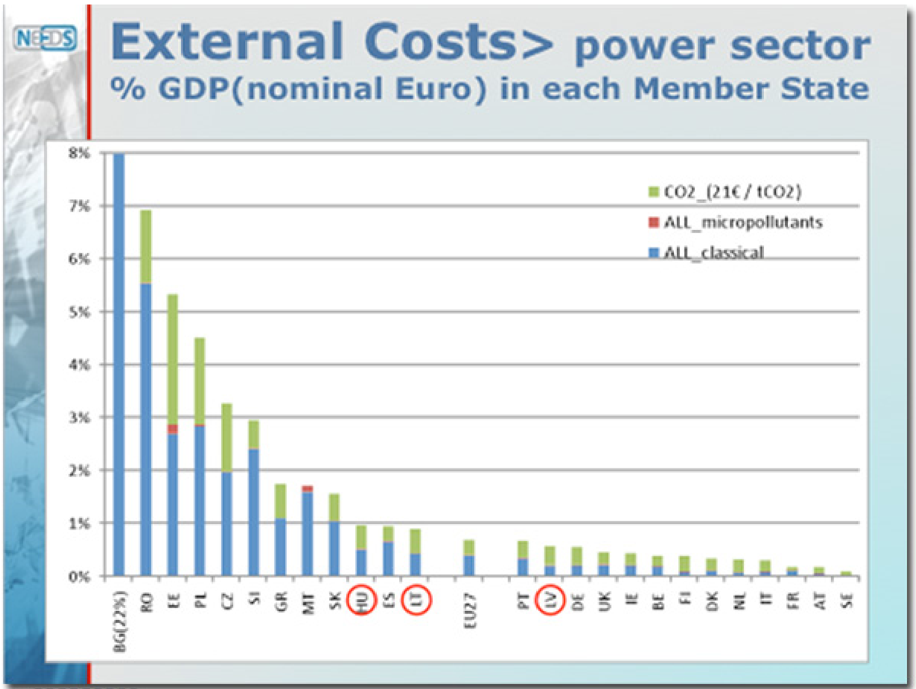


Figure 19: External costs of the power sector without PPP

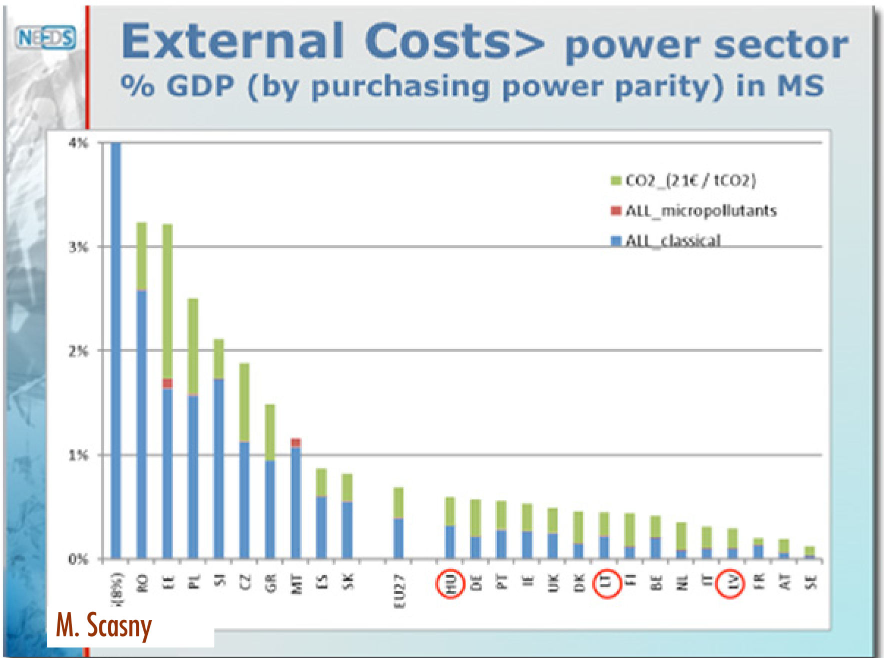


Figure 20: External costs of the power sector with PPP

3.2 Energy policy queries

3.2.1 What will be the role and relative weight of the different Energy sources in the future?

The query

Anticipating the future structure of the energy systems, and notably the share of each energy source (including those that are currently emerging), is of paramount importance to policy makers in that it provides direct insights on critical issues such as the level of security of supply, the role and relevance of domestic capacity, energy trade patterns and their budgetary implications, the environmental performance of the energy systems and the achievement of targets, and many others.

The issue is intrinsically complex, when one considers that the future structure of energy systems will result from the combined effects of (i) spontaneous technological progress, (ii) exogenous factors (economic growth, geopolitical dynamics, etc.), and (iii) the nature and effectiveness of sectorial policies and targets (energy, environment, climate change).

Major improvements from NEEDS

To deal with the above mentioned complexity, NEEDS has devoted considerable efforts to the development and subsequent application of an integrated energy modelling platform, built upon well proven and widely used modelling tools of the MARKALL-TIMES family.

Major innovative features of these developments include:

- the availability of 30, fully consistent, country models, that can be used autonomously as needed
- their full integration in a Pan European model that allows for the explicit representation of e.g. energy trade flows
- the direct link with the LCA and the External cost valuation carried out in NEEDS (i.e. the models capability to accept inputs from those)
- the potential for integration/interaction with the work carried out by NEEDS in the area of stakeholders' perception and MCDA

Selected results

Four main Policy Scenarios have been devised in NEEDS through direct and iterative interaction with stakeholders. The consistent adoption of these scenarios and of variants thereof across the project, and in particular within all modelling activities, ensures the robustness of results.

SCENARIO	MAIN ASSUMPTIONS
BAU	▪ Business as Usual ▪ No limits on CO2 emissions ▪ Minimum use of renewable energies in line with national policies ▪ Nuclear phase out in the corresponding countries
450ppm Climate protection scenario	▪ Reduction of the emissions of CO2 by 71% (compared to Kyoto base year) until 2050 in order to achieve the European 450ppm target ▪ Nuclear phase out in the corresponding countries
OLGA Climate protection + security of supply	▪ Reduction of the emissions of CO2 by 71% (compared to Kyoto base year) until 2050 plus reduction of import dependency from oil and gas ▪ Reduction of the net imports of oil by 30% and gas by 40% until 2050 compared to the net imports in 2010
OLGA_NUC Climate protection + security of supply + enhanced utilization of nuclear energy	▪ Reduction of the emissions of CO2 by 71% (compared to Kyoto base year) until 2050 plus reduction of import dependency from oil and gas ▪ Reduction of the net imports of oil by 30% and gas by 40% until 2050 c ompared to the net imports in 2010 ▪ Options for enhanced utilization of nuclear energy

Examples of results (drawn from RS2a) illustrating the scenarios outcomes, and their comparison, for what concerns the expected role of different energy sources in the future EU energy systems are shown in Figures 22, 23 and 24 below.

