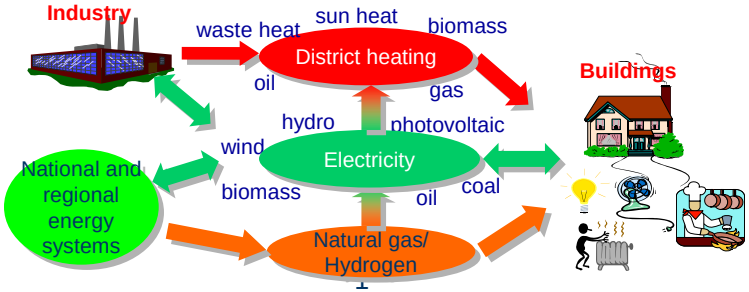
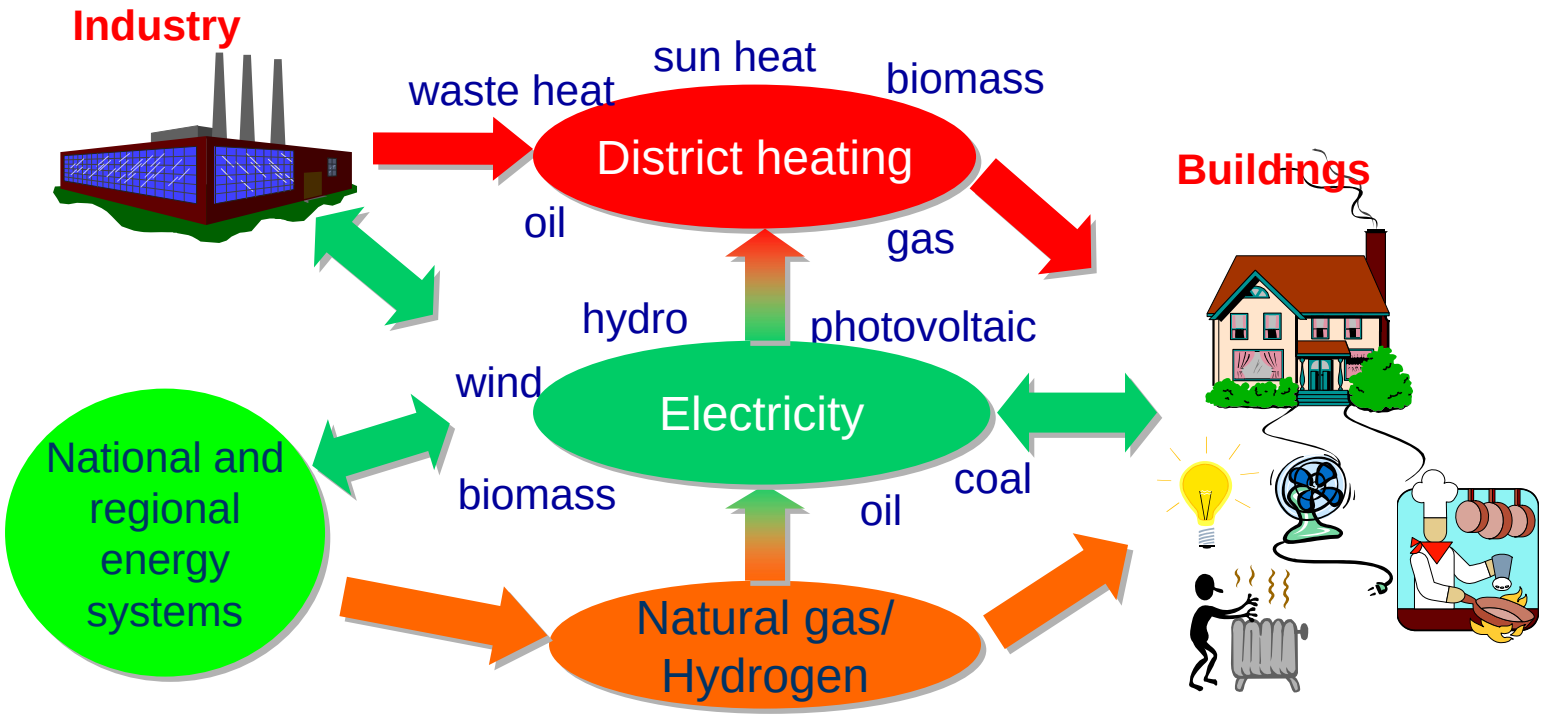
Sustainable energy distribution systems: Planning methods and models (SEDS)

