# Specifications and requirements for the ATEsT toolbox

## ATEsT Specification Report

## Deliverable D1.1

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## Abstract
In the framework of the SET-Plan the European Commission has initiated action on planning the transition of European energy infrastructure networks and systems towards a low carbon future. This FP7 Support Action is named ATEsT (Analysing Transition Planning and Systemic Energy Planning Tools for the implementation of the Energy Technology Information System). The deployment of low carbon technologies and their supporting infrastructure requires transition planning. The ATEsT project aims to provide a 'toolbox' containing the methodologies, procedures and models required to support the decision making process for this planning process. Essential prerequisites to the tools are that they fulfil the requirements for decision-making on energy system transition planning in the framework of the SET-Plan, are transparent and accessible to all interested parties as well as broadly accepted between Member States. This Specification Report is the first step in which questions and procedures that are considered of interest by various parties relevant to the implementation of the SET-Plan are identified.

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Summary

The development of energy technologies plays a vital role in achieving the European targets of reducing greenhouse gases by at least 20% of 1990 levels, increasing use of renewable energy to 20% of total energy production and cutting energy consumption by 20% of projected 2020 levels by improving energy efficiency. The European Commission pursues to guide the transition of Europe to a low carbon future by launching the Strategic Energy Technology Plan (SET-Plan), which focuses on strengthening and giving coherence to the overall effort in Europe in the advancement of new energy technology development and deployment.

In the framework of the SET-Plan the European Commission has initiated action on planning the transition of European energy infrastructure networks and systems for achieving its objectives. This FP7 Support Action is named ATEsT (Analysing Transition Planning and Systemic Energy Planning Tools for the implementation of the Energy Technology Information System). The deployment of low carbon technologies and their supporting infrastructure requires transition planning. The ATEsT project aims to provide a 'toolbox' containing the methodologies, procedures and models required to support the decision making process for this planning process.

Essential prerequisites to the tools are the fulfilment of the requirements for decision-making on energy system transition planning in the framework of the SET-Plan, transparency and accessibility to all interested parties as well as broad acceptance between Member States (MS). Consensus on the tools is vital. It enhances wider acceptance and understanding of the analysis results that will come out of the application of these tools. Consensus also stimulates the acceptance of the policies that will be derived from this analysis. The first step, of which this report summarizes the results, is to determine which questions and procedures are considered of interest by various parties relevant to the implementation of the SET-Plan.

Input was sought on how energy policy decision making is done in practice. Based on this information a first course draft list of relevant questions and procedures was compiled. From discussions within the ATEsT project team this draft list was refined. The resulting list already hinted on a number of issues and overarching topics that need to be considered:
- Strategic planning
- Technology Deployment and Transition Planning
- Innovation and R&D
- Reinforcing international cooperation

The final discussion and extension of the list of tool specifications took place through a workshop with a number of stakeholders involved in energy policy making and modelling on national and EU level. This workshop also provided the transparency of the toolbox and a basis for consensus between Member States, Industrial Initiatives, the SET-Plan Steering Group, the modelling community and other relevant stakeholders. The final list of specifications resulting from these discussion and consultation efforts is presented in this report. The key findings are listed below.

### *Strategic Planning*
Key issues that were identified under strategic planning are the need for:
- Models to address both long- and short-term options to support the potential and opportunities of technologies in different stages
- Tools to monitor whether industrial developments complement the strategic planning
- Tools which provide means to perform bottleneck analyses.

Technology performance with particular attention to potential for cost reductions will influence the deployment opportunities in the future; therefore it needs to be constantly monitored by means of suitable indicators. Also the interdependencies between energy technologies at various levels in the supply chain, the growth path of new technologies, and their overall impact on the energy system affect the deployment opportunities; these aspects therefore need to be carefully considered. A better understanding is required regarding the effects of various policy instruments on the technology introduction.

*Technology Deployment and Transition Planning*
Technology deployment and transition planning is looking into more applied issues that have to be taken into account during the introduction of new energy technologies. Spatial planning is concerned with identifying the best suitable deployment locations and with those infrastructure characteristics (e.g. connections) that may be required to harness the full benefits. The toolbox should assess the choice of demonstration projects and:

- Incorporate the necessary framework conditions (e.g. logistics)
- Anticipate a further ramp-up of technology deployment by using the demonstration projects as seeds.
- Barriers and time lags related to investment decisions need to be understood.
- Include public acceptance of technologies which are an influencing factor that could possibly hamper technology deployment.
    - The perception of risks
    - Whether better ways of implementation are feasible.

### *Innovation and R&D*

Innovation and R&D are topics that are strongly related to each other. The effects of R&D spending and the distinction between the effect of public and private R&D require further investigation. Setting targets and monitoring progress for R&D are necessary in order to utilize available funds as effectively as possible. From an innovation perspective, the identification of European champions in energy technologies can help to re-focus resources and help to position EU in relation to the rest of the world.

### *International Cooperation*

Improved international cooperation on energy technologies can help to stimulate knowledge development. It may accelerate technology development by sharing costs *and* benefits. So far, the effects of international cooperation on technology R&D have not been properly analyzed. Therefore evaluating which areas are potentially most effective for international cooperation and subsequently targeting these areas for increasing knowledge exchange may help to increase overall strength of the European Union’s position.

### *General Concerns*

The discussions, particularly those during the workshop, showed that the effectiveness of R&D funding and the role of public and private R&D are a major concern. The role and the effectiveness of policy instruments in bringing down costs and stimulating deployment as well as the understanding of the impact of a specific individual technology via policy indicators drew much attention during the workshop and should be included in the tools. This also applies to the interaction between international cooperation and competition. The technology learning curve was frequently mentioned as an instrument for the analysis of the expected cost reduction potential.

The reliability of the methodology and the availability of data are two extremely important points and should be a priority issue for ATEsT. Individual tools should be designed such that their workings are understandable and transparent. The project team should explore what other types of tools are needed in addition to ‘traditional’ (i.e. quantitative) modelling tools. For example, systematic procedures that allow stakeholder involvement and consideration of qualitative information are required to ensure an appropriate consideration of *all* relevant aspects.

Transparency and accessibility of the model toolbox is an essential condition for user acceptance of the tools and the policies based on their outcomes. Assumptions should be made visible in the model to make the model toolbox more credible to SET-Plan stakeholders. Accessibility may be enhanced by providing with an internet application of the models in the toolbox and keeping the models user-friendly and simple.

The survey conducted has resulted in an extensive list of specifications, including expectations and demands on the model toolbox and issues related to data and modelling. Finding the right tools to cover these various aspects as well as composing the required data set will be a major challenge. It is important to realize that in some cases it may be impossible to align tools and data.

# 1. Introduction

With global demand for energy rising, increasing greenhouse gas emissions and reserves of oil and gas concentrating in fewer countries, the European Union (EU) has taken action by proposing strategic energy policy objectives pursuing: A reduction of 20% of its greenhouse gas emissions compared to 1990 levels in a manner compatible with its competitiveness objectives, a market penetration of 20% renewable energy technologies and a 20% gain in overall energy efficiency. In addition, by 2050 global greenhouse gas emissions must be reduced by 50% compared to 1990 levels, implying reductions in industrialized countries by 60 to 80%.

## 1.1 SET-Plan

The development of energy technologies plays a vital role in achieving these targets and to realise the transition of Europe to a low carbon future, the European Commission has launched the Strategic Energy Technology plan (SET-Plan), focusing on strengthening and giving coherence to the overall effort in Europe in the advancement of new energy technology development and deployment. The SET-Plan proposes five implementation pillars:

1. Creating European Industrial Initiatives (EII), focusing on technologies for which the barriers, scale of investments and risk can best be tackled collectively
2. Creating a European Energy Research Alliance (EERA), to enable greater co-operation across Europe of the research work going on in universities, research institutes and specialized centres
3. Planning the transition of European energy infrastructure networks and systems
4. Creating a European Community Steering Group on Strategic Energy Technologies, which will allow Member States and the Commission to plan joint actions and coordinate policies and programmes
5. Establishment of an information system which will ‘map’ technologies and provide updated information to support policy making (SETIS)

The views of the European Commission on the impact and planning of the transition of the Trans-European energy networks and systems of the future are laid out in its Communication COM(2007) 723:

*“…To achieve a sustainable, interconnected European energy system will require massive energy infrastructure change as well as organisation innovation. It will happen over decades, transforming the energy industry and infrastructures, and represent one of the most important investments of the 21$^{st}$ century. Very diverse sectors will be affected, not only energy, environment and transport, but also information and communication technologies, agriculture, competition, trade and others. This will require a multidisciplinary approach to issues that are increasingly interconnected.*

*To plan and develop future infrastructures and policies, it is essential to have a good understanding of the full implications and logistics of new energy technology options.*

*The Commission proposes to initiate in 2008 an action on* European energy infrastructure networks and systems transition planning. *It will contribute to optimise and harmonise the development of low carbon integrated energy systems across the EU and its neighbouring countries. It will help the development of tools and models for European level foresight in areas such as smart, bi-directional electricity grids, CO2 transport and storage and hydrogen distribution.…”*

## 1.2 ATEsT

The European Commission has now initiated action on the 3rd implementation pillar of the SET-Plan with the launch of an FP7 Support Action named ATEsT (Analysing Transition Planning and Systemic Energy Planning Tools for the implementation of the Energy Technology Information System). The aim of the ATeST project is to provide a 'toolbox' containing the methodologies, procedures and models required to support the decision making of the SET-Plan in the priority area of transition planning of the deployment of low carbon technologies and their supporting infrastructures.