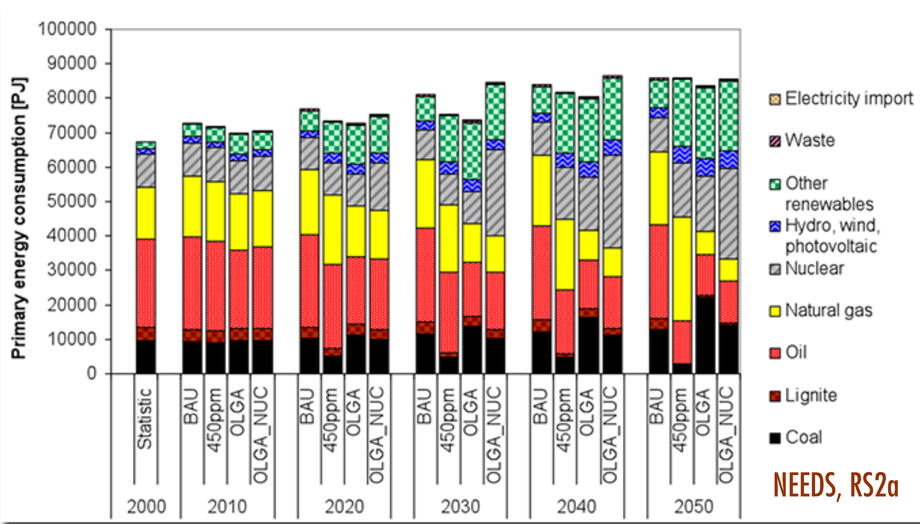


Figure 22 – Primary energy consumption in selected scenarios

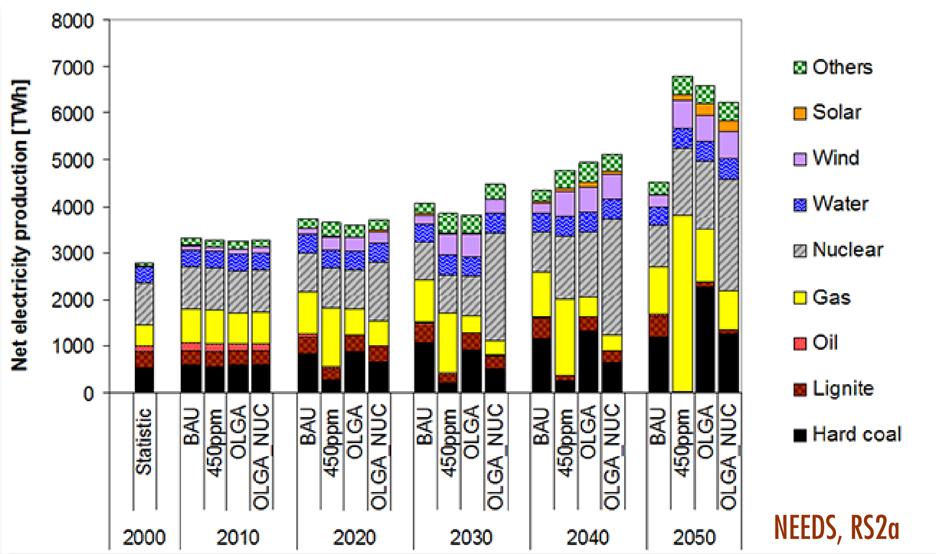


Figure 23 – Net electricity production for selected scenarios

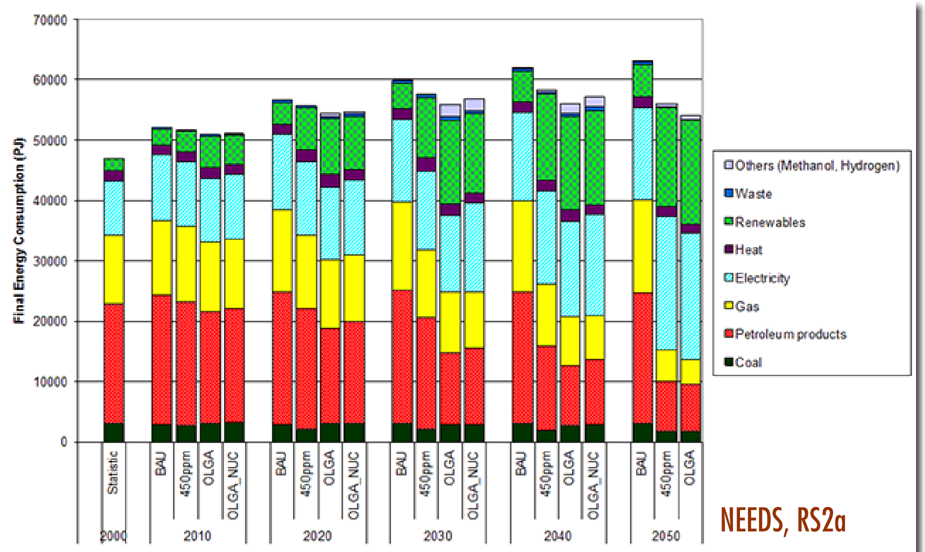


Figure 24 – Final energy consumption for selected scenarios

Among others, these results demonstrate the extent that policy can concretely influence technology penetration, when one considers e.g. that under a strong CO2 constraint, coal would almost be phased out in 2050, while under the assumption that security of supply constraint dominates the policy context, the coal share would remain double that of gas at the same time horizon of 2050.

3.2.2 What is likely to be the impact of internalisation on Energy prices, on the level of pollutants and of GHG emissions?

The query

As previously stressed, the ultimate use of scientific knowledge on the full costs of energy systems is to feed into policy decisions that are directed – among others – to correcting the market distortions associated to externalities, and to reducing those externalities in the first place. Internalisation of external costs is therefore central to the debate, and the evaluation of the possible impacts of policies that are explicitly based upon internalisation measures (taxation, subsidies, but also ETS and other economic instruments) is a fundamental information feeding into the policy making process. From the policy maker perspective, it is particularly important to assess both the extent of the desired effects of such policies (i.e. by how much will externalities be reduced) and other effects that might be perceived as negative from the community of users and operators (e.g. energy price increases)

Major improvements from NEEDS

- The scenarios adopted and subsequently modelled by NEEDS (see previous section) have been selected in close cooperation with a targeted group of stakeholders (the NEEDS Policy Advisory Group) which ensures their credibility for the community of policy users.
- The results of model runs for each scenario provide an explicit representation of all major outcomes, including emission levels and energy prices
- The variety of the scenarios adopted further allows to compare the relative merits of alternative policy packages, and in particular to quantify the contribution of internalisation instruments within integrated energy policies.