Summary per 31 December 2007



2008-02-18

Planning methods and models for sustainable energy distribution systems

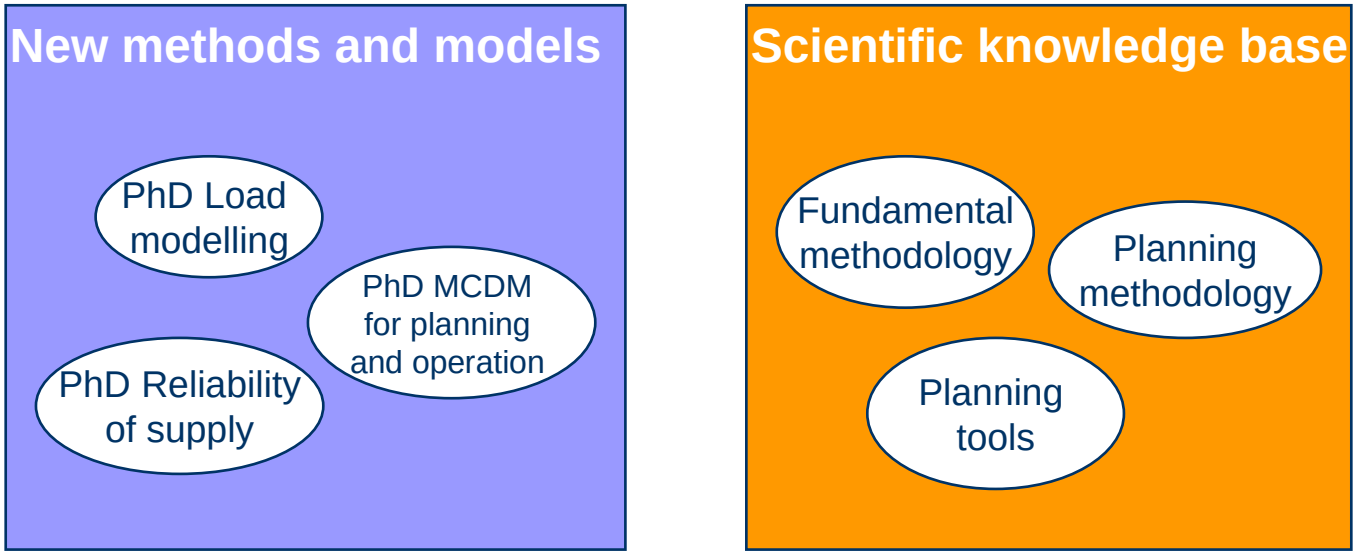


A mixed energy distribution system

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



eTransport – project http://www.sintef.no/etransport

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 Koeppel fra ETH, Zurich
  - Publications related to Arild Helseths PhD work

