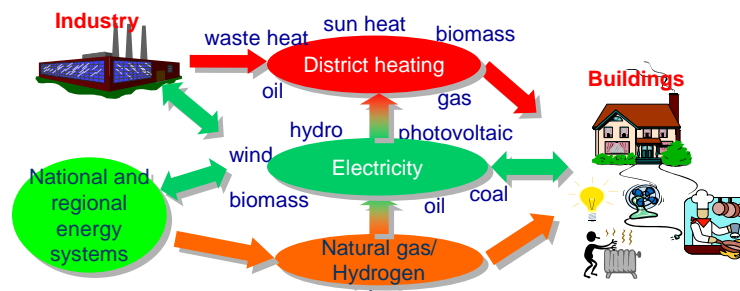


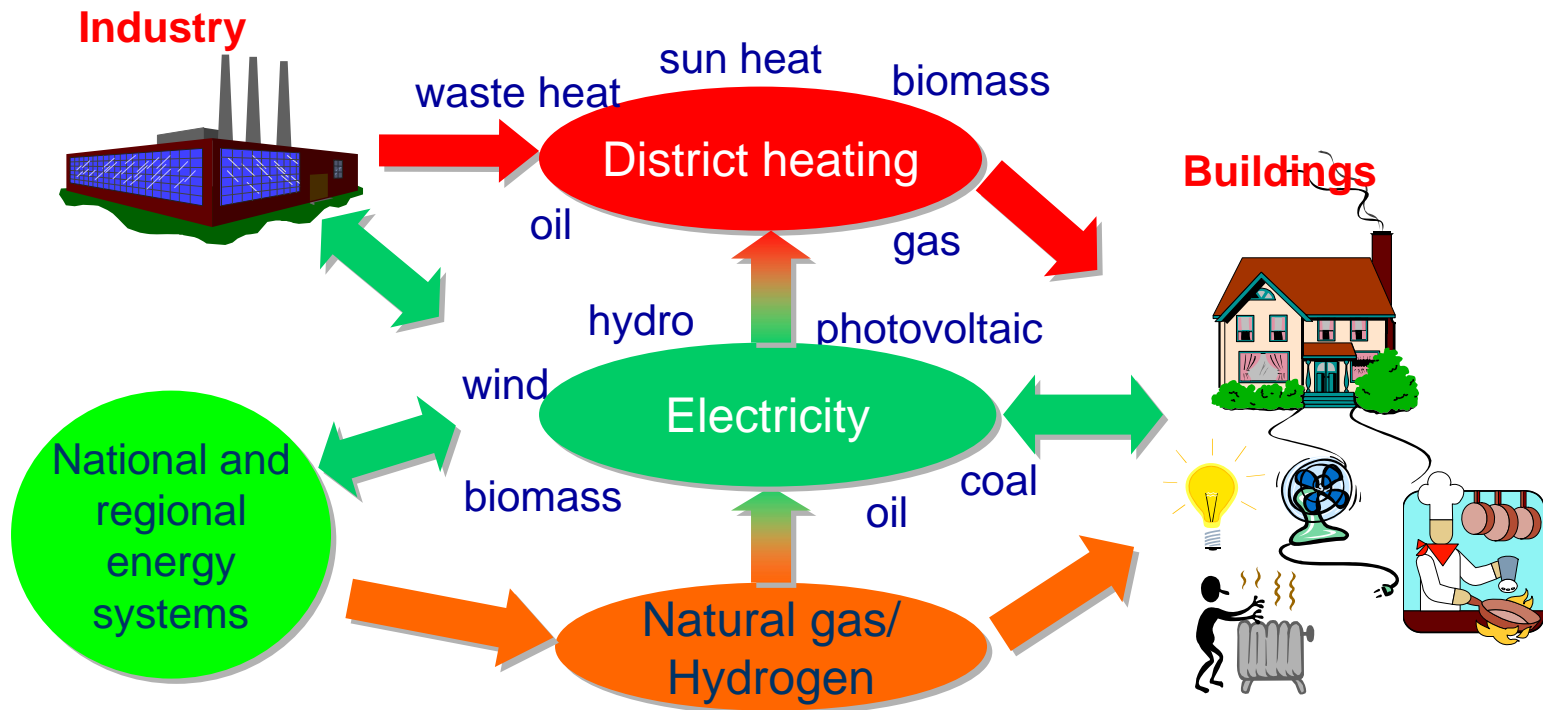
Sustainable energy distribution systems: Planning methods and models (SEDS)