Selected results

Here again, examples below illustrate some results drawn from RS2a

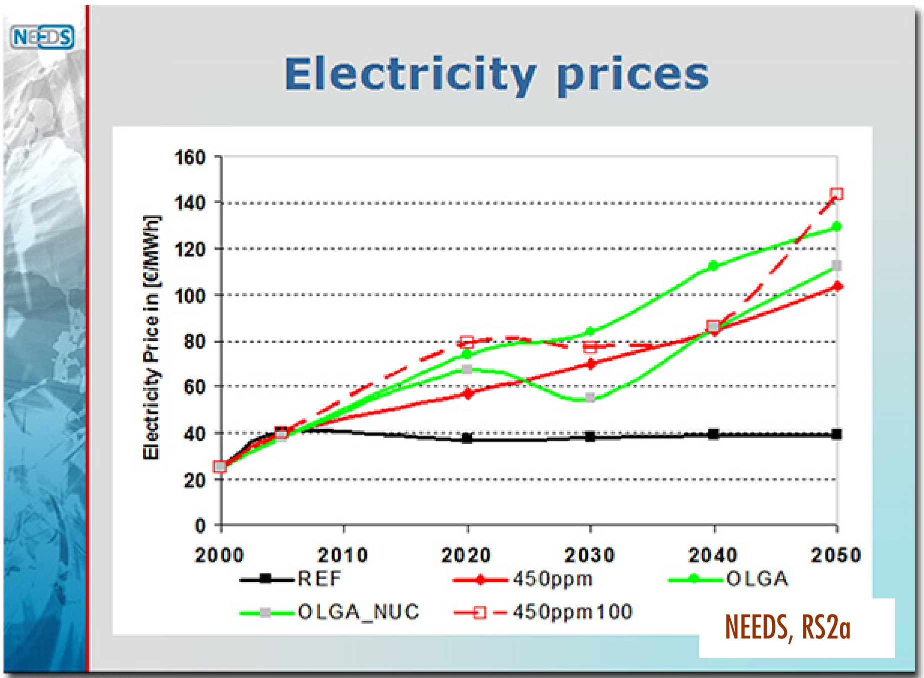


Figure 26 - Electricity prices for selected NEEDS scenarios

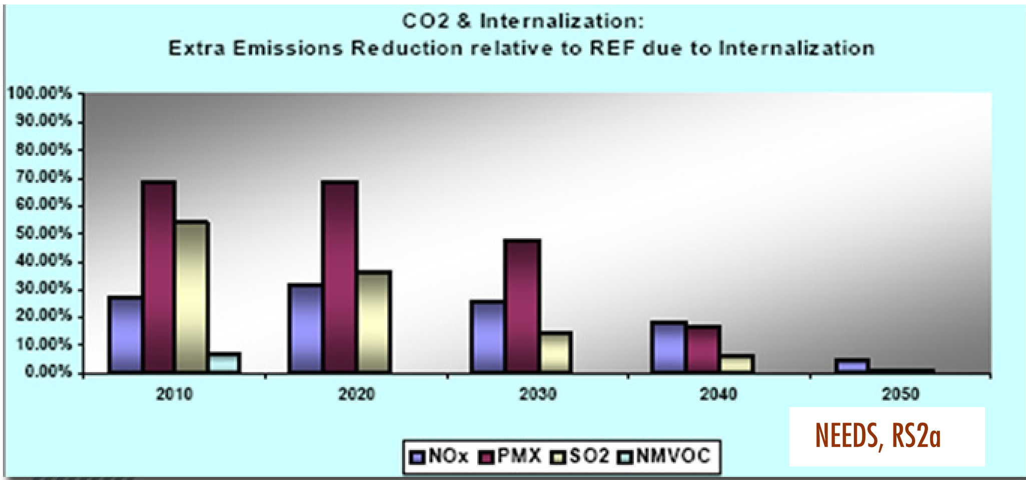


Figure 27 – Contribution of internalization to the reduction of CO2 emissions

3.2.3 What is the likely impact of targeted air quality European policies (emission standards, taxation) on emissions, costs and climate change? Are current policy targets realistic? And at what cost can they be met?

The query

Policy instruments other than those explicitly geared to the internalisation of externalities are also central to recent EU and national strategies, notably those that are driven by the need to improve air quality and combat climate change. Setting realistic and effective targets is known to be difficult, and is usually the result of political negotiation (more than straightforward techno-economic thinking). Informing policy makers about the possible impacts of specific targets and about the associated constraints (acceptability, technical achievability, costs) is therefore of primary importance to ensure that target-based policies are ultimately both realistic and effective.

Major improvements from NEEDS

The NEEDS modelling framework (see previous sections) provides abundant new evidence on policy impacts and the achievability of targets (including those included in recent EU policies) while allowing to compare the effects of alternative and/or combined policy options.

Selected results

Again based on the model runs carried out in RS2a, the Figures below illustrate sample results.

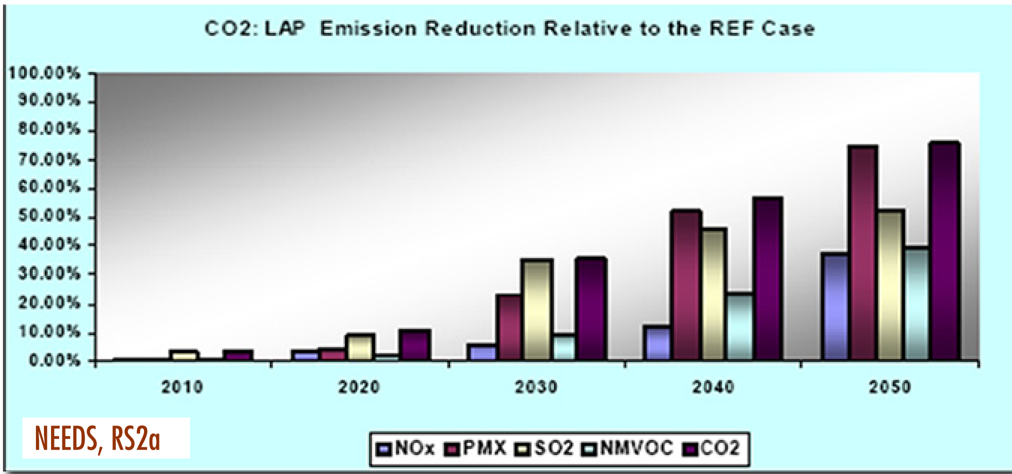


Figure 28 – Expected reduction of CO2 emissions in the Local Pollution driven scenario