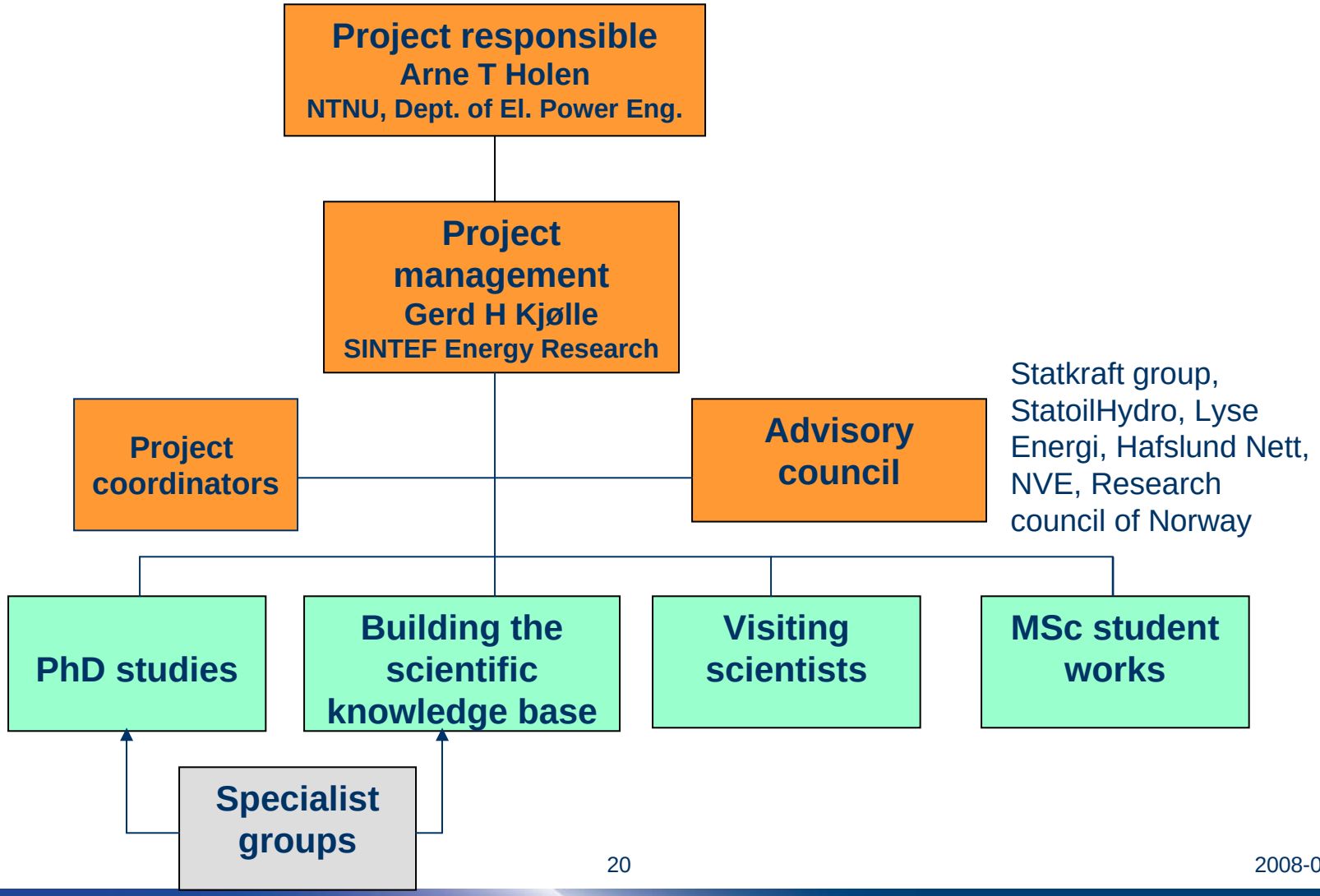
4. Project management and co-ordination

- 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