The 'tools' that will be evaluated in the framework of ATEsT are methodologies for the analysis of energy policies and mathematical models that can be used in order to simulate the development of the energy system or analyse the transition planning in the energy system. The scope of the ATEsT project includes both tools from inside and from outside of Europe.

The project assesses which tools are already present and provides a roadmap on tools that need to be developed for this purpose. In the base case, there is already a combination of models available in the market which can at least address part of the requirements for supporting decision-making on transition planning in the framework of the SET-Plan. Still, in the worst case there is no model available to answer any of the relevant questions. In the latter case, the heart of the project shifts to the roadmap activities. The project is a joint effort between European research institutes CRES, ECN, ENEA, IER, VTT, PSI, CIEMAT, EIHP and the JRC, the implementing body of the Information System of the SET-Plan (SETIS).

The objectives of the project are to:

1. Review models/tools used in European Countries, bearing in mind what is used outside Europe and what are the requirements of the SET-Plan.
2. Identify and recommend common tools and/or methods to be used in the MS and in SETIS, and gain consensus on these models.
3. Identify and recommend existing sets of data (on technologies, energy resources, statistics, etc.), and provide a roadmap for the development of the data on a European and regional level.
4. Identify the roadmap for the improvement and development of the tools and methods in order to cover the needs of the SET-Plan implementation.

In the process of energy systems planning for the future, given the European vision for the low carbon economy and the requirements for moving forward in new directions, it is important to have a set of common tools to support decisions. Essential prerequisites to the tools are the fulfilment of the requirements for decision-making on energy system transition planning in the framework of the SET-Plan, transparency and accessibility to all interested parties as well as broad acceptance between Member States (MS). Consensus on the tools is vital. It enhances wider acceptance and understanding of the analysis results that will come out of the application of these tools. Consensus also stimulates the acceptance of the policies that will be derived from this analysis. This report shows the result of a study in which we recommend and identify tools that fulfill these criteria.

## 1.3 List of Specifications

The first step is to determine which questions and procedures are considered of interest by various parties relevant to the implementation of the SET-Plan, i.e. a set of firm, broadly consented decision parameters. This information enables the project team to limit the scope for the first objective and provides a first step in gaining the consensus pursued in the second objective.

The list of relevant questions and procedures is presented in this specification report and referred to as the 'list of specifications'. The list is the result of work package 1 of the ATEsT project in which the ATEsT project team established an initial list of specifications which was presented and discussed during a stakeholder workshop. In work package 2 an inventory of existing tools will be created with the intent to cover the specifications set out in the list of specifications. This ‘model characterization report’, together with the list of specifications will serve as an input for the proposal for tools for transition planning and systemic modeling. Subsequently, data requirements are established and the tools are validated. The questions defined in the list of specifications that are not covered by currently available modeling tools will be used for suggestions for future tool development.

The methodology used for creating the list of specifications and improving it based on discussions with relevant stakeholders, is described in Chapter 2. The list of specifications itself is presented in Chapter 3. We conclude with some general observations in Chapter 4. Appendix A contains a glossary explaining abbreviations and terms used in the report. Appendix B, C and D contain the documents created for the stakeholder workshop. Appendix B contains the initial list of specifications prior to discussions with stakeholders.

# 2. Methodology

An initial list of tool specifications needed to be drawn up, as a basis for the subsequently planned stakeholder workshop. This list consists of tools and tool attributes that need to be included in the toolbox, such as model topics and model properties. It also provides some data issues and research priorities, however, these topics will be firmly dealt with in WP4 and WP6. First, input was sought after regarding how energy policy decision making takes place in practice on national level. From this initial assessment a first list was drawn up by the project team that already hinted on a number of issues and overarching topics that need to be considered. The list was then further refined through internal discussions among the project team and with colleagues from ECN Policy Studies. As a result, an initial list of tool specifications was established, structured along the following four overarching topics:

- Strategic Planning
- Technology Deployment and transition planning
- Innovation and R&D
- Reinforcing international cooperation

For each topic, a number of criteria were allocated. The list was sharpened again through a feedback round with the complete ATEsT project consortium. The full initial list of tool specifications prior to the workshop can be found in Appendix B of this report.

The final discussion of the list of tool specifications was planned to take place through a workshop with a number of stakeholders involved in energy policy making and modelling on national and EU level. The workshop took place on January 29th 2010 in Brussels at the University Club. The workshop invitees consisted of relevant governmental officials and academics from all 27 member states, as well as representatives of the EU Industrial Initiatives and Technology Platforms, the involved Directorates-general (DG) of the European Commission, Transport and Energy (TREN) and Research (RTD), and a representation of the ATEsT project team. In total, 49 people participated in the workshop. The full invitation letter for the workshop can be found in Appendix C of this report.

The workshop was structured in two sessions, a morning session and an afternoon session. The full agenda is provided in Appendix D of this report. The morning session was dedicated to provide the audience with a better idea of the ATEsT project and its linkage with the SET-Plan, as well as an introduction to the aims of the workshop and how the workshop results will be further used in the project. The afternoon session focussed on group discussions of the initial list of tool specifications. First, each topic was briefly presented to the complete audience. Afterwards, the workshop participants were divided into four groups of each about 10 participants. Each group discussed the initial list of specifications, provided comments on their relevance and new insights from the participants'[1] point of view. The discussions were moderated by one member of the project team while minutes were taken by another. Each discussion took about 30 min and each group reported their summarized results back to the reconvened audience. This procedure was then repeated for all four topics.

The workshop produced a lot of new material on the tool specifications that was thoroughly processed and checked by the project team for any double mentioning or misplacements of specifications. A streamlined version of the list of tool specifications based on the inputs from the workshop was further on circulated within the whole project consortium. After some incor-

[1] This concerns the participants other than de ATEsT project team members who gave their inputs earlier and later on.

poration of final comments the list of tool specifications was sent out to all the workshop participants for feedback. The final list of tool specifications will be presented in the next chapter.

# 3. List of Specifications

The list of specifications has been divided in five sections, each dealing with one of the main overarching topics:

- General characteristics
- Strategic planning
- Technology deployment and transition planning
- Innovation and R&D
- Reinforcing international cooperation

In each section the key issues are treated in a subsection, providing a short summary of the main findings and an elaborate list of specifications on that particular key issue. The lists distinguish between:

- Expectations and demands - expectations and questions from policy makers, industry, modellers and other stakeholders
- Modelling related issues - requirements and suggestions for modelling solutions
- Data and outcome related issues - requirements and suggestions for data collection and results analysis

## 3.1 General characteristics of the toolbox

The model toolbox resulting from ATEsT should, amongst others, include both detailed technology specific models as well as models describing the complete energy system (the latter using either a bottom-up or a top-down approach). The reason for including both is that technology specific models have different features than energy system models. For example a limitation of including solely technology specific models is that these usually do not consider whether the sum of the supply of various RES options aligns with electricity demand, nor do they account for the interactions between different technologies and sectors within the energy system, nor do they consider the change in energy demand due to energy price. Contrary, many energy system models do not capture the technology evolution in detail and will overestimate the costs. This is a reason why the results of different (bottom-up) technology road-maps do not necessarily coincide with the results from energy system models (which do take into account electricity demand).

The model toolbox should enable a rapid assessment of regularly returning questions from the SET-Plan Steering Group and may also include a more detailed assessment giving a more complete picture, taking into account uncommon and more detailed questions. For the assessment requiring a fast response, a set of specific calculations and sensitivity analyses on technologies could be performed with a simplified model with a short run time (few hours) enabling rapid verification of proposals and sensitivity analyses on a course level, which also includes the effect of these proposals on the entire energy system. For example, it should enable a quick consistency check between the claims of e.g. a technology platform and its impact on the rest of the energy system. However, more ambitious targets may need more modelling efforts in order to understand how they might be reached. Technology specific and system approaches both should be considered in these rapid analyses. Due to their simplicity, rapid assessments also enhance the transparency of the models and provide a better understanding of processes behind transition planning of the deployment of low carbon technologies and their infrastructure.