Summary per 31 December 2007



2008-02-18

Planning methods and models for sustainable energy distribution systems



A mixed energy distribution system

Main objectives

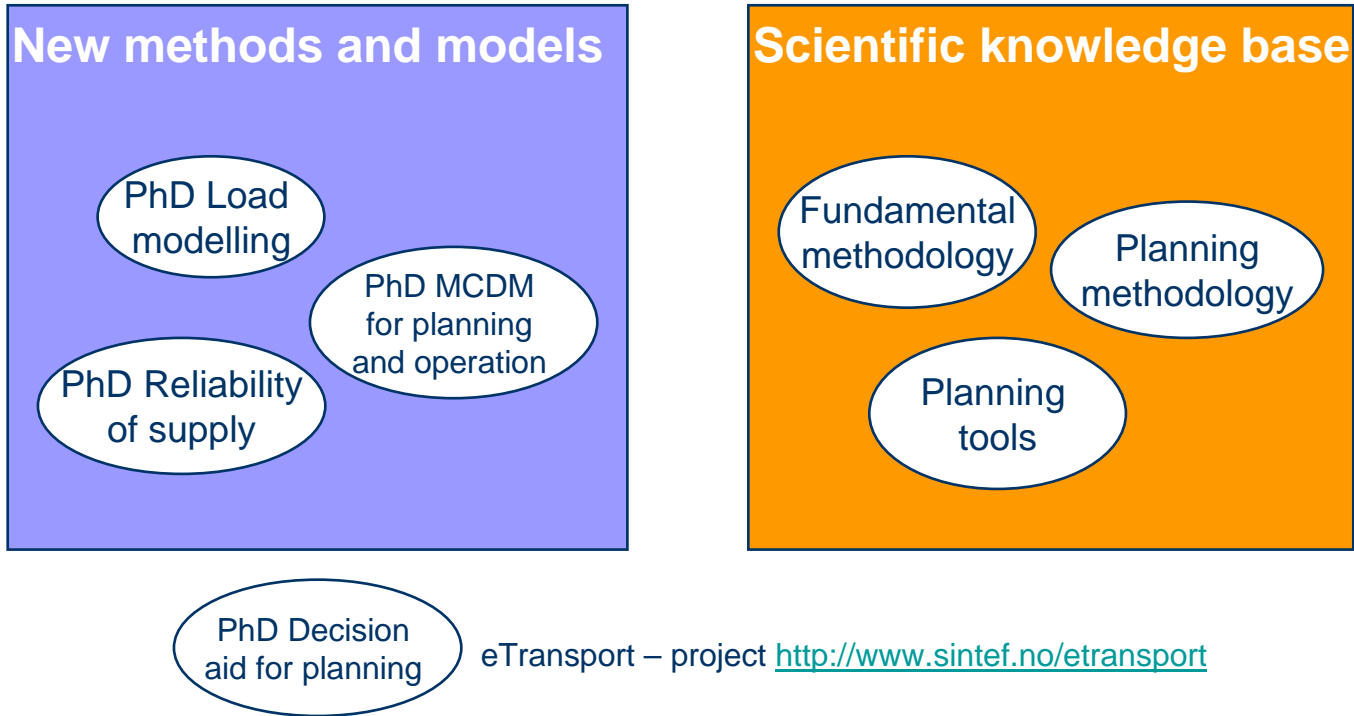
1. Develop methods and models

- for optimal integration of different energy sources and carriers with the existing electric power system
- with particular emphasis on distribution systems and integration of distributed energy sources
- including technical, economical and environmental aspects