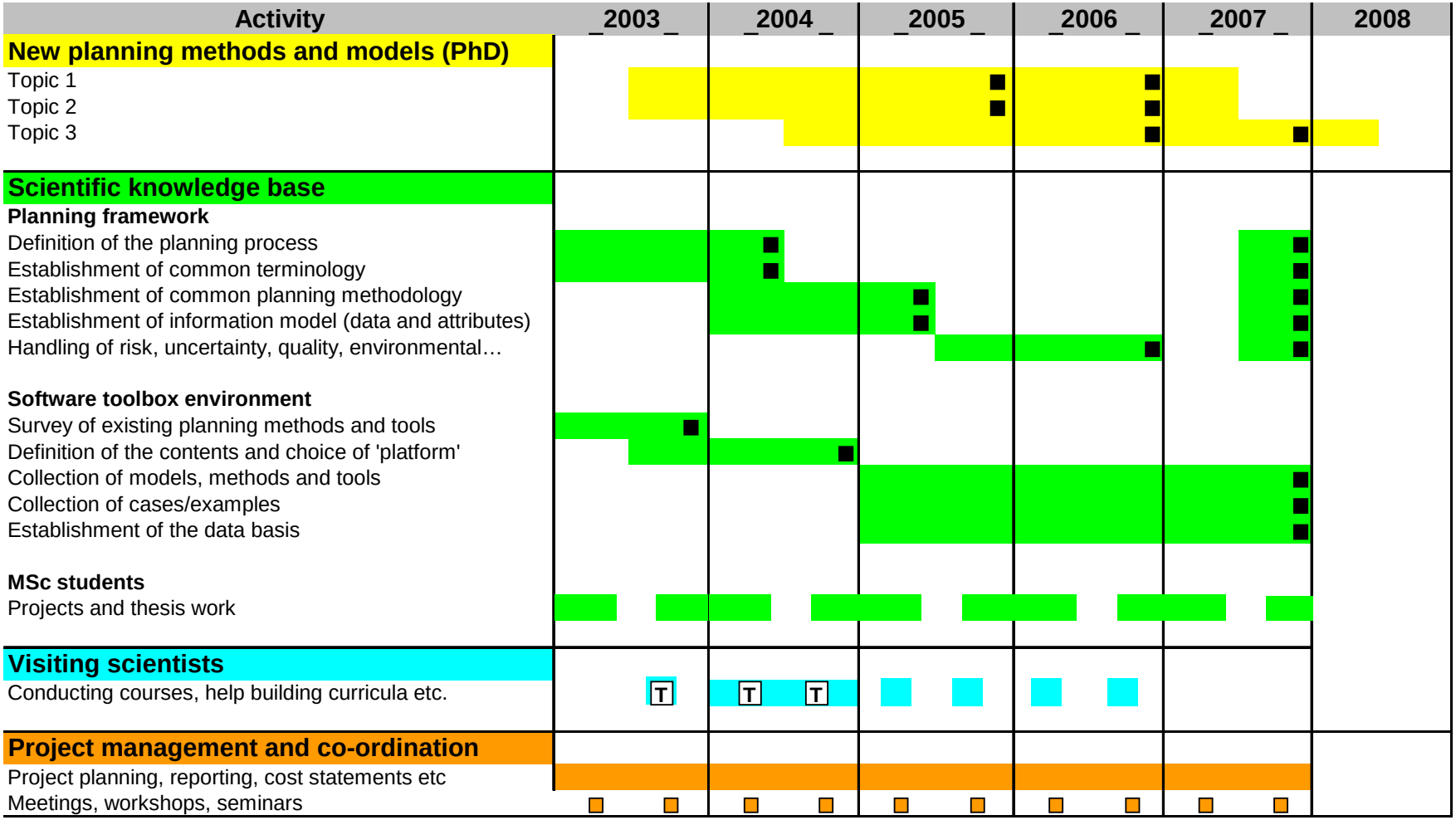
Information and dissemination of results