On the other hand the model toolbox should enable a detailed assessment which, apart from the answers from the rapid assessments, also includes answers on questions that do not come up that often, do not have a particular hurry, or are less subject to change. A longer calculation time is usually required for these detailed model runs.

It is noted that as the list of specifications is quite comprehensive, it requires a broad variety of modelling tools and approaches, e.g. European, global, regional or local models; technology rich or macro-economic models; detailed sub-sectoral or comprehensive energy sector models; etc. A similar reasoning applies to data gathering, which is a challenging area for which efforts need to be as key as for the modelling. It is important to realize that, inevitably, the different types of tools as well as the different types of data required cannot always be aligned.

*Expectations and demands*

- The reliability of the methodology of a tool and the availability of data are two extremely important points and should be a priority issue.
- Individual tools should be designed such that their workings are understandable and transparent.

*Modelling issues*

- ATEsT should explore what other types of tools are needed in addition to 'traditional' (i.e. quantitative) modelling tools: systematic procedures that allow stakeholder involvement and consideration of qualitative data/information are required to ensure appropriate consideration of all relevant aspects.

*Data and outcome related issues*

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## Acceptance of the toolbox

*Expectations and demands*

- Transparency and accessibility of the model toolbox are essential for user acceptance of the results from the tools
  - Transparency: Model assumptions should be made visible in the model in order to increase the credibility to the SET-Plan stakeholders
- Resolution of the model
  - The scope of ATEsT is decision-making on a EU wide basis. The resolution of the models should be defined as to include aspects which have impact on a European level and consider the dynamics of technology markets. A more detailed resolution will for instance, be required, when regional developments are critical from a European perspective
  - Models in the toolbox should connect to the level at which policy decisions are being made and show the effect of these decisions on the overall European energy system (compare technology specific with the system approach). Still, European transition and the achievement of EU targets should be leading.

*Modelling issues*

- Transparency and accessibility of the model toolbox are essential for user acceptance of the results from the tools
  - Accessibility and public acceptance: Internet application of the model
    - Simplicity and usability should be underlined
    - Connect tools to regional i.e. smaller level

*Data and outcome related issues*

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## 3.2 Strategic planning

The overriding goal of the strategic planning activity is (i) to identify technologies that are critical for the EU to meet its European Climate and Energy goals, (ii) to quantify their potential and related impact of their deployment on the EU policy goals and (iii) to assess the impact of research, development and demonstration investment on technology developments and further on the related benefits to the EU policy goals. In general the model toolbox should comprise:

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| *Expectations and demands*<br>• Assessment of the resilience of the energy system against shocks<br>  - Energy prices<br>  - Supply of primary energy sources<br>  - Unforeseen power system failures<br>  - Impact of extreme weather events, e.g. hot weather in France and cooling of nuclear plants<br>• The models should address both short and long term horizon issues.<br>  - Since the initial decisions on the Industrial Initiatives will be taken within this year, the ATEsT results should enable to integrate the results from the implementation of the SET-Plan conceived as a rolling programme by maintaining up-to-date analysis on the first priority technologies and support the next priorities of the SET-Plan.<br>  - The major policy questions regarding the future of the energy systems will arise for the period after 2020 (e.g. in order to reach the targets of 2050) since there is a lot of inertia in the energy system, with most technologies and infrastructures having long lifetimes and high investment requirements |
| *Modelling issues*<br>• The models should address both short and long term horizon issues.<br>• The planning of the energy system's transition should consider the economic growth<br>  - As well as to the economic growth agenda when assessing future developments<br>• In-depth barriers/bottleneck analysis such as infrastructure developments, resource potential/availability/quality, etc. that is/will be required for the deployment of a given technology. Bottleneck analysis is important for the decision-making in the early phase of a technology development and should accompany the strategy planning. |
| *Data and outcome related issues*<br>• The planning of the energy system's transition should consider the economic growth<br>  - As well as to the economic growth agenda when assessing future developments<br>• Reality check of industrial developments will complement the strategic planning that looks forward in time (technology availability, industrial capacity), especially when models predict large capacity expansion in a very short term. |

Other issues related to specific key topics are listed below.

### 3.2.1 Technology performance and development potential

In general technology performance and development potential concern the following issues. The estimation of the effects of additional R, D&D and learning curve effects on a specific technology is of importance to provide a better understanding of the future potential in terms of cost-competitiveness and to improve decision-making. Limited availability of historic data poses a barrier for defining proper learning curves. Including learning curves in the analysis can only be achieved in combination with enhanced data gathering activities. The influence of raw material prices can be significant depending on the technology and have to be also considered in the forecast. Over time, technology performance needs to be measured by means of indicators providing better information on the achievement of targets and necessary re-adjustments. The model toolbox should enable rapid assessment of:

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| *Expectations and demands*<br>• Key performance indicators (KPI)<br>  - Used for monitoring progress in learning, potential for further (power) cost reductions, energy conversion efficiency, environmental performance, deployment, grid integration etc. The definition of KPI is a critical task |
| *Modelling issues*<br>- |
| *Data and outcome related issues*<br>- |

A more elaborate analysis with the toolbox should address technical performance (focused on the technology itself)

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| *Expectations and demands*<br>• Potential and expected cost reduction<br>  - As a function of time<br>  - As a function of deployment<br>  - Learning curves for better understanding of cost evolution<br>• Necessary upfront investments<br>• Operation and Maintenance cost<br>• How much overall efficiency can be gained?<br>  - Per technology option (per kWh and for all installations constructed)<br>  - Consider National/ EU Biofuels targets<br>• Quantify the effect of research development and demonstration on technology cost and technical performance |
| *Modelling issues*<br>• Quantify the effect of research development and demonstration on technology cost and technical performance<br>  - Requires in-depth analysis.<br>    ▪ E.g. via complementing some econometric methodologies such as learning rates with an engineering costing approach as currently performed in the Industry. |
| *Data and outcome related issues*<br>• Potential and expected cost reduction<br>  - Learning curves for better understanding of cost evolution<br>    ▪ This requires high quality cost data which should be constantly updated (monitored)<br>      • Competitiveness (confidentiality) issues may pose a barrier<br>      • Retrieval of reliable data may be hampered by strategic pricing behavior<br>• Ultimate cost level (the level at which raw material prices take over from learning and economies-of-scale effects)<br>  - Reliable data for raw materials, contact to technology platforms could be helpful<br>  - Consider the global economic framework, what is the impact of growing economies in Asia on raw material prices (could be taken into account by a sensitivity analysis)<br>• How much overall efficiency can be gained?<br>  - How to measure energy efficiency improvement?<br>• Quantify the effect of research development and demonstration on technology cost and tech- |

nical performance
- Necessity to reduce the uncertainty gap, by ensuring an accurate and up-to-date data stream for modelling (this is particularly challenging for private R&D investments and activities)
    - Energy technology statistics (including R, D&D data) could be used as a key parameter for robust modelling. However, the availability of reliable data could be a bottleneck.

### 3.2.2 Technology deployment

In general technology deployment concerns the following issues. The choice of location for technology deployment can have an effect on its potential and needs therefore to be taken into account. A strategic planning across country-borders can also help to improve overall potential. The models should be able to show short- and long-term effects as some technologies will only develop their full potential over a longer time horizon, leading to intermediate situations that do not represent the full picture. The model toolbox should enable rapid assessment of:

*Expectations and demands*
- Impact on the energy system structure
- Interdependencies between different technologies
- Effect on the time evolution of technologies and achievement of goals

*Modelling issues*
- Interdependencies between different technologies
    - Systemic approach recommended
    - E.g. Wind turbine support is not successful if not investing in grid development as well.
- Effect on the time evolution of technologies and achievement of goals
    - For long-term modelling it is important to show the short- and medium-term goals and some undesired side effects that have to be accepted in order to reach the long-term target (e.g. for establishing a hydrogen economy)
    - Include the possibility in the models to differentiate between long-term research and short-term demonstration investments. For industry it is important to include the long-term strategic planning in their decisions.

*Data and outcome related issues*
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A more elaborate analysis with the toolbox should address acquisition of data on:

*Expectations and demands*
- Potential analysis: Maximum potential of a given technology and pathway

*Modelling issues*
- Potential analysis: Maximum potential of a given technology and pathway
    - Consider and analyse simultaneously in the strategic planning, different geographical scales from global, EU and regional to be able to understand in a comprehensive way the technology market and derive the right policy tools at the right scale.
    - Need to consider the potential of flexible mechanisms that have to be included in the models because they give the global dimension of market potential. Learning rates for technologies have to be evaluated globally as well.