2. Develop a scientific knowledge base

- built on a consistent framework and concepts for mixed energy systems
- in the field of planning methods and models
- as a cornerstone for the curriculum Energy and environment at NTNU
- develop a competent staff for the curriculum

Main products from the project



Main products from the project

- Technical reports: “Planning of sustainable energy distribution systems” in four parts
- Web-site for energy planning methods and tools
- Three PhD candidates
- Publications in international journals and conference papers
- Presentations at workshops and seminars
- Numerous student project reports and Master theses

<http://www.energy.sintef.no/Prosjekt/SEDS>

<http://www.energy.sintef.no/prosjekt/energyplanningtoolbox>

Budget 2003 - 2007

(1000 NOK)	2003	2004	2005	2006	2007	Total
New planning methods and models (PhDs)	550	1400	1650	1100	300	5000
Building the scientific knowledge base	850	500	500	700	800	3350
Visiting scientists	250	650	250	200		1350
Project management and coordination	500	400	450	450	400	2200
Travels and stays abroad	100	150	250	250	200	950
Project total	2250	3100	3100	2700	1700	12850

Funding partners

- Statkraft alliance
 - Statkraft SF
 - Trondheim Energi AS
 - Bergenhalvøens Kommunale Kraftselskap AS (BKK AS)
- StatoilHydro ASA
- Lyse Energi AS
- Hafslund Nett AS
- Research Council of Norway

National co-operating partners

- NTNU:
 - Dept of Electrical Power Engineering
 - Dept of Energy & Process Engineering
 - via NTNU: Institute for Energy Technology (IFE, Energy Systems)
- SINTEF Energy Research
 - Energy Systems, Energy Processes
- Norwegian Water Resources and Energy Directorate (NVE)

- Associate: Enova SF

International partners

- University of Porto and INESC
- Helsinki University of Technology and VTT
- Co-operating institutions
 - Argonne National Laboratory, Chicago
 - Swiss Federal Institute of Technology (ETH), Zurich

The results are made possible by the following contributors:

- Arne T. Holen (Project responsible)
- Gerd H. Kjølle (Project manager 2003, 2006 – 2007)
- Einar Jordanger (Project manager 2004 – 2005)
- Rolf Ulseth
- Eivind Solvang
- Kjell Sand
- Maria D. Catrinu
- Linda Pedersen
- Espen Løken
- Arild Helseth
- Audun Botterud
- Anne S. R. Risnes
- Øyvind Vessia
- Inger M. Lundhaug
- Hege Størseth

Activities

1. New planning methods and models (PhD-studies)
2. Building the scientific knowledge base
3. Visiting scientists
4. Project management and co-ordination

1. New planning methods and models (PhD studies)

- Linda Pedersen 2003 – 2007
 - Load and customer modelling of combined end-use (heating, cooling, electricity), Disputas May 16, 2007
- Espen Løken 2003 – 2007
 - Multiple criteria decision methods for planning and operation of energy distribution systems, Disputas May 11, 2007
- Arild Helseth 2004 – 2008
 - Modelling reliability of supply in multi-carrier energy distribution systems

- Regular meetings in specialist groups

2. Building the scientific knowledge base

- Development of a consistent planning framework for mixed energy distribution systems:
 - Planning of mixed energy distribution systems. Problem identification and formulation, Memo, February 2005
 - Review of MSc projects and theses within Energy systems planning, Memo, September 2005
 - Planning methodology: Structure, analyses and data, Memo, Oct. 2006
 - Socio-economic principles in planning of mixed energy systems, Memo, December 2006
 - Life cycle assessment of local energy systems, Memo, April 2007
 - Planning methodology – Flowchart, November 2007

