Smart grids and energy research at the Oulu Business School

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Sustainable Energy Economics Research group

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1. **Consumption preferences:**
   a. *Households' attitudes toward alternative heating systems and renewable energy*
   b. *Energy consumption preferences, distributed energy resources and smart management*
2. **Incentive mechanism in demand management**
   a. *Real-Time Pricing and efficient production.*
   b. *Demand management and Real-Time Emission.*
3. **Efficient and sustainable production**
   a. *Dynamic models for photovoltaics with storage.*
   b. *Strategic behavior of hydro power producers: Buffering the intermittent electricity generation?*
4. **Distributed energy generation, smart management and the role of ecosystem**
   a. *Modeling distributed energy system as two-sided markets.*
   b. *Policy analyzes and impact assessment of smart management of distributed energy and ecosystem – experiments in HINKU municipalities*
5. **Dynamic distribution price and efficient regulation**

Households' attitudes toward alternative heating systems and renewable energy

- Residential heating accounts for a large fraction of the overall residential energy demand (over 80 % in Finland)
- A hybrid heating system is an alternative to a traditional heating system (oil or direct electric heating), which uses a supplementary heating system alongside the main heating system
  - Hybrid home heating systems can utilize many sources of renewable energy to generate heat: solar, solid wood, wood pellet and ground heat as well as outside air and exhaust air
- Research questions:
  - What kind of heating system choices would the consumers make under new heating alternatives?
  - What are the determinants of the adoption of hybrid home heating systems?
- We use choice experiment (CE) to analyze consumers' preferences for characteristic of hybrid home heating systems and renewable energy

Energy consumption preferences, distributed energy resources and smart management

- Choice experiment approach to investigate the determinants of the adaption of smart grid technologies by households in Finland.
- What energy saving tasks (turning off lights, delayed usage of dish washing machine etc.) consumers are willing to take under alternative energy pricing mechanisms.
- The empirical electricity market simulation model is extended so that the impact of smart technology, new consumer oriented pricing mechanisms (and contracts) and knowledge of consumer preferences is utilized.
- Data collected through a survey.

Optimal subsidies for photovoltaics with storage in Germany

- Generous feed-in tariff has caused large adoption of photovoltaics in Germany (35 GW). Germany targets to have 52 GW of installed photovoltaics by 2020.
- Intermittent nature of solar power generation causes large variations in electricity supply. This becomes expensive (via back-up power plants) if excess energy can not be stored.
- Modelling households' solar panel purchasing behaviour it can be studied: **What are the optimal subsidies (amount, form, schedule) that encourage households to store self-generated energy (with battery banks) instead of selling it to the utility while still reaching the target adoption level?**
- E.g. high feed-in tariff encourages purchasing solar panels but does not encourage storing the generated electricity.

Strategic behavior of hydropower producers: Buffering the intermittent electricity generation?

- Hydropower: unique production technology
  - Flexible adaptation of production level
  - Ability to 'store' energy in water reserves
  - → Thus, hydropower is able to provide beneficial 'balancing services' to the electricity system.
- As the share of intermittent electricity increases (e.g. wind-generated power), flexibility is required from other components.
- This paper models a thermal-hydro-windpower system, asking:
  - How does hydroproducer allocate the water reserve in different market environments?
  - As wind power enters, what is the reaction of hydroproducer and how does hydropower affect the market outcome: electricity prices, carbon dioxide emissions and investment incentives?
- Analyse on the level of flexibility this intermittent production requires from the rest of the supply side of the electricity system.

Modeling distributed energy system as two-sided markets

- Literature survey: learning from other fields of economy
  - traditional examples of two-sided markets are credit cards, video games and consoles and browsers but many other examples can be given (see Rochet and Tirole 2003 for a more detailed classification).
- A virtual model based for theoretical results for two-sided market is created.
- Need for new innovations (smart management, smart grid) and value of ecosystems is shown/regocnized.

Policy analyzes and impact assessment of smart management of distributed energy and ecosystem

Policy analyse:

- Incentive base supply and demand side management.
  - RTP, RTE, etc.
- Simulation model
  - Data from Nord Pool (system level analysis) and HINKU municipalities (municipality/industry/household level analysis) is used.
  - Need for technical and non-technical innovations for well functioning ecosystem is shown

Experiments in HINKU municipalities

Dynamic distribution price and efficient regulation

- Distributed energy and smart technology creates new challenges for managing electricity distribution and transmission efficiently.
- Market based pricing → Real-Time Pricing
- Event based pricing:
  - Demand-response payments
  - Critical peak prices
  - Direct load control
  - Rebate for reduction

- To optimize benefits of various pricing structures and new smart technology new type of regulation is needed

Publications

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