*Data and outcome related issues*

- Potential analysis: Maximum potential of a given technology and pathway
  - Specify the time horizon
  - Include regional specificities

### 3.2.3 Policy indicators

In general policy indicators concerns the following issues. A better understanding is required regarding the effects of different policy instruments to stimulate deployment and bring down cost. For example how much $CO_2$ reduction may be expected per technology? Policy indicators are also necessary to understand the individual impact of a certain technology towards EU policy goals such as security of supply. It is recommended to have a comprehensive approach with respect to policy instruments for technology development that is to consider and devise at the same time demand pull and technology push instruments. Furthermore, the importance to develop a 'harmonised' methodology for devising policy instruments across Europe has been raised to provide internal market coherence. The model tool box should enable rapid assessment of:

*Expectations and demands*

- The effect of policy instruments:
  - Which instruments are most effective in what stage of technology development?
  - The effect of different forms of stimuli (feed-in tariffs, grants, quota obligations and targets, fiscal measures, etc.) on deployment and price/cost development
  - Effect on the (future) share of renewables in the total energy production
- The effect of public and private R&D
  - The impact of different (proposed) forms of stimulating public or private R&D?
  - Total investment required from public and private funds (for whole program) to make a technology competitive with fossil and nuclear options
  - When is the break-even reached and how to avoid windfall profits?
- Risk assessment
  - Performing R&D in sustainable energy also means that we have be ready for some failures
    - Failures are generally not within the ambitions of the industry
  - Tools capable of dealing with uncertainties and sensitivity analyses are required
  - Identify lock-in situations: technology choice makes 'not chosen' technologies lagging behind because of lack of interests/investment in further development.

*Modelling issues*

- The effect of policy instruments:
  - Shifting technology options
    - It should be possible to calculate different scenarios where specific technology options may be prioritized
- Risk assessment
  - Calculate scenarios with non-success e.g. of technologies (risk assessment, impact on energy system)
    - Tools that can deal with "change of plans"
    - Tools with stochastic methods
    - Simulate what happens to the energy system if technology fails

*Data and outcome related issues*

- The effect of policy instruments:
  - Lessons learned from support schemes in different countries

A more elaborate analysis with the toolbox should address:

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| *Expectations and demands*<br>• How much CO2 reduction per technology also accounting for the deployment of technologies (LCA)<br>• Impact on security of supply for Europe i.e. decreased use of imported fuels and electricity<br>• Economics<br>  - Impacts on economic development and growth<br>  - Employment (see also Deployment and Planning the Transition; Acceptance/perception of technology)<br>  - Societal costs<br>    ▪ External impacts of political decisions<br>    ▪ Health and/or mortality<br>    ▪ Relation between expected cost reduction of a technology and external impacts on e.g. health strongly related<br>  - Other environmental impacts (water, particulates, soil, etc.) than GHG emissions<br>  - System costs<br>    ▪ Minimize (related to complete chain)<br>  - Competitiveness considerations for regional industry. How do vulnerable industries react? (System boundaries)<br>  - Cradle-to-grave (LCA type of analysis)<br>• Capability to account for the possibility of global disturbances like economic crisis 2008/2009 |
| *Modelling issues*<br>- |
| *Data and outcome related issues*<br>- |

## 3.3 Technology Deployment and Transition Planning

Technology deployment and transition planning aims at understanding the transition of the energy system and how it could be implemented. Its goal is to support the decision-making related to investments for instance, in commercial-scale demonstration projects providing guidance on how these projects can be used as seeds for further deployment. This section focuses on Europe; however deployment may also be linked with international cooperation, i.e. deploying technologies and contributing to the energy transition outside Europe.

Within this activity key issues are: spatial planning, deployment pathways, timing, market design and organizational changes, acceptance or perception of technologies and an analysis on the impact of the transition. We elaborate on these issues below.

The broad range of issues involved in energy transition and deployment of new technologies requires the model toolbox to enable examination within a broader framework of system transition, understanding the multi-perspective/dimension and multi-level nature of system transition. Because of the large number of issues and the complexity of their interlinkages, clear boundaries of the tool box are essential to warrant comprehensibility of the tools and their outcomes.

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| *Expectations and demands*<br>• In addition it is required that the tools should rather be made to answer some specific question, than providing output on a broad range of issues at once.<br>• Consideration of uncertainty should be included as well. |
| *Modelling issues*<br>- |
| *Data and outcome related issues*<br>- |

### 3.3.1 Spatial planning

In general spatial planning concerns the following issues. The main focus here is to gain understanding on where energy technologies could best be developed and deployed from a geographic point of view, whereby considering local availability of resources. This also includes geopolitical issues like security of supply. The model tool box should enable rapid assessment of:

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| *Expectations and demands*<br>• Where and when to deploy the technology to anticipate and have a better understanding in, for instance, the requirements for the supply chain, logistics, trans-national electricity interconnections, taking into account environmental aspects, resource potential and other uses<br>• Spatial planning which accounts for the whole energy system, including its infrastructure<br>  - Spatial planning of infrastructure to connect generation capacity to the grid (e.g. in the case of wind and solar power).<br>  - Fuel supply (e.g. for biomass the whole supply chain)<br>• Security of supply issues: Policy issues outside Europe (like policy issues in Northern Sahara countries in the case of Desertec) should be taken into account<br>  - Assessment of how the transition of the energy system affects security-of-supply issues |
| *Modelling issues*<br>- |
| *Data and outcome related issues*<br>- |

A more elaborate analysis with the toolbox should address:

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| *Expectations and demands*<br>• Links to geography<br>  - Potential of an area to provide power with a specific technology<br>  - Where is a technology deployed most effectively<br>    ▪ From a cost perspective<br>    ▪ From a perspective of availability or access to (natural) resources<br>  - Identification of cross-border issues should be considered<br>• Decision for a particular renewable energy technology should also take into account territorial considerations.<br>  - Territorial integration<br>  - Migration flows driven by investments in specific energy technologies<br>  - Feedback effects on labour demand<br>  - Local development<br>  - Possible population concentration close to the energy sources (in stead of bringing en- |

ergy sources to the people)?

*Modelling issues*

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*Data and outcome related issues*

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### 3.3.2 Deployment pathways

In general deployment pathways concern the following issues. Although the main focus of ATEsT is on R&D policy, one should bear in mind that in order to take most benefit from demonstration projects, they should be arranged such that they serve as ideal seeds for further technology deployment. This implies that deployment issues should, to some extend, be included in the ATEsT model toolbox. The model tool box should enable rapid assessment of:

*Expectations and demands*

- Logistics requirement and planning for deployment
  - How grids and transport networks should evolve (including long term effects) to accommodate the shift to a low carbon energy system - concept proposals
  - Balancing capacity requirements
  - Include supply chain logistics (including population size, etc.)
    - Assess whether requirements for deploying a technology are or can be fulfilled reasonably
    - Assess the interaction between local demand and global supply. For example how European demand for biomass affects global availability. What are the consequences of that (environmental effects, biomass price, security-of-supply)
    - Include time dependence of supply chain logistics
    - Include impact of the energy system transition (i.e. impact of changes of the energy system)
- A systemic approach is required combining the results from top-down and bottom-up assessments
  - In order to take into account the changes in demand that could appear as a result of the application of certain technologies (e.g. zero energy buildings etc).
  - To deal with synergies and interdependencies between technological, industrial, social and policy changes
    - E.g. wind turbines support not successful if not investing in grid development as well.
  - Account for agent behaviours both public and private according to their respective role and considering also public-private partnerships
  - To assess the impact of the transition of the energy system on sectoral changes (e.g. implementation of solar energy in buildings makes the construction sector stakeholder in the energy system and stimulates adoption of this new technology into their construction methods.)
- Tools should model effect of 1st demonstration projects in Europe

*Modelling issues*

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*Data and outcome related issues*

- Logistics requirement and planning for deployment
  - Electronics to control the grid
  - TSO’s dealing with intermittent supply

- Interconnections and electricity infrastructure planning

A more elaborate analysis with the toolbox should address:

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| *Expectations and demands*<br>• Transition planning support tools to bridge the gap between demonstration and commercialisation, using demonstration projects as deployment clusters. |
| *Modelling issues*<br>• Barrier analysis: a methodology for analyzing different categories of barriers. |
| *Data and outcome related issues*<br>- |

### 3.3.3 Timing

In general timing concerns the following issues. Understanding of the effect of time delays in implementing a technology. Including tools addressing timing issues may also provide insight on how time-consuming barriers like permitting procedures and investment decision procedures may be reduced. Timing of investments should be taken into account in elaborate assessments. The model tool box should enable rapid assessment of timing effects in case changes in regulations are proposed:

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| *Expectations and demands*<br>• Time lag from investment decision to actually producing energy should be accounted for in the tools<br>  - The effect of different regulatory frameworks in Member States (e.g. the length of permitting procedures) should be accounted for in the model toolbox. Regulatory frameworks are one of the mechanisms affecting the time lag between investment decisions and actually producing electricity. |
| *Modelling issues*<br>- |
| *Data and outcome related issues*<br>• Time lag from investment decision to actually producing energy should be accounted for in the tools<br>  - A model understanding of the time dependencies of the steps in corporate decision processes is preferred |

There are no items identified which may be included in a more elaborate analysis with the toolbox.

