Universität Stuttgart
Institut für Energiewirtschaft und Rationelle Energieanwendung

IER

EUSUSTEL

European Sustainable Electricity; Comprehensive Analysis of Future European Demand and Generation of European Electricity and its Security of Supply

WP5: „Most Optimal Solution for Electricity Provision“

Prof. Dr. Alfred Voß, USTUTT

Institute of Energy Economics and the Rational Use of Energy (IER)
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Institute of Energy Economics and the Rational Use of Energy (IER)

Departments:

- Energy Use and Energy Management (EAM)
- Energy Economics and Systems Analysis (ESA)
- System Analysis and Renewable Energies (SEE)
- Technology Assessment and Environment (TFU)

Institute of Energy Economics and the Rational Use of Energy (IER)

Research Topics:

- Analysis and assessment of new technologies and energy systems
- Technology assessment and environmental analysis
- Development of models and decision support systems for energy economics and energy policy
- Energy systems analysis
- Rational use of Energy

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Prof. Dr.-Ing. habil. Rainer Friedrich (Deputy)

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- **Energy Economic Analysis**
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- **Technology Assessment**
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System Analysis and Renewable Energies (SEE)

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- **Bioenergy**
  Dr. sc. agr. Johannes Moerschner

Energy Use and Energy Management (EAM)

Prof. Dr.-Ing. Alfred Voß (provisional)

- **Rational Use of Energy**
  Dipl.-Ing. Sven Eckardt
- **Energy and Risk Management in Power Supply**
  Dipl.-Ing. Derk Jan Swider

Energy Economics and Systems Analysis (ESA)

- Analysis and assessment of heat supply concepts (district heating and combined heat and power production) as well as of new transport technologies, propulsions and fuels
- Life cycle assessment of energy technologies and energy supply chains
- Liberalised energy markets
- Sustainable development of the energy system
- Development and application of energy system and energy economic models on international, national, regional and urban level
  - greenhouse gas control strategies
  - importance of the different energy technologies
  - supply guarantee and trade relations
  - assessment of energy and environmental policy instruments

Energy Use and Energy Management (EAM)

- Energy and environmental management in industry and service sectors
- Possibilities and strategies for sustainability oriented consumption patterns
- Energy demand analysis
- Assessment of policy instruments to increase energy and ecological efficiency
- Tools for load forecasting and electricity price formation
- Operative planning (unit commitment and energy trade) and risk management for utilities

System Analysis and Renewable Energies (SEE)

- Technology analysis of renewable energies (biomass, biofuels, wind, geothermal energy, photovoltaics, etc.) including potential assessment and scientific monitoring of pilot and demonstration plants
- Micro- and macro-economic assessment of renewable energies and RE-systems
- Ecological analysis, including life cycle assessment of renewable energy technologies
- Renewable energies and sustainable development in developing countries
- Information and technology transfer

Technology Assessment and Environment (TFU)

- Assessment of external costs, especially for energy and transport systems
- Determination of strategies to achieve an efficient protection of the environment and human health based on the concept of welfare optimisation and sustainable development
- Sustainable use of non-renewable resources
- Generation of emission inventories for air pollutants
- Identification of efficient air pollution control strategies
- Analysis and assessment of ecopolitical instruments

WP5: „Most Optimal Solution for Electricity Provision“

Objectives: *Determine the total social cost for electricity generation, both statically and taking into account system interaction. Perform scenarios to determine the ‚most optimal solution‘ for electricity provision in the EU.*

5.1: Determination of the overall static social cost for electricity

5.2: Comparison and evaluation of simulation models & codes and existing scenarios for electricity generation

5.3: Performing and interpreting four (contrasting) scenarios with one or two of the most appropriate models (with ‚improved‘ input data)

5.1 Determination of the overall static social cost for electricity (1)

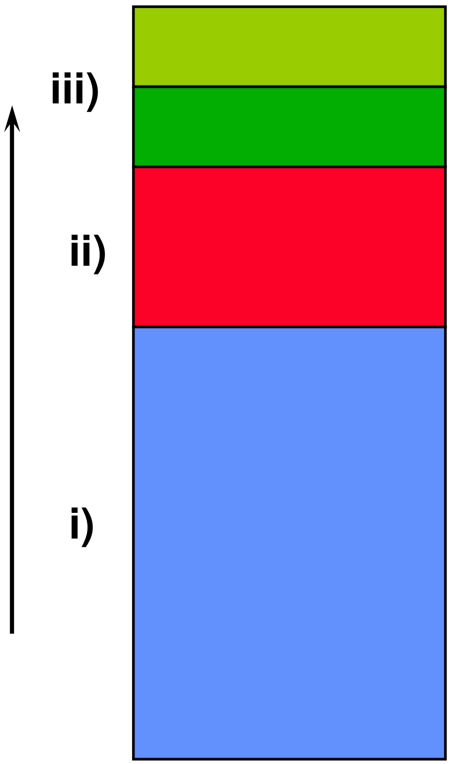
The overall static social cost for electricity include:

i) private costs
- *for each generic electricity supply technology*
- *for the years 2005, 2010, 2020 and 2030*
- *based on input data provided in WP 3*
- *for at least two different fuel price projections*

ii) cost of system integration

iii) global external cost

5.1 Determination of the overall static social cost for electricity (2)



Integration of global <u>external</u> costs due to

- specific emissions
- other external life cycle costs

Costs of <u>system integration</u> due to

- Stochastic wind, solar and hydro power supply
- spatial distribution, share of total generation