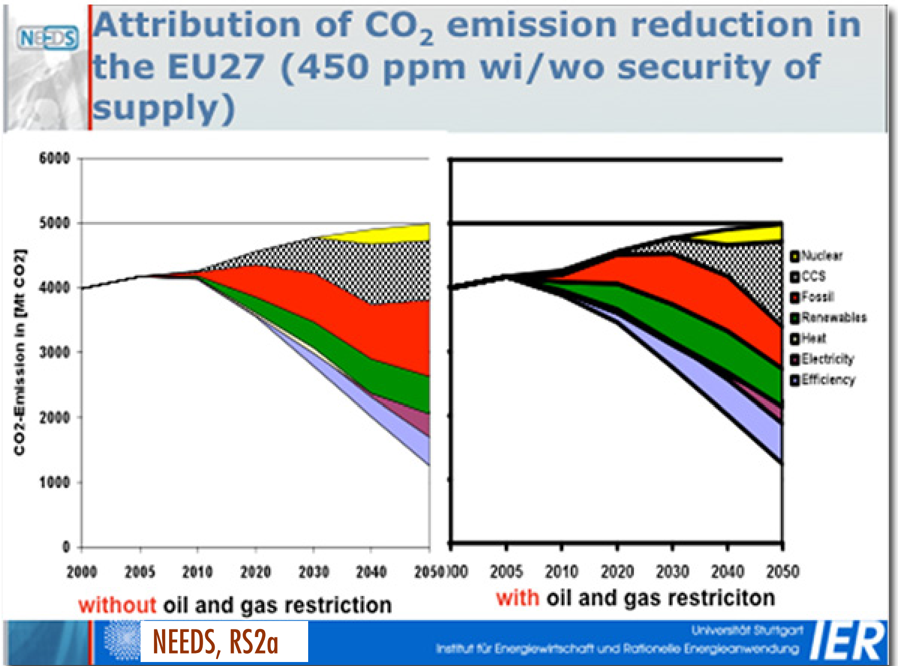


Figure 29: Expected contributions to the achievement of CO2 targets for selected scenarios

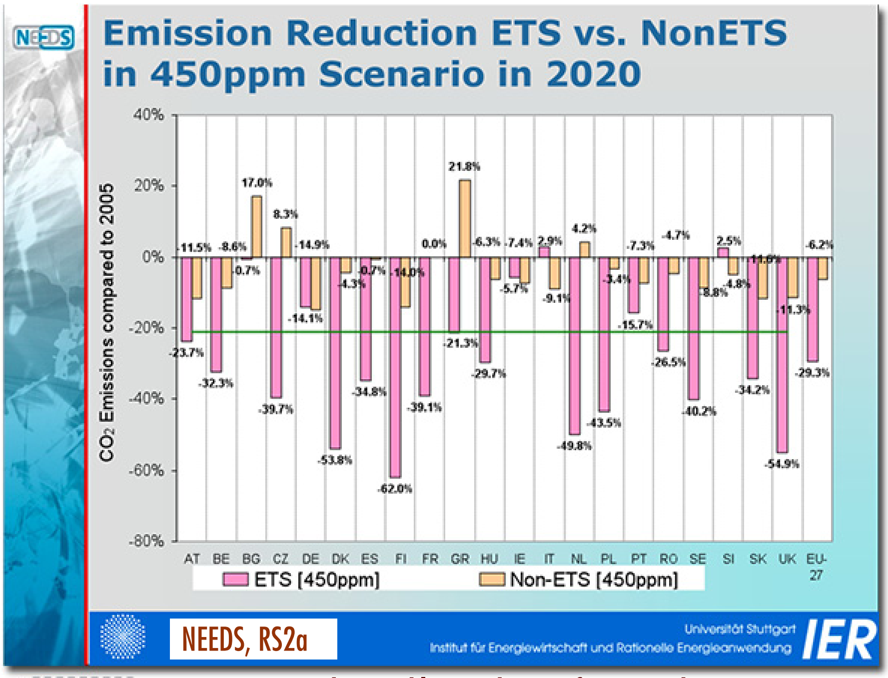


Figure 30 – The possible contribution of ETS to reducing CO2 emissions

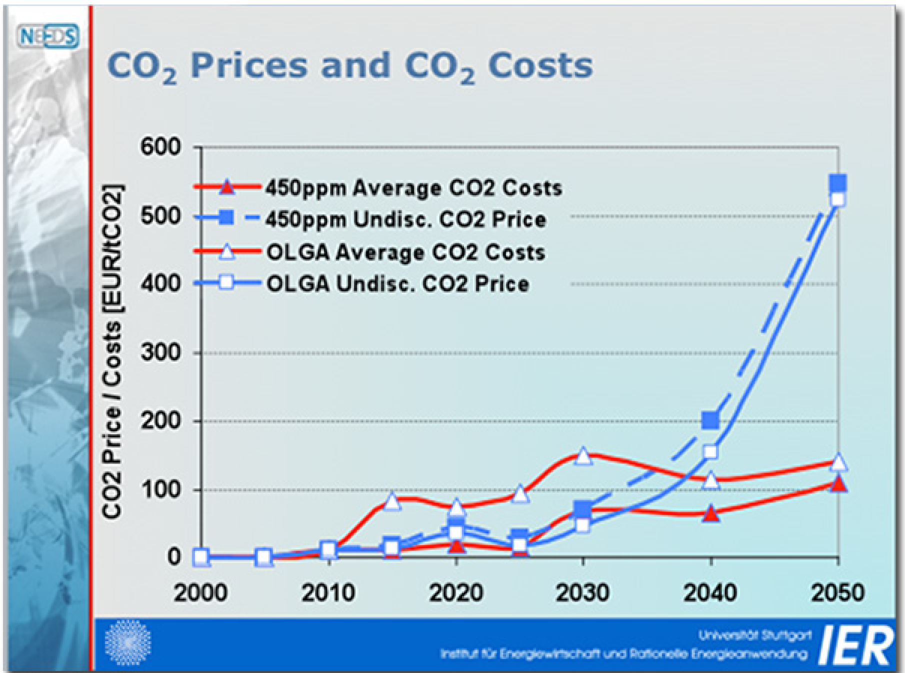


Figure 31: CO2 reduction costs for selected NEEDS scenarios

As can be seen, the BAU scenario is only likely to achieve a share of 8% of RES by 2020, increasing to 14% by 2050, but altogether largely failing to achieve current policy targets. On the other hand, selected policy scenarios can lead to much higher shares of renewables (20-24% in 2020, and 26-31% in 2050), thus demonstrating that current targets can be achieved under specific conditions.

CO2 targets can also be considered realistic under specific conditions, at a cost that might however presently be considered as excessive: thus, a 71% reduction in CO2 emissions is achievable in 2050, at a cost exceeding 500 €/t.

3.2.4 How can we deal with the social dimension of sustainable Energy policies? Which kind of social effects must be considered for the implementation of new Energy technologies?

The query

It is a well known fact that the "social pillar" of sustainability frameworks is the weakest in terms of both methodological developments and subsequently of the robustness of the corresponding appraisals. While the economic and environmental dimensions have been thoroughly analysed, and their quantitative measurement is generally considered to be rather advanced, the social dimension still poses significant conceptual and methodological problems.
The specific issue of appraising the sustainability of energy policies is no exception, and in urgent need of novel developments.