### 3.3.4 Market designs and organisational changes

In general market designs and organisational changes concerns the following issues. Although the SET-Plan does not deal with market pull instruments, the implementation of low carbon technologies will imply a demand for more flexibility. Part of the challenge of the transition resides currently in understanding the operating conditions that will be required from the generating units. For instance, there is a current need for a better understanding of the amount of flexibility that will be required from the currently base-load operated plants to integrate such feature into the design of their next generation. It is reminded that integrating such flexibility features will have an impact on the profitability and may require different business models. There are clear need for tool developments and R&D programs on this front. There are no items identified which may be included in a rapid analysis with the toolbox. A more elaborate analysis with the toolbox should address:

*Expectations and demands*
- What are the required changes to overcome market and organisational barriers
- Creation of a level playing field for all market participants (utilizing incumbent and/or novel technologies) within and among Member States

*Modelling issues*
- Creation of a level playing field for all market participants (utilizing incumbent and/or novel technologies) within and among Member States
  - Realization of the distinction between the ideal world in models and the real world where societal and political issues causes deviations from the 'ideal world's' optimum.

*Data and outcome related issues*
- What are the barriers for market participants and other stakeholders (investors, system operators, etc?)
- Creation of a level playing field for all market participants (utilizing incumbent and/or novel technologies) within and among Member States
  - Determine the definition and requirements of a level playing field is crucial

### 3.3.5 Acceptance/Perception of a technology

In general social acceptance and perceptions of technologies (and more in general behavioural responses) concerns the following issues. We acknowledge that public acceptance issues are difficult to integrate in a quantitative modelling approach. 'Measuring' public acceptance is a complex issue. It should be noted that projections of the future acceptance and perception are hard to make. Mathematical models intrinsically are not capable of dealing with uncertainties like the changing logic behind argumentations by which people make decisions or erratic behavior. The nature of mathematical models therefore differs so much from the methodologies and procedures involved in acceptance and perception studies, that interactions between these two approaches are virtually absent. However, having information on perception and acceptance issues in a database and providing guidelines for their systematic consideration may give good insight. On these issues there is no basis for distinguishing between rapid and elaborate assessments. As public acceptance and perception are subject to change, constant monitoring is required. The model tool box should enable rapid assessment of:

*Expectations and demands*
- Quantify employment that can result from the deployment of low carbon technologies (especially when the implementation phase starts)
  - From the supply chain perspective
  - Taking a regional approach
  - Accounting the impact of changes to (i.e. the transition of) the energy system
- Public acceptance of technologies
  - Necessity for and level of public awareness
  - Necessity for and level of public understanding on
    - The technology in itself
    - How to make use of a technology
    - A technology's implications
  - Relations between the expectations and current implementation scale
  - Necessity for pubic participation/user involvement

- Governance issues (e.g. in demand-side management)
- Mistrust in a technology as a reliable energy source
- Energy prices (for different groups: consumer, SME, commodity prices)
- Resistance from stakeholders, based on issues of principle
- Concerns on large companies being involved (only) in order to improve their image
- Influence of competing technologies
- Risk perception
  - Individual investments; high transition and transaction costs
  - Immaturity of technologies (high investment, low income)
  - Reputation of the operator or initiator
  - Management of risks
- Concerns about competences in installation firms
- Management of local supply chains
  - Economically efficient
  - Environmentally sustainable
  - Socially responsible
  - System operation concerns
    - Integration in the grid (especially for small-scale power generation)
    - Intermittency
    - Stability
- Environmental impact
  - Land-use intensity
  - Diverging views on landscape preservation
  - Siting issues
  - Concerns on health impacts
  - Safety issues (and how this is perceived)
- Social impact
  - Local costs and benefit and their equal distribution

*Modelling issues*

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*Data and outcome related issues*

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## 3.4 Innovation and R&D

This topic is as such not part of the structure of the SET-Plan, but created by the ATEsT project team. It deals with specific issues that play a role in innovation and R&D decision-making. Still, these are core activities of SETIS (and the basis of the SET-Plan) through, for instance, the monitoring and review (KPIs) and capacity mapping activities. General issues to consider in the framework of innovation and R&D are:

*Expectations and demands*

- Long term perspective considering
  - Economic potentials
  - Risks by definition involved in research activities

*Modelling issues*

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*Data and outcome related issues*

- Platforms for international cooperation: IEA, IRENA
  - The influence of strategic documents is important to the decisions for demonstration projects and long term research.
- Long term perspective
  - Risks by definition involved in research activities
    - Establishment of an ex-ante monitoring mechanism that is frequent and robust enough to manage these uncertainties and guide the efforts.

For R&D and innovation specifically, the toolbox should include the issues listed below.

### 3.4.1 R&D

In general R&D concerns the following issues. By setting performance targets for technology development, the effects of support measures will become more visible. Monitoring of R&D effects should distinguish between public and private R&D funding and also indicate how much more efforts are necessary to reach the defined technology targets. The model tool box should enable rapid assessment of:

*Expectations and demands*

- The effects of R&D spending (patenting, deployment)
- Public vs. private R&D
  - Distinguish between the effects of public and private R&D
  - Effectiveness of stimulation of co-operation between public and private spending
  - Identify right moment in time to start R&D support

*Modelling issues*

- The multiplier effect of R&D on technology learning and the associated impact on EU policy goals. Although techniques are available, they do not fully capture the early stage of development and industrial dynamics of where the production comes from.

*Data and outcome related issues*

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A more elaborate analysis with the toolbox should address:

*Expectations and demands*

- Definition of technology R&D targets
  - Should be monitored
  - Input for periodical discussions on achievement of (interim) targets
    - Include decision parameters for actions in case of deviations, for example adjustment of time path, increasing the ambitions (when technology develops faster than expected) or lower targets (when technology develops slower than expected)
- Amount of available funding being spent (gives insight in whether there is a structural problem that needs more attention or a logical explanation of why developments lag behind)
- Assessment of R&D funding mechanisms
  - Organization and structure of new technology proposals on a European level (link to EERA)

*Modelling issues*

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| *Data and outcome related issues*<br>• Definition of technology R&D targets<br>  - Should be technology specific |

### 3.4.2 Innovation

In general innovation concerns the following issues. The identification of advanced industry sectors (technologies) within EU countries or in comparison with the rest of the world can help to focus on further development support and initiate cross-border cooperation. This information could also be used in decision making on an EU level if countries should concentrate on their national champions. As a second step, the competitive position of Europe as a whole can be compared with the developments outside and future potential (industrial chances) assessed. The model tool box should enable rapid assessment of:

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| *Expectations and demands*<br>• What is Europe strong at?<br>  - Identification of industry sectors in which Europe has a strong position<br>  - Find out weak sectors<br>    ▪ E.g. to find out for what technologies co-operation among countries should be stimulated and to what extend (how much cooperation?)<br>  - Check Europe's position in technologies compared to the rest of the world, quantify necessary R&D spending to catch up<br>  - Identify European 'champions'<br>    ▪ E.g. for supporting them more than other technologies<br>• Which technologies do we need for reaching our targets (also those after 2020) |
| *Modelling issues*<br>• Which technologies do we need for reaching our targets (also those after 2020)<br>  - Make sure not to just consider industrial strength, but also that you actually contribute to further emission reductions.<br>  - Is the technology economically or environmentally driven? |
| *Data and outcome related issues*<br>• What is Europe strong at?<br>  - Methodological issue: Is being the 'world leader' quantifiable?<br>    ▪ Maybe via export data<br>    ▪ Capacity controlled by European companies could be a useful measure when assessing the present situation |

A more elaborate analysis with the toolbox should address:

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| *Expectations and demands*<br>• Identification of industrial chances<br>  - For example opportunities for Europe's energy industry to expand on global markets<br>• Identification of technologies where we are not the world leader and for which European cooperation is required to arrange further developments effectively and efficiently<br>• Identification of sectors/technologies that need particular attention due to worldwide competition |
| *Modelling issues*<br>- |

*Data and outcome related issues*
- Identification of industrial chances
  - E.g. the global economic potential for a technology and the ability of the European energy industry to have an impact on global developments.