Estimation of overall <u>private</u> generation cost

- from an investor‘s point of view, additional premium due to risks in liberalised markets (e.g. fuel, electricity prices, economic, regulatory and political factors) should be considered
- from an overall system oriented point of view a standardised methodology: **Average Lifetime Levelised Electricity Generation Cost (used in OECD study)** should be used

5.1 Determination of the overall static social cost for electricity (3)

ii)

Costs of system integration due to

- stochastic wind, solar and hydro power supply
- existing electricity generation system,
- the spatial distribution of wind and hydro resources
- and the share of wind, solar and hydro of total generation

⇨ *Representative values should be based on WP 3.4*

5.1 Determination of the overall static social cost for electricity (4)

iii)

Calculation of direct generation related externalities

- for each technology
- based on emission coefficients [t emission/kWh]
- based on cost per unit of emission [€/t emission]

Calculation of other external life cycle investment and operation costs

- for each technology and its improvement over time
- based on EU electricity generation mix
- and projected changes in generation mix to 2030

5.2 Comparison and evaluation of simulation models & codes and existing scenarios for electricity generation (1)

Studies regarding the European Union	Focus of Study	Regional Segmentation
European Energy and Transport – Trends to 2030	Assessment of the impacts following the accession of ten countries to the European Union	EU-15, EU-25 (disaggregated)
World energy, technology and climate policy outlook (WETO 2030)	Elaboration of long-term energy supply and demand projections	• WEU, EU-15 (aggregated) • 6 other world regions
World Energy Outlook 2004 *IEA, OECD*	• World energy system to 2030 • Global energy trends	• OECD Europe, EU-25 (aggregated) • 15 other world regions
ACROPOLIS *(EU - Framework Programme V)*	Assessing Climate Response Options: Policy Simulations	• WEU (agg. / disagg.) • other world regions
CASCADE-MINTS *(EU - Framework Programme VI)*	Energy Trends for Europe in a Global Perspective	• WEU, EU-15 (aggregated) • 5 other world regions
GreenNet *(EU - Framework Programme V)*	Least Cost Integration of Green Electricity into the European Grid	EU-15 (aggregated in 6 to 8 regions)
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5.2 Comparison and evaluation of simulation models & codes and existing scenarios for electricity generation (2)

Models	Typ of Model	Regional Segmentation
PRIMES *NTUA, Athens*	Energy System Model	EU-25, Countries
POLES • *IEPE, Grenoble* • *IPTS, Seville* • *EC-DG XII, Brussels*	Modular Simulation Model	World, EU-15, Countries
TIMES-EE *IER, Stuttgart*	Electricity and Heat Market Optimization Model	EU-25, Countries
Other models exist, which cover various EU countries agg. or disa.: BALMOREL, PERSEUS-ICE, CEEM, E2M2, ...		

Alternative model approaches to address various issues related to electricity market development. E.g.: • Stochastic Supply • Competition • Network Constraints	Models to address stochastic renewable energy supply	• Optimization Models • Simulation Models
	Models to address load flow issues in the european power networks	• Optimization Models • Simulation Models
	Models to address imperfect competition in the liberalised european electricty markets	• Oligopoly Models • Game Theoretic Approaches

5.3 Performing and interpreting four (contrasting) scenarios with one or two of the most appropriate models (with ‚improved' input data)

Necessary conditions for model choice and application:

- Detailed technological treatment of electricity generation
- Models have to cover EU-25 on a country level
- Possibility of integrating global external costs and computation of overall social cost, proper modelling of system integration aspects and its cost
- Documentation of model codes, assumptions and data

i) Scenario 1: According to present policy in different EU-25 countries (Baseline)
ii) Scenario 2: Total nuclear phase out in EU-25 with post-Kyoto limits
iii) Scenario 3: Overall Nuclear renaissance in EU-25 with stringent post-Kyoto limits
iv) Scenario 4: Based on the interpretation and conclusion of scenarios 1, 2 and 3

⇨ *Assumptions and boundary conditions characterising the scenarios have to be determined later*

5.1 Determination of the overall static social cost for electricity (1)

The overall static social cost for electricity include:

i) private costs FIN/DEU

- *for each generic electricity supply technology*
- *for the years 2005, 2010, 2020 and 2030*
- *based on input data provided in WP 3*
- *for at least two different fuel price projections*

ii) cost of system integration BEL/GBR/SWE

iii) global external cost DEU/FRA/ESP