2. Building the scientific knowledge base cont.

- Development of a consistent planning framework for mixed energy distribution systems:
 - Planning of sustainable energy distribution systems, Technical reports in four parts, December 2007:
 - Executive summary (TR A6556)
 - Part I: Problem definition and planning principles (TR A6557)
 - Part II: Planning methodology and tools (TR A6558)
 - Part III: A Life Cycle Assessment Perspective (TRA6560)

2. Building the scientific knowledge base cont.

- Development of a software toolbox environment for simulation and demonstration
 - Survey of existing planning methods and tools: Memo from eTransport/ TRANSES 2005: Software tools for energy planning: Overview and comparison
 - Energy system Planning Toolbox, Memo, December 2007
 - web-site: <http://www.energy.sintef.no/prosjekt/energyplanningtoolbox/>
 - Important basis: eTransport analysis tool <http://www.sintef.no/etransport>

2. Building the scientific knowledge base cont.

■ MSc students – Projects and thesis work:

- Projects: 22

 - (+ 6 SEDS related)

- Theses: 22

 - (+ 9 SEDS related)

- (see lists <http://www.energy.sintef.no/Prosjekt/SEDS/>)

■ Trainees

- Anne Sofie Ravndal Risnes, September – December 2005

- Øyvind Vessia, September 2006 – May 2007

3. Visiting scientists

- Tutorial: Application of risk analysis and multi-criteria models in energy systems planning, 2003-10-06/09, Trondheim
 - Prof. Manuel Matos and Prof. Jorge Pinho de Sousa, INESC Porto
- Post doctoral fellowship: Multi criteria decision aid and risk based methodology
 - PhD Audun Botterud, currently at Argonne National Laboratory (www.anl.gov)
 - Supervising PhD-students, contributions to the scientific knowledge base
- Visiting scientist:
 - PhD Gaudenz Koepfel fra ETH, Zurich
 - Publications related to Arild Helseths PhD work

4. Project management and co-ordination

- 6 meetings in the advisory council
- Co-operation on the annual conference Distributed Energy, 2003, 2004, 2005, <http://www.energy.sintef.no/arr/DE2005/>
- 5 workshops:
 - Planning methods and models, 2003-05-28
 - Load and customer modelling, 2004-06-17/18
 - Reliability of supply in energy distribution networks, 2005-04-19
 - Socio-economic principles and system boundaries, 2006-01-19
 - Planning methodology and tools, 2007-03-15

Information and dissemination of results

■ Web-sites:

- <http://www.energy.sintef.no/Prosjekt/SEDS>,
- <http://www.energy.sintef.no/prosjekt/energyplanningtoolbox>