Major improvements from NEEDS

Here is another area where NEEDS has clearly and decisively pioneered, notably through:

- The establishment of a comprehensive and internally consistent set of indicators that cover all three dimensions of sustainability, and therefore, in particular, the "social pillar"
- The careful selection and validation of social indicators through the direct involvement (surveys and questionnaires) of stakeholders
- The sectoral specificity of the selected indicators, which are not "generic", but explicitly related to energy technologies and policies
- The direct use of the framework of indicators within a dedicated MCDA, which has produced a wealth of original results

The highly innovative contents of this work, and its experimental nature, clearly call from some measure of caution in the validation and interpretation of results, while allowing for the identification of improvement opportunities within further research endeavours.

Selected results

The social sustainability criteria were designed, along those addressing the economic and the environmental dimension of the NEEDS framework, to generate a set of indicators for the MCDA. A specific set of indicators was then derived and validated, as illustrated below.

	Criterion	Indicator [Unit]
SOCIAL DIMENSION	SOCIAL AND INDIVIDUAL RISKS	
	Expert-based Risk Estimates for Normal Operation	
	Reduced life expectancy due to normal operation	Mortality due to normal operation [YOLL/kWh]
	Non-fatal illnesses due to normal operation	Morbidity due to normal operation [DALY/kWh]
	Expert-based Risk Estimates for accidents	
	Expected health effects from accidents	Expected mortality due to severe accidents [Fatalities/kWh]
	Maximum consequences of accidents	Maximum credible number of fatalities per accident [Fatalities/accident]
	Perceived Risks	
	Perceived risk characteristics for normal operation	Subjective health fears due to normal operation [Ordinal scale]
	Perceived risk characteristics for accidents	Psychometric variables such as personal control, catastrophic potential, perceived equity, familiarity [Ordinal scale]
	Terrorist Threat	
	Potential of attack	Potential for a successful attack [Ordinal scale]
	Likely potential effects of a successful attack	Expected number of fatalities [Ordinal scale]
	Proliferation	Potential for misuse of technologies and substances within the nuclear energy chain [Ordinal scale]

Source: NEEDS Project; Hirschberg et al., 2007

Figure 32 – From social sustainability criteria to indicators

3.2.5 How do economic sectors compare in terms of their environmental performance?

The query

The sectorial dimension of energy policies is extremely important, whereby different sectors (e.g. household, industry, transport, services) exhibit highly differentiated energy profiles, notably in terms of:

- Their current energy performance/maturity
- The mix of energy sources and the opportunities for substitution
- The ranges of technologies that are specifically relevant
- Their overall weight and relevance in the overall picture of national economies, includ ing trade etc.

On the other hand, the effectiveness of sectorial policies ultimately contributes to the achievement of overall objectives at the national (or regional) level. For instance, the contribution that each individual sector (and possibly sub-sector) can provide to the achievement of energy efficiency, environmental protection and CO2 reduction targets is a well known “hot topic”, one that is currently very high on most political agendas worldwide.

Major improvements from NEEDS

- The NEEDS modelling platform relies on a highly structured and detailed representation of energy systems at the sectorial and subsectorial level, which is fed and supplemented by an original database of energy technologies (including their sectorial relevance).
- This in turn allows for the generation of modelling outputs at levels of disaggregation that illustrate sectorial and subsectorial differentiation.
- Here again, it should be stressed that one of the most original and valuable features of the NEEDS results is their full consistency across countries, ensuring the robustness of cross country comparisons and aggregations.

Selected results

Figure 32 below, which illustrates the relative contribution of the main economic sectors to CO2 emissions for selected scenarios, exemplarily shows the considerable potential role of CCS under specific policy circumstances

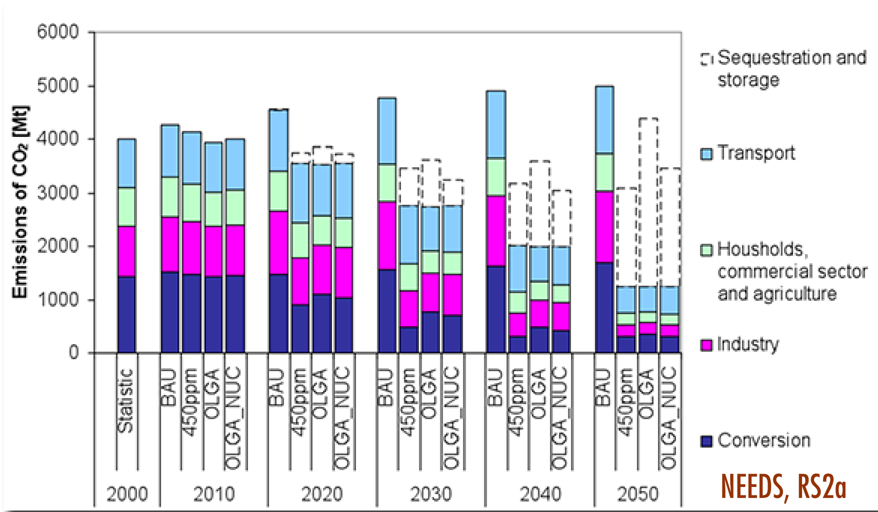


Figure 33 – Contribution of economic sectors to CO2 emissions for selected scenarios, and the potential role of CCS

3.2.6 Is it possible to estimate the extent to which the total external costs of the Energy system "weigh" in the overall economy of a country?

The query

External costs (at least until they are totally or partially internalised), are in fact "hidden" in traditional accounts, whether at the micro level or at the level of national accounts, which therefore provide a misleading picture of the national economy, including distortions that derive from the uneven incidence of external costs on total costs across different sectors and subsectors.

A systematic measure of the absolute and relative importance of external costs is therefore immediately useful to policy makers in order to, notably

- identify priorities of intervention e.g. in those areas/costs categories where external costs are higher
- monitor the impacts of policy interventions on the national economy
- carry out cross country comparisons/benchmarkings

Major improvements from NEEDS

The meaningfulness and usability of results directly depends on the availability and quality of data, and NEEDS has significantly contributed to improving existing datasets through

- the collection of fresh data for countries previously under studied (Eastern and Mediterranean)
- updating and improving the accuracy of existing datasets as a direct result of new methodological developments in NEEDS
- filling data gaps where necessary thanks to the application of the generalisation and transferability approaches developed in NEEDS

Moreover, the further development and application carried out in NEEDS of Green Accounting methods and practice provides new evidence on the welfare effects of adjusting GDP values for environmental effects.