## 3.5 Reinforcing International Cooperation

This activity aims at understanding in which fields international cooperation is beneficial to enhance the transition of the energy system. Its goal is to support decision making related to how cooperation between the EU and third countries enhance the development of energy technologies and their deployment. In general this refers to:

*Expectations and demands*
- Potentials of Joint Implementation (JI) and Clean Development Mechanism (CDM)
  - Can we make our targets elsewhere outside the EU

*Modelling issues*
- Potentials of Joint Implementation (JI) and Clean Development Mechanism (CDM)
  - Include a representation of the rest of the world in the toolbox in order to analyze JI and CDM options
    - This is already done to a certain extent in existing models. These models should be used to analyze the quota obligations for investments in mitigation technologies, following the Copenhagen decisions.

*Data and outcome related issues*
- Potentials of Joint Implementation (JI) and Clean Development Mechanism (CDM)
  - Can we make our targets elsewhere outside the EU
    - Methodological issue: Costs in non-OECD countries might be difficult to define however, methodologies have been developed.

### 3.5.1 International cooperation on R&D

In general international cooperation on R&D concerns the following issues. Continuously changing international developments in R&D strategies and interests require for constant updating of the assessments for possibilities for international cooperation (outside Europe). Still, we can make a distinction between information that should be available at short notice and information that could be covered in a more elaborate analysis. The model tool box should enable rapid assessment of:

*Expectations and demands*
- Need to better model the role of knowledge sharing platforms[2]
  - Identification of win-win situations is required; areas in which international cooperation is beneficial both to European and other parties
  - Monitor the effects of international cooperation on R&D for example jointly with IEA or the new International Renewable Energy Agency (IRENA) as deemed necessary in the implementation of the SET-Plan

[2] Considering different levels of legal framework for knowledge exchange (e.g. intellectual property right issues). It is stressed that this knowledge sharing can be a formidable accelerator of technology development, but also a source of negative regional spill-over (industrial associations sustain that, due to unfair competition, sharing information sometimes cannot be considered an optimal strategy; in any case intellectual property rights have to be maintained).

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| ▪ Or other well-established cooperation vehicles which properly cover intellectual property issues<br>- Identify the need for global centres of excellence:<br>▪ Identify (potential) centres of excellence already active in these fields and determine if they already exist or should still be developed?<br>▪ Identify fields in which centres of excellence should be developed (identify in which areas acquiring/attracting talent is required)<br>• What are the main interests of research here and outside the EU<br>- For identifying with whom to create common programs<br>- Cooperate on technologies where even the EU cannot bear the costs alone (e.g. nuclear fusion)<br>- Technology mapping: international comparison of the state-of-the-art in different technologies (not technology fields) at the world level. Compare which technologies connect to European knowledge<br>- Identifying fields for cooperation by mapping international (governmental) investments and programs such as support instruments like feed-in tariffs, etc.<br>- Beware: This could also be Europe's main competitors so mapping of conditions under which countries are likely to cooperate/compete is required.<br>- Make sure that knowledge is not transferred in one direction (brain drain) but that all parties (European and other parties) benefit.<br>- Knowledge produced outside Europe should be taken mind, as well as possible investments from outside Europe to research centres within the EU.<br>• Combining the information on the identified win-win situations for cooperation, in particular the identification of 'centres of excellence' in third countries with the identified partners for common programmes and addressing these particular countries result in a list of potential partners recommended for EERA and the EIIs to engage with. |
| *Modelling issues*<br>- |
| *Data and outcome related issues*<br>• Need to better model the role of knowledge sharing platforms<br>- Monitor the effects of international cooperation on R&D for example jointly with IEA or the new International Renewable Energy Agency (IRENA) as deemed necessary in the implementation of the SET-Plan<br>▪ Good example: ITER (in which global resources are essential to made the project happen; no country or continent can bear this project alone)<br>▪ The influence of strategic documents is important to the decisions for demonstration projects and long term research. |

A more elaborate analysis with the toolbox should address:

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| *Expectations and demands*<br>• Benefits of international cooperation initiatives like IPHE, CSLF<br>- The effect of turning partial spill-over to perfect spill-over (for example by exchanging knowledge on local learning aspects of energy technologies like installation, utilization, etc. |
| *Modelling issues*<br>- |

*Data and outcome related issues*

- Benefits of international cooperation initiatives like IPHE, CSLF
  - Mapping of past international cooperation's
    - What have they brought/effectiveness?

### 3.5.2 Technology deployment issues in international cooperation

In general technology deployment issues in international cooperation concerns the following. The model toolbox requires taking into account the consequences of international cooperation in technology development. This includes assessing where international cooperation is potentially most effective, analysing its effect on global developments and whether its benefits are equally distributes among all partners. These issues need constant updating. The model tool box should enable rapid assessment of:

*Expectations and demands*

- Assessment of spill-over between different regions of the world and sectors.
- Development of deployment and costs outside Europe

*Modelling issues*

- Assessment of spill-over between different regions of the world and sectors.
  - To address this issue modellers suggest a two step strategy in order to evaluate benefits of international cooperation and to decide whether or not it is worth to sell a technology to another country or another sector. They suggest running initially a technology explicit model in order to understand which could be the winning technologies at a global level (and the dimension of the related market). They also suggest running a general equilibrium model in order to evaluate which regions gain from the trade of the emerging technologies. For the market distortions that cannot be taken into account by the general equilibrium model, modellers suggest using surveys in order to assess these aspects.

*Data and outcome related issues*

- Development of deployment and costs outside Europe
  - Purse joint efforts with the IEA with respect to technology outlooks and projections, 'toolbox' development and use, harmonise the databases with the IEA databases. Make the constraints that have been applied in the development of these databases clear and available.
- Monitor the different market developments to ensure an equal footing and to have a benchmark of the efforts (e.g. R&D investment) and developments (capacity, cost etc.) occurring in the different regions of the world.

A more elaborate analysis with the toolbox should address these same items.

# 4. Conclusion

The final discussion and extension of the list of tool specifications took place through a workshop with a number of stakeholders involved in energy policy making and modelling on national and EU level. This workshop also provided the transparency of the toolbox and a basis for consensus between Member States, Industrial Initiatives, the SET-Plan Steering Group, the modelling community and other relevant stakeholders. The final list of specifications resulting from these discussion and consultation efforts is presented in this report. The key findings are listed below.

### *Strategic Planning*

Key issues that were identified under strategic planning are the need for:

- Models to address both long- and short-term options to support the potential and opportunities of technologies in different stages
- Tools to monitor whether industrial developments complement the strategic planning
- Tools which provide means to perform bottleneck analyses.

Technology performance with particular attention to potential for cost reductions will influence the deployment opportunities in the future; therefore it needs to be constantly monitored by means of suitable indicators. Also the interdependencies between energy technologies at various levels in the supply chain, the growth path of new technologies, and their overall impact on the energy system affect the deployment opportunities; these aspects therefore need to be carefully considered. A better understanding is required regarding the effects of various policy instruments on the technology introduction.

*Technology Deployment and Transition Planning*

Technology deployment and transition planning is looking into more applied issues that have to be taken into account during the introduction of new energy technologies. Spatial planning is concerned with identifying the best suitable deployment locations and with those infrastructure characteristics (e.g. connections) that may be required to harness the full benefits. The toolbox should assess the choice of demonstration projects and:

- Incorporate the necessary framework conditions (e.g. logistics)
- Anticipate a further ramp-up of technology deployment by using the demonstration projects as seeds.
- Barriers and time lags related to investment decisions need to be understood.
- Include public acceptance of technologies which are an influencing factor that could possibly hamper technology deployment.
    - The perception of risks
    - Whether better ways of implementation are feasible.

### *Innovation and R&D*

Innovation and R&D are topics that are strongly related to each other. The effects of R&D spending and the distinction between the effect of public and private R&D require further investigation. Setting targets and monitoring progress for R&D are necessary in order to utilize available funds as effectively as possible. From an innovation perspective, the identification of European champions in energy technologies can help to re-focus resources and help to position EU in relation to the rest of the world.

### *International Cooperation*

Improved international cooperation on energy technologies can help to stimulate knowledge development. It may accelerate technology development by sharing costs *and* benefits. So far, the effects of international cooperation on technology R&D have not been properly analyzed. Therefore evaluating which areas are potentially most effective for international cooperation and subsequently targeting these areas for increasing knowledge exchange may help to increase overall strength of the European Union's position.

*General Concerns*

The discussions, particularly those during the workshop, showed that the effectiveness of R&D funding and the role of public and private R&D are a major concern. The role and the effectiveness of policy instruments in bringing down costs and stimulating deployment as well as the understanding of the impact of a specific individual technology via policy indicators drew much attention during the workshop and should be included in the tools. This also applies to the interaction between international cooperation and competition. The technology learning curve was frequently mentioned as an instrument for the analysis of the expected cost reduction potential.

The reliability of the methodology and the availability of data are two extremely important points and should be a priority issue for ATEsT. Individual tools should be designed such that their workings are understandable and transparent. The project team should explore what other types of tools are needed in addition to 'traditional' (i.e. quantitative) modelling tools. For example, systematic procedures that allow stakeholder involvement and consideration of qualitative information are required to ensure an appropriate consideration of *all* relevant aspects.