■ Status reports

■ Workshops

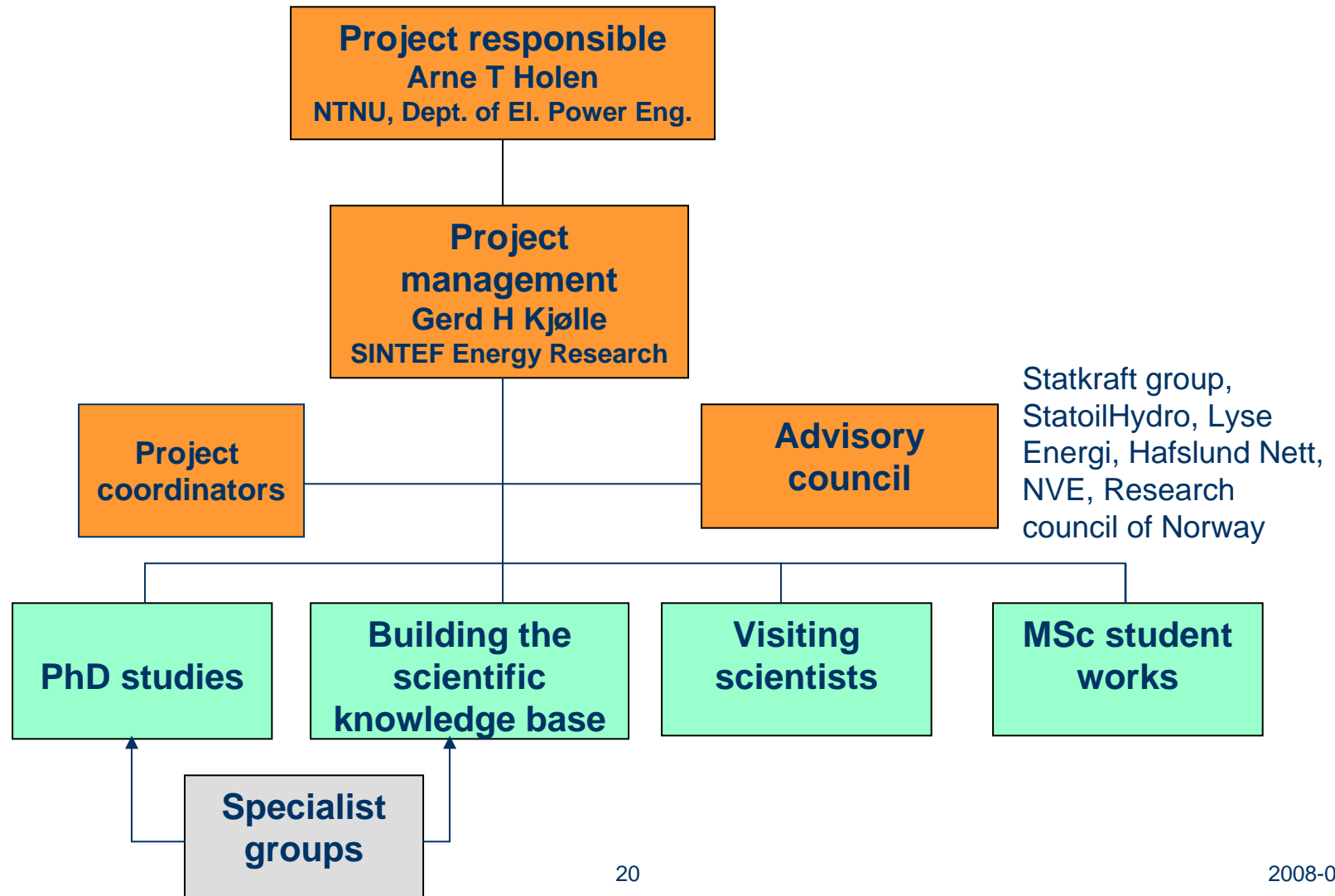
■ Annual national conference Distributed Energy

■ Publications: Journals, periodicals and conferences (see list www.energy.sintef.no/Prosjekt/SEDS)

■ Technical reports in four parts:

- Planning of sustainable energy distribution systems

Project organization



Work schedule/reporting

Activity	2003	2004	2005	2006	2007	2008
New planning methods and models (PhD)						
Topic 1				■	■	
Topic 2			■	■	■	
Topic 3				■	■	■
Scientific knowledge base						
Planning framework						
Definition of the planning process		■				■
Establishment of common terminology		■				■
Establishment of common planning methodology			■			■
Establishment of information model (data and attributes)			■			■
Handling of risk, uncertainty, quality, environmental...					■	■
Software toolbox environment						
Survey of existing planning methods and tools		■				
Definition of the contents and choice of 'platform'			■			
Collection of models, methods and tools						■
Collection of cases/examples						■
Establishment of the data basis						■
MSc students						
Projects and thesis work						
Visiting scientists						
Conducting courses, help building curricula etc.	T	T T				
Project management and co-ordination						
Project planning, reporting, cost statements etc						
Meetings, workshops, seminars	■	■	■	■	■	■