Selected results

As an example, Figure 34 below illustrates, for the external costs of GHG emissions, the highly differentiated incidence of the energy sector in the overall economy across EU 27 Member States

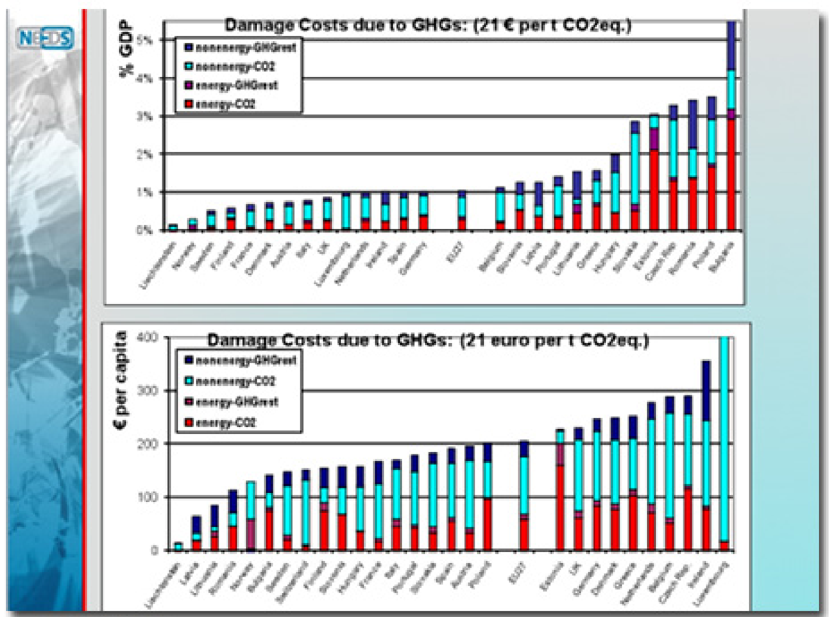


Figure 34 – Contribution of the energy systems to CO2 damage costs

3.2.7 What is the likely impact of alternative scenarios on the future penetration of end use Energy technologies?

The query

Energy systems are not only characterised by the mix of energy supply options and technologies. Their performance also depends considerably on the penetration of end use technologies, especially in terms of the final energy efficiency. In turn, the relative penetration of end use energy technologies strongly depends on the structure of the supply mix and on targeted policies to promote them. Anticipating the impact of future technological developments and that of energy policies on the demand side technologies allow policy makers to identify priorities for demand side and energy efficiency policies, and to anticipate their effects on selected manufacturing sectors.

Major improvements from NEEDS

The level of detail of the representation of the energy systems in the NEEDS modelling platform (and, upstream, in the Technology Repository Database) is such that the effects on demand side technologies can be estimated at a highly disaggregated level.

Selected results

Figures 35 and 36 below illustrates the high differentiated profile of end use technology future contribution depending on the specific characteristics of selected scenarios (respectively for the household and services sector, and for the transport sector)

	BAU	450 ppm	OLGA	OLGA_NUC
Energy saving measures space heating	+	++	++	++
Energy saving measures space cooling	+	++	++	++
Oil boilers	+	●	●	●
Oil condensing boilers	●	+	+	+
Gas boilers	+	–	–	–
Gas condensing boilers	++	+	+	+
Gas heat pump	+	++	++	++
Heat exchanger	+	+	+	+
Absorption heat pump	–	●	●	●
El. groundwater heat pump	●	+	+	+
El. air heat pump	++	+	+	+
Electric heating	++	+	+	+
Compression chiller for space cooling	++	++	++	++
Absorption chiller for space cooling	+	+	+	+
Biomass boilers	++	+	+	+
Solar collectors	+	++	++	++
Advanced electric appliances	+	++	++	++

NEEDS, RS2a

Figure 35- Technologies in household and commercial sector in 2050 in different scenarios

(++ more than 10 %; + between + 10 % and 1 %, o less than 1 %, - not used)

	BAU	450 ppm	OLGA	OLGA_NUC
Diesel	++	++	++	++
Gasoline	++	●	●	●
Hybrid	●	++	+	++
LPG	+	●	●	●
Biodiesel	●	●	●	●
Ethanol	+	+	+	+
Natural Gas	+	+	+	+
Combined combustion	–	–	–	–
Dimethyleter	●	●	●	●
Methanol IC	●	+	●	●
Methanol FC	–	–	–	–
Hydrogen (g) IC	–	–	–	●
Hydrogen (l) IC	–	+	●	●
Hydrogen (g) FC	●	+	++	++
Hydrogen (l) FC	–	–	–	–
Battery electric	●	+	+	+
Plug-In-Hybrid	●	++	++	++

NEEDS, RS2a Figure 36 - Technologies in the transport sector in 2050 in different scenarios

(++ more than 10 %; + between 10 % and 1 %, o less than 1 %; - not used; IC Internal Combustion Engine; FC Fuel Cell; (g) gaseous; (l) liquid)

• 3.3 Investment decision queries

This section deals with the issue of Social Cost Benefit Analysis and its merits/applications in the perspective of the future developments of energy systems. The scale and scope of the investment decisions that can be addressed by SCBA can vary considerably, from the micro level of site specific projects (a new plant), all the way to the assessment of the costs and benefits of EU Directives affecting the energy sector. It therefore regroups a bundle of policy queries that, despite their difference in scope and scale, can be tackled with broadly similar answers, e.g. "How to select the best technology option for a given site specific generation plant?, or "Which energy technologies to invest in the future?" etc.

The queries
Traditional Cost Benefit Analyses fail to explicitly and fully consider the values of those cost and benefit items that are not recorded by an explicit economic transaction, despite their being costs (and benefits) for society in their own right. Decisions that are typically informed by the results of CBA (i.e. investment decisions) are thus based on incomplete information, which can (and often does) significantly distort the final ranking of alternative options, misleading decision makers.

Social Cost Benefit Analysis (SCBA) corrects these distortions by explicitly including the full range of social costs (i.e. including externalities) in the accounting framework. Although SCBA as a concept is now largely accepted, its practical, systematic adoption is often hindered by the lack of reliable data.

Major improvements from NEEDS
NEEDS has made significant progress towards a more systematic and reliable adoption of SCBA, notably through:

- the consolidation of a highly structured, robust and well proven methodology for SCBA, and the publication of detailed and friendly guidance to its application
- the contribution of value transfer techniques (developed and validated in NEEDS) to filling the gaps in site-dependent data that are required for SCBA at the project level (without re-curring to highly resource consuming bottom-up analyses which cannot always be justified at the scale of an individual project decision)
- the illustration of the merits and decision effects of a correct application of SCBA to a series of case studies

Selected results
Several applications of SCBA to the construction of new power plants have been carried out in NEEDS. Figure 37 below shows how the inclusion of external costs and benefits in project assessment can radically change the final results, not only in terms of the viability of each alternative (NPVs changing sign), but, even more importantly, for what concerns the ranking of alternatives, and therefore the option to be preferred.