Transparency and accessibility of the model toolbox is an essential condition for user acceptance of the tools and the policies based on their outcomes. Assumptions should be made visible in the model to make the model toolbox more credible to SET-Plan stakeholders. Accessibility may be enhanced by providing with an internet application of the models in the toolbox and keeping the models user-friendly and simple.

The survey conducted has resulted in an extensive list of specifications, including expectations and demands on the model toolbox and issues related to data and modelling. Finding the right tools to cover these various aspects as well as composing the required data set will be a major challenge. It is important to realize that in some cases it may be impossible to align tools and data.

# Appendix A Glossary

**ATEsT**: Analysing Transition Planning and Systemic Energy Planning Tools for the implementation of the Energy Technology Information System
**CDM**: Clean Development Mechanism
**CSLF**: Carbon Sequestration Leadership Forum
**EERA**: European Energy Research Alliance
**EII**: European Industrial Initiatives
**EU**: European Union
**IEA**: International Energy Agency
**IPHE**: International Partnership for the Hydrogen Economy
**IRENA**: International Renewable Energy Agency
**ITER**: International Thermonuclear Experimental Reactor
**JI**: Joint Implementation
**KPI**: Key Performance Indicators
**LCA**: Life Cycle Analysis
**OECD**: Organisation for Economic Co-operation and Development
**R&D**: Research and Development
**R, D&D**: Research, Development and Demonstration
**RES**: Renewable Energy Sources
**SETIS**: SET-Plan Information System
**SET-Plan**: Strategic Energy Technology Plan
**SET-Plan Steering Group**: European Community Steering Group on Strategic Energy Technologies
**Tool**: methodology that needs to be applied in software as well as software-supported systematic frameworks and procedures that are capable of handling e.g. qualitative data in appropriate ways.
**Transition planning**: Analyse and recognize the evolution of the energy system reaching the target point, focusing on the technology mix of the entire energy chain, including analysis of the social impact, policy drivers and sustainability.
**TSO:** Transmission System Operator

# Appendix B Workshop background information

## B.1 Project and Workshop Background

ATEsT

***Analysing Transition Planning and Systemic Energy Planning Tools for the implementation of the Energy Technology Information System***

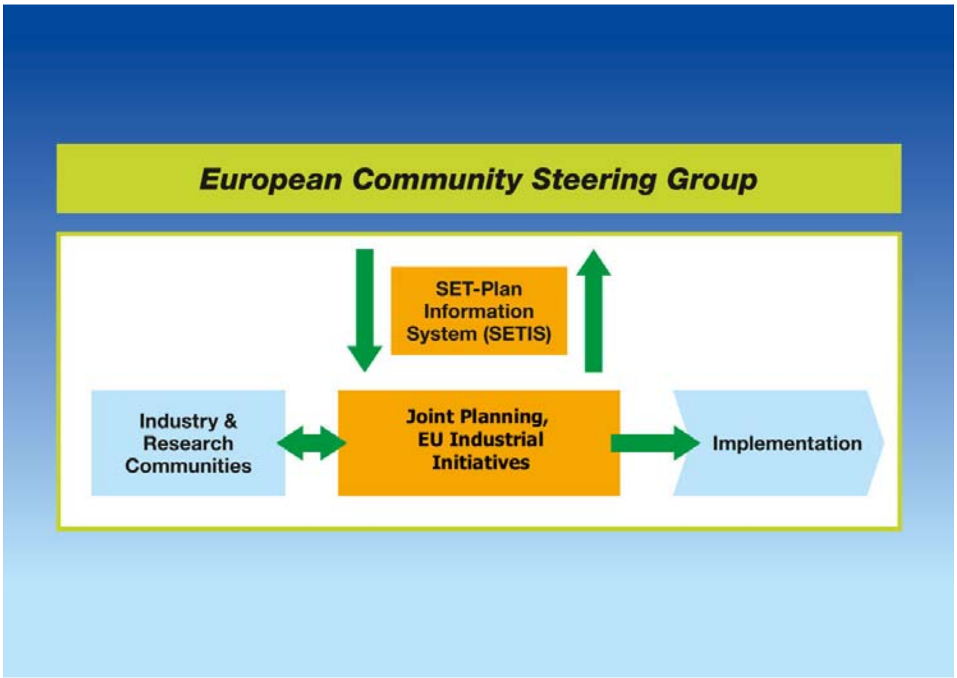
## ATEsT stakeholder workshop background information

Brussels, 29 January 2010

*The SET-Plan*

The European Strategic Energy Technology Plan (SET-Plan) is the technology pillar of the EU's energy and climate policy. It is a blueprint for Europe to develop a world-class portfolio of affordable, clean, efficient and low emission energy technologies through coordinated research. It has been proposed by the Commission on 22 November 2007, and endorsed by the Council of the European Union and the European Parliament as the appropriate way forward. It lays out the EU's strategy to accelerate the development of these technologies and to bring them more quickly to the market.

The SET-Plan describes concrete actions to build a coherent energy research landscape in Europe. The idea is to better organize research efforts across Europe, selecting technologies with the greatest potential and planning together how money should be invested.



Alongside the European Industrial Initiatives (EII) and the European Energy Research Alliance (EERA), the 3rd implementation pillar relates with activities addressing future *European energy infrastructure networks and systems transition planning.*

**Trans-European energy networks and systems of the future** COM(2007) 723

*"…To achieve a sustainable, interconnected European energy system will require massive energy infrastructure change as well as organisation innovation. It will happen over decades, transforming the energy industry and infrastructures, and represent one of the most important investments of the 21st century. Very diverse sectors will be affected, not only energy, environment and transport, but also information and communication technologies, agriculture, competition, trade and others. This will require a multidisciplinary approach to issues that are increasingly interconnected.*

*To plan and develop future infrastructures and policies, it is essential to have a good understanding of the full implications and logistics of new energy technology options.*

*The Commission proposes to initiate in 2008 an action on* European energy infrastructure networks and systems transition planning*. It will contribute to optimise and harmonise the development of low carbon integrated energy systems across the EU and its neighbouring countries. It will help the development of tools and models for European level foresight in areas such as smart, bi-directional electricity grids, CO2 transport and storage and hydrogen distribution…."*

*ATEsT*

The European Commission has now initiated action on the 3rd implementation pillar with the launch of an FP7 Support Action named ATEsT (Analysing Transition Planning and Systemic Energy Planning Tools for the implementation of the Energy Technology Information System).

The aim of the ATeST project is to address the methodologies and modelling toolbox required to support the decision making of the SET-Plan in the priority area of transition planning of the deployment of low carbon technologies and their supporting infrastructures, through a joint effort between European research institutes (CRES, ECN, ENEA, IER, VTT, PSI, CIEMAT, EIHP) and the JRC, the implementing body of the Information System of the SET-Plan (SETIS).

The "tools" that will be evaluated in the framework of ATEsT are methodologies for the analysis of energy policies and mathematical models that can be used in order to simulate the development of the energy system or analyse the transition planning in the energy system.

The objectives of the project are to:

1. Review models/tools used in European Countries, bearing in mind what is used outside Europe and what are the requirements of the SET-Plan.

2. Identify and recommend common tools and/or methods to be used in the MS and in SETIS, and gain consensus on these models.

3. Identify and recommend existing sets of data (on technologies, energy resources, statistics, etc.), and provide a roadmap for the development of the data on a European and regional level.

4. Identify the roadmap for the improvement and development of the tools and methods in order to cover the needs of the SET-Plan implementation.

More information can be found on the ATeST project website: http://www.atest-project.eu/.

*This workshop*

Determining which information is needed by policy makers to enable their decision making concerning the transition towards a low carbon energy system is one of the key objectives of the project. This information serves as specifications for the modelling toolbox used to analyse the energy system as well as the planning of the transition. Below, an initial list of specifications is drafted which reflects the current view of the ATEsT project team. The aim of the workshop is to retrieve feedback on this draft list of specifications and share recommendations and suggestions on which information is essential to come to good decisions in the framework of the SET-Plan. The intended result is a set of broadly consented decision parameters.

## B.2 Initial List of Specifications (prior to the workshop)

### B.2.1 Strategic planning

The overriding goal of this activity is (i) to identify technologies that are critical for the EU to meet its European Climate and Energy goals, (ii) to quantify their potential and related impact of their deployment on the EU policy goals (iii) to assess the impact of RD&D investment on technology developments and further on the related benefits to the EU policy goals.