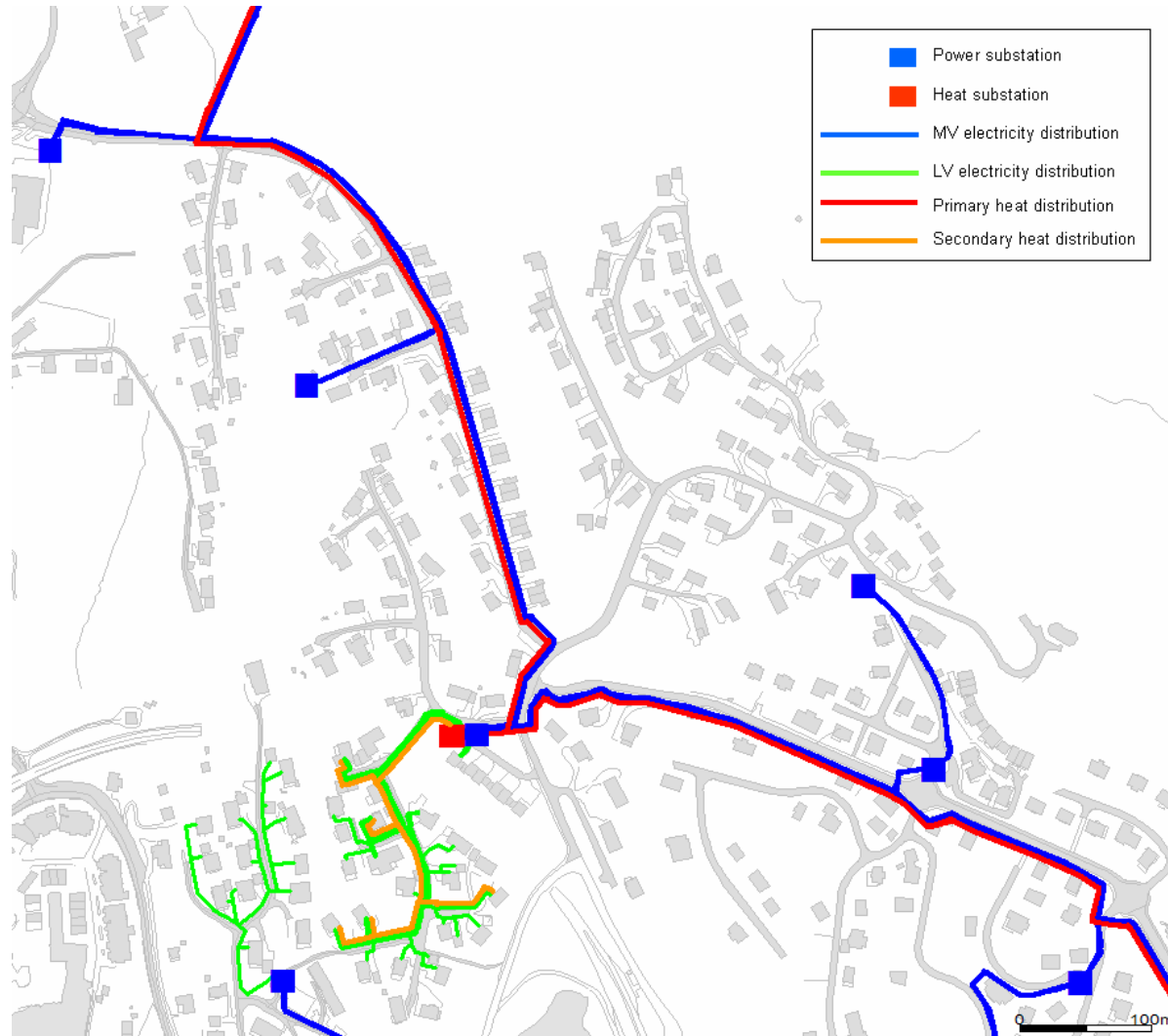
■ Reports/publications

T Tutorial

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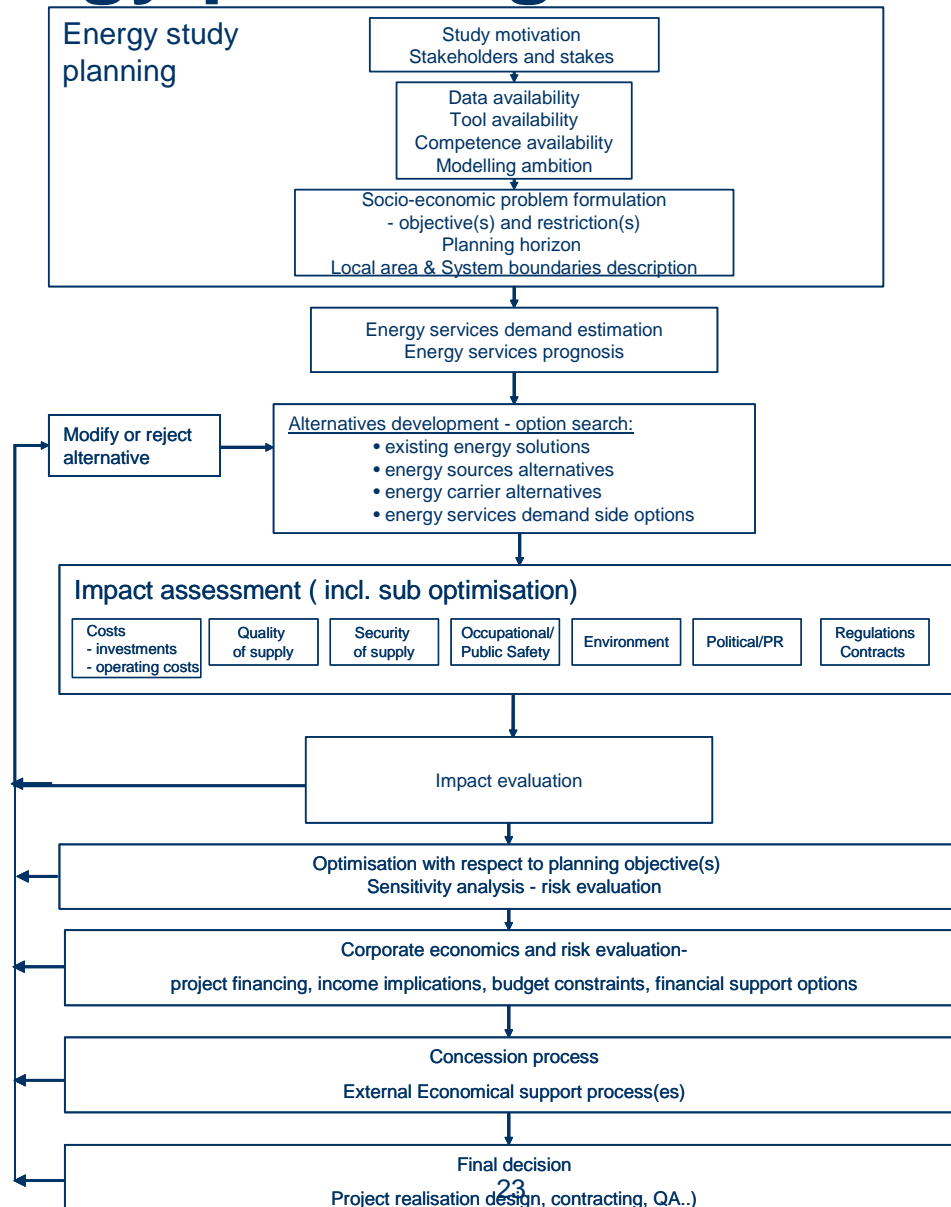
2008-02-18

Example of infrastructures for electricity distribution and district heating



2008-02-18

Local energy planning flowchart



2008-02-18

Energy Planning Toolbox

Energy Planning Toolbox - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Home Search Favorites

Address http://www.energy.sintef.no/projekt/energyplanningtoolbox/index.asp

Energy Planning Toolbox

Planning tools

Data sources
Load models

Impact assessment
models

Decision support
models

Case studies
Examples

Reports
Research papers
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The SEDS project

Content

This *Energy Planning Toolbox* provides guidance for carrying out the planning process and for selecting and applying tools that can support energy system planning decisions.