- 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

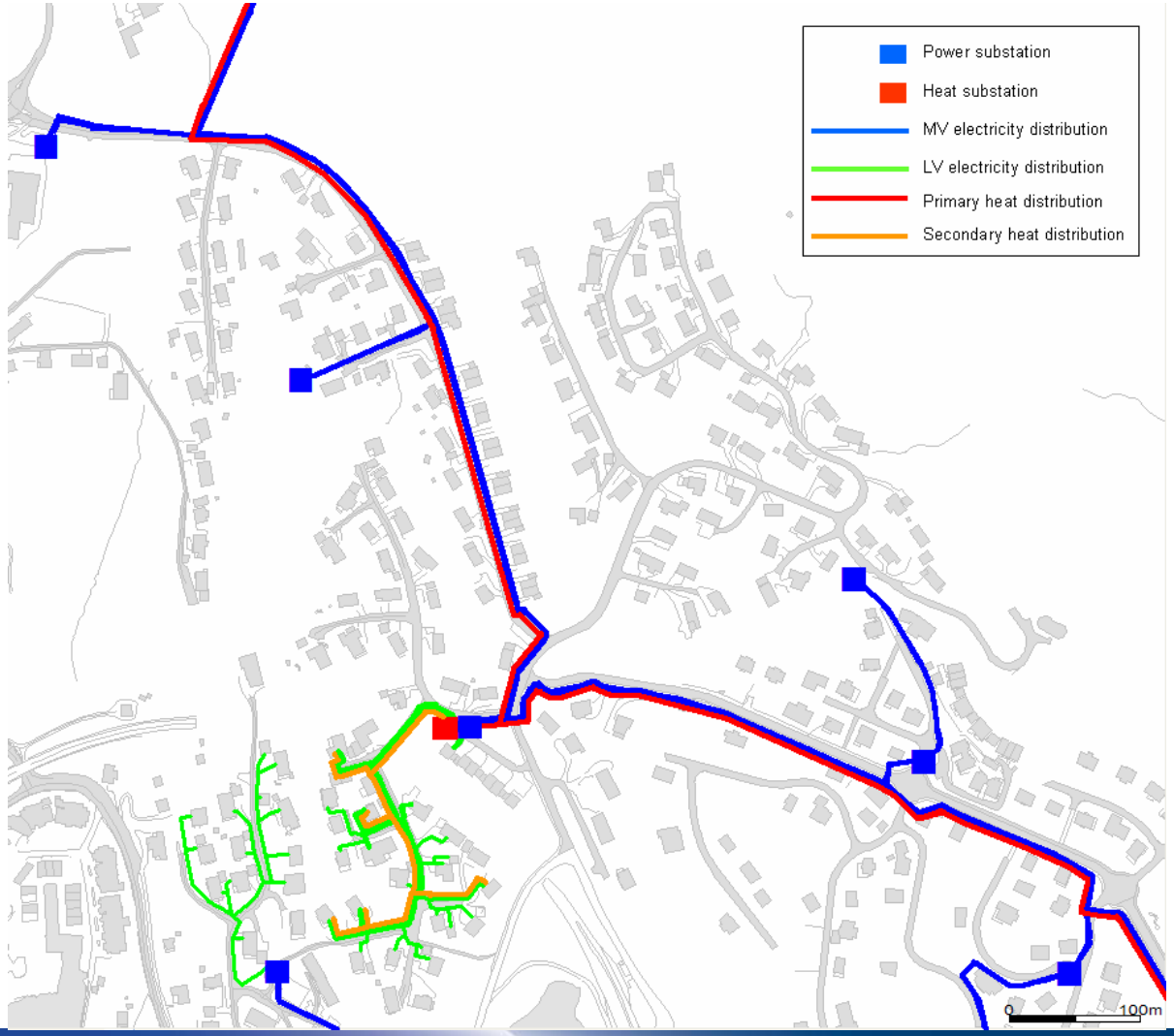


Work schedule/reporting

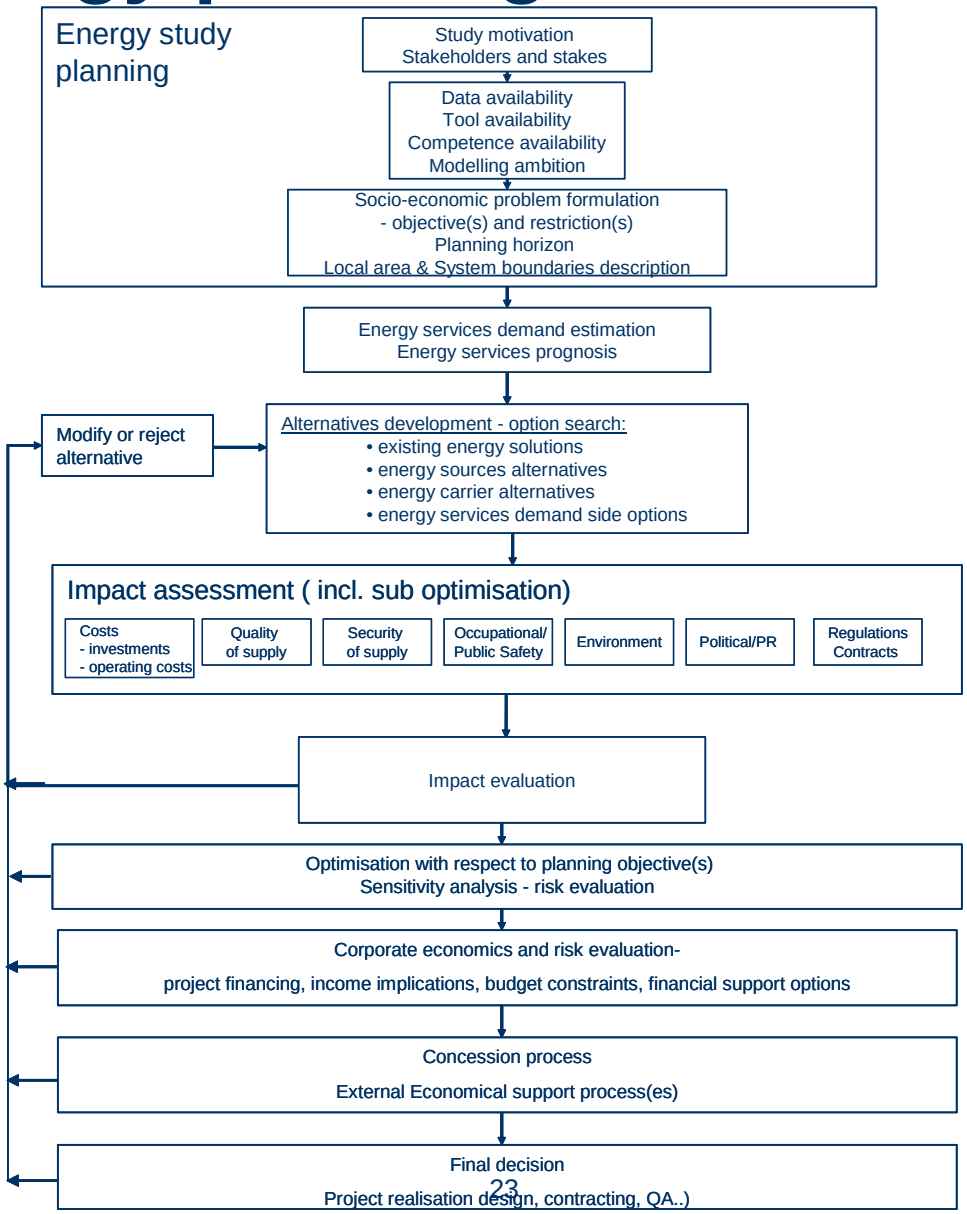


■ Reports/publications T Tutorial

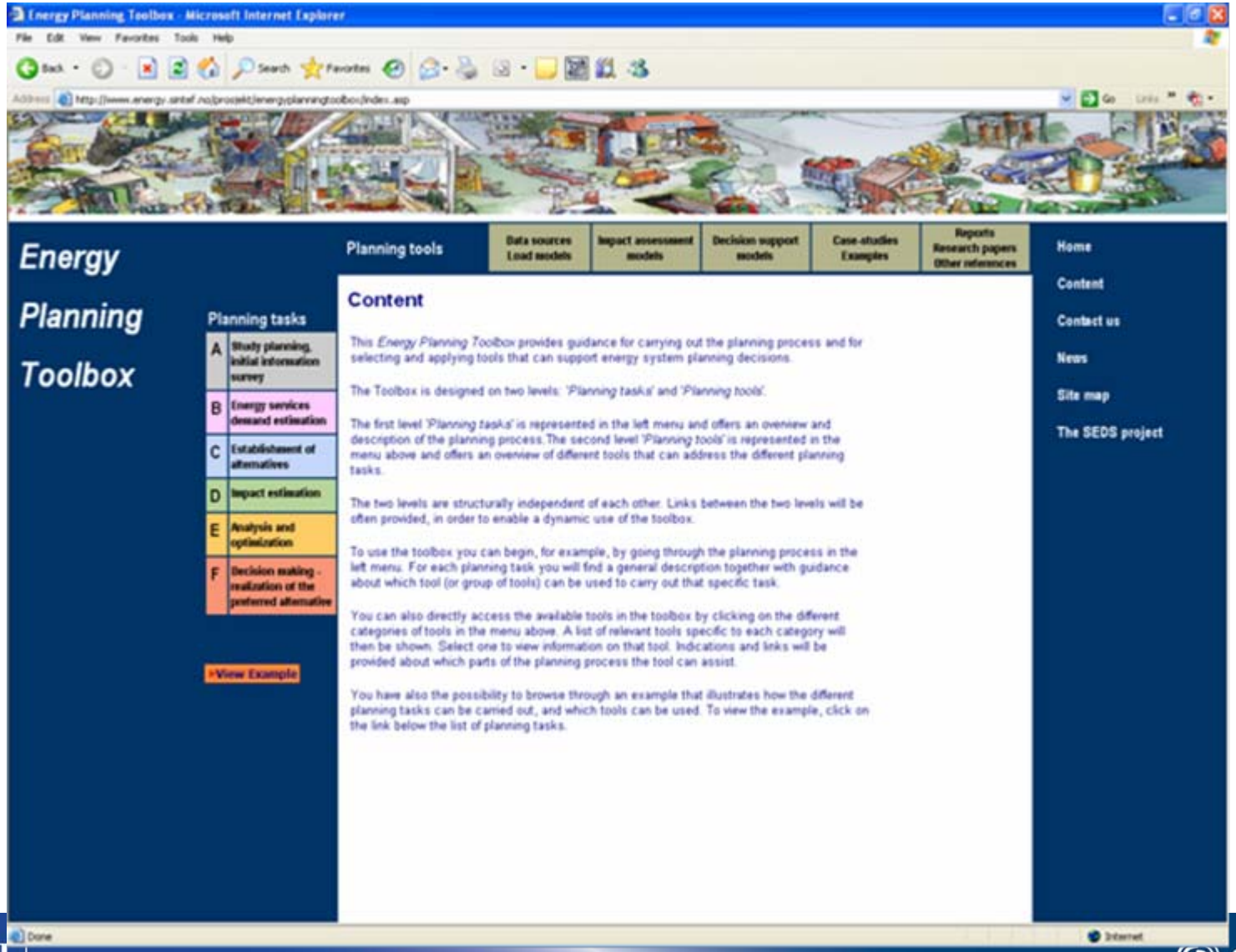
Example of infrastructures for electricity distribution and district heating



Local energy planning flowchart



Energy Planning Toolbox



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: 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: 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: Day 4

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