Cost Benefit Analysis

	Status quo	FBC brown	IGCC	FBC biomass	CHP
PV Investment costs	300	38	494	340	339
PV Operating costs	387	389	475	499	395
PV Benefits	2070	2070	2070	2070	2070
NPV (w/o ext. costs)	1384	1364	1102	1232	1803
Ranking (w/o ext. Costs)	2	3	5	4	1
PV External costs	1340	1891	737	1867	1289
NPV (with ext. Costs)	44	-527	365	-635	514
Ranking (with ext. Costs)	3	4	2	5	1

A.Ricci

PV values in M€ (2005)

Figure 37 – Social Cost Benefits Analysis: the effects of including externalities

PV (NPV): Present Value (Net Present Value)
Comparison of alternative coal combustion technologies (Czech Republic)

- FBC brown = Fluidized bed boiler combusting brown coal
- IGCC = Integrated gasification combined cycle firing hard coal
- FBC biomass = Fluidized bed system cofiring coal and biomass
- CHP = Combined Heat and Power

4 The NEEDS products: format, functionalities and accessibility

The NEEDS "products" can be broadly classified in three main categories:

- Reports, including (i) documents that illustrate methodological issues, the science behind them and the process that has led to their development, and (ii) documents that present the results obtained (both qualitative and quantitative)
- Databases
- Tools, i.e. software that is fully or partially available to third parties.

Reports are by far the most numerous. Although several of these "paper Deliverables" present results that are in fact derived from collaborative work that has involved teams from different Workpackages and Streams, they are by and large "standalone" products, whose fruition is straightforward. Accordingly, it does not seem useful to list and describe here what would in fact be a replication of the list of project Deliverables. The emphasis hereafter is therefore on the other two categories, Databases and Tools, which are more amenable to interactive and dynamic fruition.

4.1 LCA database (RS1a)

This database includes the LCI values for all the technologies analysed within NEEDS. It is worth noting that, beside providing a "cradle to grave" resource assessment and costs for power supply options into the energy models and the IPA framework, in NEEDS LCA has been further developed in a highly innovative direction, whereby processes have been analysed not only based on their present, known characteristics, but also in the perspective of their future evolution (time- and scenario-dependent). The LCI database is freely available on the web via http://www.isistest.com/needswebdb/ (see Figure 38). Data are available in the EcoSpold data format (xml technology), the most widespread and technically most advanced data exchange format worldwide. It allows for an easy import into leading life cycle assessment software tools such as SimaPro, OpenLCA or Umberto. The files are also offered in Excel and html formats.

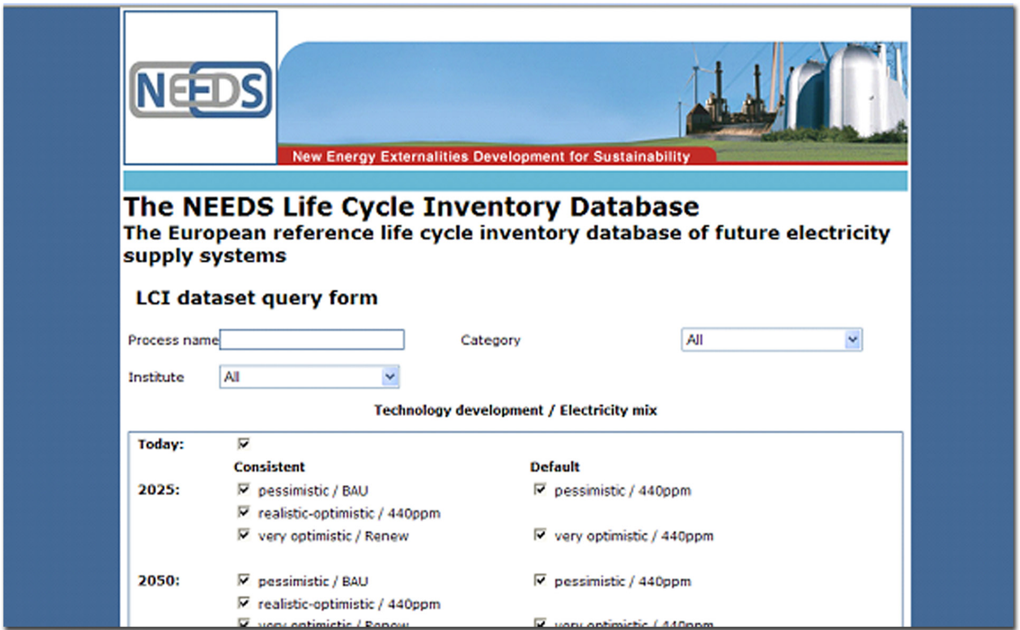


Figure 38 - User interface of the NEEDS life cycle inventory database

4.2 EcoSense Web (RS1b)

EcoSense Web is an interactive tool, developed within NEEDS and incorporating the full range of new findings from the project. It allows to estimate the external costs of energy technologies by taking account of the specific, context dependent variables associated to energy conversion (geography, population densities, etc.). It has been designed to be used also by non experts, and is available on the web. Results can be downloaded by the user who can then further process them to carry out sensitivity analyses, testing alternative assumptions (e.g. regarding monetary valuation in different countries etc.).

EcoSense Web is expected to be directly useful to all European and national policy makers, notably within charge setting processes and cost benefit analyses.

EcoSense Web has already been extensively used and validated within NEEDS (RS3a) to produce generalised values (Euro/ton of emission) per country and for the most important pollutants.

Partners of NEEDS and CASES, as well as EC officers have free access to EcoSense Web. For other users, access will be granted for a small fee, in order to cover (at no profit) the running expenses. EcoSense Web will be updated as improved methodologies and data are available (e.g. new concentration response function, new pollutants, updated monetary values, improved dispersion modelling, etc.). Users will be regularly informed about such updates, and will be provided with the updated methodological references directly on-line.

4.3 Technology repository SubRES (RS2a).

The Reference technology database includes a fairly complete set of technologies involved in all sectors of the economy, namely: primary energy extraction, energy processing and conversion, energy transport, and end-uses by four main sectors (residential, commercial, industry, transportation) with default technological and economical parameters to be used to perform any model development or scenario analysis. All data were assembled in Excel format and converted into a model's user-interface ready format that allows direct import into the models. Among these, thanks to an iterative process of data harmonization among streams, it was possible to constitute a common technology database for the electricity generation sector, that represents a more complete subset of the whole reference technology database. The full description of this database and of how to access it is presented in the Technical Paper RS2a_T2.7: Reference technology database

4.4 Integrated modelling platform: the NEEDS Pan-European model (RS2a)

The 30 NEEDS TIMES country models were implemented on the basis of common European data sources (mainly the Eurostat energy section and DG TREN transport information) integrated with national data to correct major inconsistencies and complete missing data.
Five "templates", that are elaborate Excel spreadsheets, lay down the basic structure of the country models and hold the data necessary to calibrate the energy flows of the base-year (2000) per each sector modelled (RCA: Residential/Commercial/Agriculture, IND: Industry, TRA: Transport, ELC: Electricity/Heat production, and SUP: Energy Supply). To carry out the long term analysis (over a 50-year time horizon) three additional inputs have to be specified into VEDA-FE:

- Existing and future technologies and fuels
- Demand drivers and elasticities
- Scenarios parameters

Technical and economic information on each existing and future technology in each sector (Supply and Power generation, Industry, Residential, Commercial, Transportation) over the entire time horizon are provided in Excel files (SubRes New Techs) that include life cycle emissions coefficients and external costs.