Key issues to consider are:

Technology performance and development potential

- Technology costs ((upfront) investment, O&M etc.
- Technology environmental performance
- Technical performance

- Expected cost reduction
  - Potential for cost reduction
    - as a function of time
    - as a function of deployment
  - Ultimate cost level (the level at which raw material prices take over from learning and economies-of-scale effects)
  - Total investment required from public and private funds (for whole program) to make technology competitive with fossil and nuclear options
  - Potential for technical improvements

Technology deployment
- Maximum potential of a given technology and pathway at which time horizon
- Regional specificities
- Impact on the energy system structure

Policy indicators
- How much CO2 reduction per technology
  - Also accounting for the deployment of technologies
- How much % renewables
- How much efficiency gain
  - Overall
  - Per technology option (per kWh and for all installations constructed)
  - Consider National/ EU/ Biofuels targets
- Impact on EU security of supply
  - Decreased use of imported fuels and electricity

- Economics
  - Societal costs
  - System boundaries
    - Competitiveness considerations for regional industry. How do vulnerable industries react?
    - healthcare costs
    - etc.
  - Shifting technology options

        - It should be possible to calculate different scenarios where specific technology options may be prioritized
    - The effect of different forms of stimuli (feed-in tariffs, grants, quota obligations and targets, fiscal measures, etc.) on deployment and price/cost development
- External impacts of political decisions
    - Health and/or mortality
    - Other environmental impacts (water, particulates, soil, etc.) than ghg emissions
    - Employment
    - Etc.

### B.2.2 Deployment and planning the transition

This activity aims at understanding the transition of the energy system and how it could be implemented. Its goal is to support the decision-making related to investments for instance, in commercial-scale demonstration projects providing guidance on how these project can be used as seeds for further deployment etc.

- *Spatial planning*
    - Where and when to deploy the technology to anticipate and have a better understanding in, for instance, the requirement in supply chain, logistics, trans-national electricity interconnections, taking into account environmental aspects, resource potential and other uses
- *Deployment pathways*
    - how demonstration projects can be used as seeds for deployment ramp-up
    - How grids and transport networks should evolve to accommodate the shift to a low carbon energy system - concept proposals
    - Logistics requirement and planning for deployment

- *Market designs and organisational changes*
    - What are the barriers, required changes

- *Acceptance of technology*
    - Behavior change
    - Public acceptance of technologies
    - People's perceptions on technologies
    - Having this sort of information in the database may already be enough, projections for the future are hard to make

- *Impact analysis of the transition*
    - System reliability, Security of supply
    - Supply chain and logistics
    - Economics
    - Employment
    - Sectoral changes etc.

### B.2.3 Innovation & R&D

- R&D funding mechanisms
- Industrial chances
    - For example opportunities for Europe's energy industry to expand on global markets. This may be expressed in the global economic potential for a technology and the ability of the European energy industry to have an impact on global developments.
- Influence of strategic documents

- Learning potential
  - Rate of cost reduction
  - Ultimate cost level
- Long term perspective
  - Economic potentials
- What is Europe strong at?
- What are the Member States strong at?
- Which technologies do we need to reach our targets (also those after 2020)
  - Make sure not to just consider industrial strength, but also that you actually contribute to further emission reductions.
  - Is the technology economically or environmentally driven?
- Are the areas that need particular attention due to worldwide competition?

### B.2.4 Reinforcing international cooperation

This activity aims at understanding in which fields international cooperation is beneficial to enhance the transition of the energy system. Its goal is to support decision making related to how cooperation between the EU and third countries enhance the development of energy technologies and their deployment.

- Potentials of Joint Implementation and Clean Development Mechanism
  - Can we make our targets elsewhere outside the EU
  - Which technologies do we need (and in what form)
- Benefits of international cooperation initiatives like IPHE, CSLF
  - The effect of turning partial spill-over to perfect spill-over (for example by exchanging knowledge on local learning aspects of energy technologies like installation, utilization, etc.
- Development of deployment and costs outside Europe (i.e. integrate IEA projections in SETIS)
  - for example for exploring possibilities of free riding

# Appendix C Workshop Invitation Letter

| | | | | | |
|---|---|---|---|---|---|
| Date | : | Amsterdam, 25 November 2009 | Tel direct | : | +31 224 56 4143 |
| Your ref. | : | | Fax direct | : | +31 224 56 8339 |
| Our ref. | : | | E-mail | : | schoots@ecn.nl |

Subject : personal invitation to ATEsT stakeholder workshop

Dear Mr./Mrs. …,

The European Strategic Energy Technology Plan (SET-Plan) adopted by the Commission on 22 November 2007, and endorsed by the Council of the European Union on 28 February 2008 has proposed three main implementation instruments as a basis for an Energy Technology Policy for Europe.

Alongside the European Industrial Initiatives and the European Energy Research Alliance, the $3^{rd}$ implementation pillar relates with activities addressing future *European energy infrastructure networks and systems transition planning.* The European Commission has now initiated action on this front with the launch of an FP7 Support Action named ATEsT (Analysing Transition Planning and Systemic Energy Planning Tools for the implementation of the Energy Technology Information System).

This project aims to address the methodologies and modelling tool-box required to support the decision-making of the SET-Plan in the priority area of transition planning of the deployment of low carbon technologies and their supporting infrastructures, through joint efforts between European research institutes and the Information System of the SET-Plan (SETIS).

One of the primary activities of the project is to determine which information is needed by policy makers to enable their decision making concerning the transition towards a low carbon energy system. On this front, we organize a workshop, in which, we wish to engage with key stakeholders involved in the decision making around the SET Plan. The aim of the workshop is to establish a set of broadly consented decision parameters. Hence, the workshop will be a forum to share recommendations and suggestions on which information is essential to come to good decisions and to provide feedback on the ATEsT project team's vision. During this workshop we will also present the objective of the ATEsT project, our methodology and how your input will be used in the course of the project.

**Energy research Centre of the Netherlands**

| | | | |
|---|---|---|---|
| Petten | P.O. Box 1, 1755 ZG Petten<br>Westerduinweg 3, Petten, The Netherlands | Tel. : +31 224 56 43 47<br>Fax : +31 224 56 83 38 | VAT number : NL001752625B01<br>Trade Register : 41151233 |
| Amsterdam | P.O. Box 56890, 1040 AW Amsterdam<br>Radarweg 60, Amsterdam, The Netherlands | Tel. : +31 224 56 44 31<br>Fax : +31 224 56 83 39 | www.ecn.nl |

The workshop will be attended by representatives from various relevant European Technology Platforms, the modelling community and staff from Commission Services.

We would like to enable your organization to express its views on the decision parameters required and therefore we cordially invite you to attend this workshop. It will be held in ***Brussels on 29 January 2010***. Please register by giving notice to Koen Schoots of ECN Policy Studies until December 11, schoots@ecn.nl, +31 224 56 4143. Registered participants will be sent a full program and details about the time and venue in due time. Please note that neither the ATEsT consortium nor the Commission will be able to reimburse your expenses.

On behalf of the ATEsT project team,
Yours sincerely,

Dr. K. Schoots
ECN Policy Studies

# Appendix D Workshop Program

## AGENDA
## Stakeholder Meeting

***Club of the University Foundation***
***Egmontstraat 11/rue d'Egmont 11 - 1000 Brussels***

**Friday, January 29th 2010**

10:00 Registrations and Coffee

10:30 Start of the meeting
Opening by *K. Schoots (ECN) and G. Giannakidis (CRES)*

*Plenary presentations*

10:45 Introduction SETIS – *A. Mercier (JRC-IE)*

11:15 Overall description of the ATesT project.
Presentation of the goals and expected outcomes – *G. Giannakidis*

11:45 Coffee break

12:00 WP1- Specifications of models by *K. Schoots (ECN)*
Summary and linkage to the workshop

12:30 WP2- Identification of common tools by *U. Ciorba (ENEA)*
Methodology & linkages with the workshop

13:00 Lunch break.

*Group discussions*

The discussions are structured along the SET-Plan structure. For each topic the ATEsT project team will present its view on the specification of the tools that are needed to support decision making for European energy technology policy. The following issues will be discussed:

- How does the ATEsT framework fit the needs to support decision making on the SET-Plan?

- What energy technology policy questions are relevant?
- What tools are needed to answer these questions?
- Which geographical levels (EU, MS, regions) should be addressed by the modelling framework?
- How do the specified tools relate to the possibilities models have to offer, i.e. are there models available to provide answers to specific policy questions?

The discussion will be structured along the following topics:

14:00 Strategic Planning – *K. Schoots (ECN)*

14:45 Deployment and planning the transition – *I. Bunzeck (ECN)*

15:30 Coffee break

15:45 Innovation and R&D – *K. Schoots (ECN)*

16:30 Reinforcing international cooperation – *I. Bunzeck (ECN)*

17:15 Wrap-up of the meeting and conclusions by *K. Schoots (ECN) and G. Giannakidis (CRES)*

17:30 End of meeting