The Toolbox is designed on two levels: 'Planning tasks' and 'Planning tools'.

The first level 'Planning tasks' is represented in the left menu and offers an overview and description of the planning process. The second level 'Planning tools' is represented in the menu above and offers an overview of different tools that can address the different planning tasks.

The two levels are structurally independent of each other. Links between the two levels will be often provided, in order to enable a dynamic use of the toolbox.

To use the toolbox you can begin, for example, by going through the planning process in the left menu. For each planning task you will find a general description together with guidance about which tool (or group of tools) can be used to carry out that specific task.

You can also directly access the available tools in the toolbox by clicking on the different categories of tools in the menu above. A list of relevant tools specific to each category will then be shown. Select one to view information on that tool. Indications and links will be provided about which parts of the planning process the tool can assist.

You have also the possibility to browse through an example that illustrates how the different planning tasks can be carried out, and which tools can be used. To view the example, click on the link below the list of planning tasks.

Planning tasks

A Study planning, initial information survey

B Energy services demand estimation

C Establishment of alternatives

D Impact estimation

E Analysis and optimization

F Decision making - realization of the preferred alternative

[View Example](#)

2008-02-18

Tutorial: Day 1

- **Outline of the tutorial**
- **Basic concepts and definitions**
 - The role of the decision maker
 - Modeling criteria
 - Multiattribute problems
 - Multiobjective problems
 - Uncertainty issues
 - Probabilistic and fuzzy models
- **Decision Support Systems**
 - Structure and components
 - Design issues
- **Review of typical problems**

Tutorial: Application of risk analysis and multi-criteria models in energy systems planning, Trondheim 2003-10-06/09,
Prof. Manuel Matos and Prof. Jorge Pinho de Sousa, INESC Porto

Tutorial: Day 2

■ Multiattribute problems

- Prescriptive approaches
- Using risk indices
- Indifference curves and trade-off values
- Building and using value functions
- Distance to the ideal
- Non-prescriptive approaches

■ Multiobjective problems

- Discrete and binary variables
- Use of value functions
- Interactive approaches
- Generation methods

■ Meta-heuristics

- Structure and components of a meta-heuristic approach
- Review of meta-heuristics
- Multiobjective meta-heuristics

Tutorial: Application of risk analysis and multi-criteria models in energy systems planning, Trondheim 2003-10-06/09,
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Tutorial: Day 3

■ Decisions under uncertainty

- Risk definitions
- Risk analysis and risk indices
- Extended multicriteria analysis
- Building scenarios
- Robust analysis paradigms
- Basic utility functions
- Multiattribute utility functions

■ Decision trees

- Building and using decision trees
- Using different decision paradigms
- The value of information

■ Simulation

- Modeling issues and scope of use
- Visual Interactive Simulation

Tutorial: Application of risk analysis and multi-criteria models in energy systems planning, Trondheim 2003-10-06/09,
Prof. Manuel Matos and Prof. Jorge Pinho de Sousa, INESC Porto

Tutorial: Day 4



■ Applications to planning problems

- Discussion on methodologies
- What kind of results do we want?
- Integrated approaches
- Applications
- Final discussion

Tutorial: Application of risk analysis and multi-criteria models in energy systems planning, Trondheim 2003-10-06/09,
Prof. Manuel Matos and Prof. Jorge Pinho de Sousa, INESC Porto