A Business As Usual – BAU scenario was implemented taking into account the national normative on energy and environment and the main requirements of the Pan EU model in order to allow an effective multi-region integration of country in a Pan EU framework.
The results obtained in BAU constitute the baseline for scenarios analysis at country

The ***NEEDS-TIMES Pan European model*** represents a new alternative instrument for policy analysis of the European energy system, allowing to create contrasting scenarios representing the potential development of the energy panorama over the years up to 2050 according to the take up of different policy measures.
It has a complex multi-region structure, based on the integration of 30 EU TIMES country models, including externalities linked to emissions and the main LCI data for EPG technologies.

The model generator utilized for implementing the energy system models is The Integrated MARKAL-EFOM System (TIMES), developed by the Energy Technology Systems Analysis Programme (of the International Energy Agency (IEA), and used worldwide to implement both national and global models.

A common structure for the implementation of the country models was defined, based on a Reference Energy System and a set of data files that fully describe the energy in a format compatible with the associated model generator, allowing to obtain coherent policy insights both at Pan EU and country level. The main macroeconomic and sectoral assumptions are in line with the EU projections were derived with the GEM-E3 general equilibrium model and used to derive the sectoral demand projections. The integration efforts among streams resulted in the introduction of LCA and external costs data into the Pan European model.

A set of contrasting scenarios was defined in agreement with stakeholders and analysed to illustrate how the Pan European TIMES model developed within the NEEDS project can contribute to the evaluation of long term policies for the energy system.

The reference scenario (REF) describes the development of the EU-27 energy system in agreement with most of present policies, providing a baseline for comparing policy scenarios. Besides the Reference scenario, the policy scenarios analysed in the NEEDS project were aimed at addressing different policy issues on the table at EU level like environmental issues linked to energy (climate policy and local pollution linked to energy) and energy issues, such as energy dependence, international oil price, nuclear availability. Moreover, taking into account the current variability of oil prices, it was also investigated in depth the stability of the model's solutions to oil price variations.

This constitutes the basis for the analysis of many possible futures (scenario analysis), according to the aim of the study and stakeholders objectives. In particular, the NEEDS Pan European Model can support decision making by evaluating:

- The impact of targeted air quality EU policies (emissions standards) on emissions, costs and climate change
- The full costs and benefits of EU Directives that have an impact on the energy system
- The impact of different Post Kyoto strategies on the future of energy technologies
- The impact of alternative internalization policies and their contribution to sustainability
- The technologies and policies that exhibit the most robust behavior in an overall sustainability perspective

4.5 Stakeholders database (RS2b)

This database includes an extensive sample of stakeholders. Although contacts are included for 49 countries, including non EU states, it primarily addresses four countries (France, Germany, Italy and Switzerland), plus selected stakeholders in Belgium and the UK. It features ca. 2200 names of targeted stakeholders to whom the NEEDS surveys have been addressed.

4.6 Database of electricity generation technology-specific sustainability indicators (RS2b)

This database also covers the four countries explicitly targeted by the NEEDS surveys. For a full description of this database, please refer to

- RS2b_T3.2: Report on candidate set of criteria and indicators
- RS2b_D3.1: Final set of criteria and indicators to be quantified to the extent possible for the use in NEEDS

4.7 Web based platform for the elicitation of stakeholder preferences (RS2b)

This interactive platform has been design for eliciting stakeholder preferences and for carrying out Multi-Criteria Decision Analysis (MCDA) combining interdisciplinary technology performance indicators with user-specific preferences. For a full description of this tool, please refer to:

- RS2b_T9.2 Report on the survey of suitable MCDA methods and tools, including recommendations for use in NEEDS
- RS2b_T10.1: Final test of MCDA methodology

5 Conclusions and way forward

NEEDS was set out to achieve a variety of very ambitious goals:

- Devising new and improved methodologies, notably for what concerns the LCA of energy technologies, the valuation of external costs, the assessment of stakeholders preferences, the theory and practice of benefit transfer, and the representation and simulation of energy systems in a EU-wide perspective
- Developing and applying tools (databases, models, indicators) to operationalise and validate these new methodologies
- Generating new datasets (LCI, external costs, sustainability indicators) as a result of the application of these tools, and through new surveys and data collection campaigns
- Identifying alternative policy options and simulating their effects within alternative energy scenarios at both the national and the EU level
- Building capacity within and beyond EU Member States to promote the widespread and consistent application of state-of-the-art methods and tools

As extensively documented by the full set of NEEDS Deliverables and Technical Papers (more than 230, all available on the NEEDS website www.needs-project.org), these goals have been abundantly achieved, thanks to the continuing effort of a team of more than 200 scientists and researchers and to the contribution of external stakeholders and policy makers.

Importantly, NEEDS was set up as an Integrated Project, where the reference to Integration means much more than the juxtaposition of individual efforts: in fact, integrating the various components of the project, the multidisciplinary teams behind them and the outcomes thus produced, has proved to be both a challenge and a major source of added value.

The sheer number of partners (more than 60) and their "biodiversity" (geographical, disciplinary, human and cultural), have on the one hand prompted the need for a highly structured approach to management and communication, on the other they have generated a multitude of opportunities to confront and discuss scientific opinions, through heated and at times controversial debates. Ultimately, this has contributed to both the scientific value of results and, through the process of consensus building, to their robustness.

The complex web of interactions between work packages and tasks was identified at the outset and provisions were accordingly made in the project design to ensure the timeliness and effectiveness of information and data exchanges that were known to be critical for the overall project success. In addition, many opportunities for synergies between tasks have emerged in the course of the project, and have in fact generated considerable added value, such as e.g. the intense collaboration between Stream 1d (Extension of geographical coverage) and Stream 3b (Transferability and generalisation).

The complexity of internal collaboration and exchanges also included the need for iterative mechanisms, to ensure e.g. that the input provided by LCA and external cost valuation to the integrated energy models could be then followed by appropriate feedbacks. More such iterations could have been useful, to allow e.g. for the results of Stream 2b (stakeholders perspective) to feed back into externality valuation and into energy models, but time constraints have not always fully allowed to achieve them.

Furthermore, effective integration is a basic requirement for ensuring the policy relevance of the project results. NEEDS has devoted particular attention, and dedicated efforts and resources, to ensuring the policy usability of the results, through the involvement of policy makers and stakeholders, the production of summaries and briefs, the staging of dedicated policy sessions within the project events, and the production of guidelines for the policy use of the project results.

As illustrated in Section 4 of this report, NEEDS has developed operational tools that have not only allowed to generate the outcomes and results that were originally targeted, but – even more importantly – that can be considered as a solid, largely integrated toolbox for further applications and policy support. The NEEDS partners are individually and jointly committed to promote and diffuse this analytical platform and, possibly, to further enhance it and improve it.