Lappeenranta University of Technology

- Founded in 1969
- Over 8 000 have obtained a Master’s degree in technology or business, and over 300 have obtained a doctorate in technology, business or philosophy
- Approximately 900 staff members
- 5 500 undergraduate students, 300 of them from abroad
- 19% of first-year students in autumn 2008 were foreign nationals
- 47 languages are spoken at LUT
- Life-long learning: 1 500 students in continuing professional education, 1 200 students in open university education
Strategic areas of expertise

Energy efficiency and the energy market

Strategic management of business and technology

Scientific computing and modelling of industrial processes

EXPERTISE IN RUSSIAN BUSINESS AND INDUSTRY RELATED TO THE AREAS ABOVE
LUT Energy
LUT ENERGY

The largest energy research and education organization in Finland

Degree Programmes in Energy and Environmental Technology and Electrical Engineering

180 experts
16 professors
45 research scientists (teachers)/researchers
125 Masters of Science (Tech)/year
12 Doctors of Science (Tech)/year
8 M€ research budget/year
4 M€ teaching budget/year
Energy chain

ENERGY SOURCES = > ENERGY GENERATION TECHNOLOGY = > POWER NETWORKS, MARKETS = > ENERGY USE, GENERATION PROCESSES

IEA 2030 (2002)

Oil

Gas

Coal

Renewables

Nuclear power

Global Electricity Generation by Fuel - IEA Scenarios 2003-2050
(Source: IEA, June 2006)

CO₂ Sources

Residential and other sectors 14%

Transport 24%

Manufacturing and construction 18%

Public power and heat production 35%

Other energy industries 9%

Total emissions 23,684 M tonnes

2001 emissions data, source: IEA

Energy consumption in Finland 2005
**LUT Energy**
Research and Education

**COMBATING CLIMATE CHANGE**

Emissions = Population x GNP/person x Energy/GNP x Emissions/energy

**INSTRUMENTS OF ENERGY TECHNOLOGY**

- Efficiency of energy use
- Energy efficiency of production processes and equipment
- Energy saving
- Energy generation
  - Electricity
  - Heat
  - Traffic

**ENERGY SUFFICIENCY, WELFARE**
Cutting the global energy-based emissions into half?

**Baseline Emissions 62 Gt**

- CCS industry and transformation 9%
- CCS power generation 10%
- Nuclear 6%
- Renewables 21%
- Power generation efficiency & fuel switching 7%
- End-use fuel switching 11%
- End use electricity efficiency 12%
- End use fuel efficiency 24%

**BLUE Map Emissions 14 Gt**

WEO2007 450 ppm case  ETP2008 BLUE Map scenario

2005 2010 2015 2020 2025 2030 2035 2040 2045 2050
### LUT Energy areas of expertise

<table>
<thead>
<tr>
<th>ENERGY GENERATION</th>
<th>ENERGY MARKETS, POWER NETWORKS</th>
<th>ENERGY USE AND PRODUCTION PROCESSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuclear power</td>
<td>Future power networks</td>
<td>Energy saving</td>
</tr>
<tr>
<td>New emission-free energy with fossil fuels</td>
<td>Functioning of energy markets</td>
<td>Energy efficiency of energy use</td>
</tr>
<tr>
<td>Distributed systems</td>
<td>Electricity and emissions trade</td>
<td>Energy efficiency of production processes and equipment</td>
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<tr>
<td>Renewables</td>
<td>Electricity distribution network business</td>
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<tr>
<td>Bio-energy</td>
<td>Fuel markets</td>
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<tr>
<td>Wind power</td>
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<td></td>
</tr>
<tr>
<td>Fuel cells</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fossil fuel emissions/efficiency</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

LUT Energy

Electricity | Energy | Environment
Industrial innovations

**ABB**: PMSM-series and ACS 600/800 PMSM-DTC, ACS 600/800 active network bridge, ACS 6000 synchronous machine drive, Motion control research for packaging solutions

**VACON**: New frequency converter technology

**The Switch**: New distributed energy power electronic technology, large windmill generators 3 MW 16 rpm, High-speed technology 8 - 10 MW 12000 rpm, BioCHP 1000 kW, 14000 rpm

**STATOIL**: New insulation systems for hermetic gas compressors

**Wärtsilä**: New generation technologies

**Heatmasters**: induction heating systems

**AXCO-Motors**: Special electric machines e.g. for small windmills and vehicles

**Robert Bosch**: SR-drive for automotive use

**Metso**: paper drying system, Condition monitoring systems

**Waterpumps**: automation and new small water power generators

**KONE**: lift motor development work

**FIMA**: Energy efficient working machines with electric energy recovery systems
LUT Energy areas of expertise

**Areas of expertise in energy research at LUT**

**LUT Energy**

**Leading Projects**

- Bio-energy, renewables
- Nuclear technology
- Environmental engineering
- Thermodynamics

**Advanced Energy Systems**

- High relevance of the research
- Heat transfer and fluid dynamics

**Fundamentals**

- Electrical machines and drives
- Energy economics
- Electromechanical energy conversion
- Transformation of electric power

LUT Energy

Electricity | Energy | Environment
Laboratory of electricity markets and power systems
Major research activities

- Electricity distribution
  - Interactive customer interface and smart grids
  - Network and business impacts of the DER (e.g. EVs, heat pumps)
  - Business opportunities of the smart grids
  - Strategic planning of the distribution networks
  - Power electronics in electricity distribution and LVDC systems
  - 1000 V low voltage distribution system
  - Economic regulation of the electricity distribution business
  - Business models and outsourcing cases in electricity distribution

- Electricity markets
  - Market models and market integration
  - Wholesale and retail markets in Europe and Russia
  - Market impacts of the smart grids and active resources
SGEM-research program

1. Smart Grids architectures
2. Future infrastructure of power distribution
3. Intelligent management and operation of smart grids
4. Active resources
5. Energy market

- SGEM-research program
- CLEEN
- Open your mind. LUT.
- Lappeenranta University of Technology
SGEM-research program - consortium

Coordinator
1. Cleen Ltd

Industrial Partners
1. ABB
2. Aidon
3. Areva T&D
4. Elisa
5. Empower
6. Emtele
7. Fingrid
8. Fortum
9. Helen Sähköverkko
10. Nokia Siemens Networks
11. Tekla
12. The Switch
13. Vantaan Energia
14. Vattenfall Verkko

Research Partners
1. Helsinki University of Technology
2. Lappeenranta University of Technology
3. MIKES
4. Tampere University of Technology
5. University of Kuopio
6. University of Vaasa
7. VTT
Interactive customer interface

Business players; TSO, DSO, supplier, aggregator

Information systems

Grid

Active customer gateway

Energy storage

Generation
Solar, wind, fuel cell, biogas

Loads

Interactive customer interface

Open your mind. LUT.
Lappeenranta University of Technology
Interactive customer interface
Input Parameters on Electric Car Network Simulation

National passenger transport survey
- Spatial and temporal variations in passenger trips
- Length of daily trips
- Annual length of driving (region dependent)
- Length of daily trips according to housing type
- Length of daily trips according to residential area
- Length of daily trips according to the month of year
- Length of trips according to the time of day
- Number of cars in households

Properties of electric cars
- Energy consumption, kWh/km
- Capacity of the batteries, kWh
- Charging power, kW
- Required charging time, h/day (battery properties)

Town planning statistics
- Workplaces according to the area and time of day
- Residential areas (detached houses, terraced houses, apartment houses)

Penetration of electric cars
- Development of electric car markets

Tariffs and supplier
- Distribution fee

Area-specific additional energy
___ kWh/day
(working hours/leisure time)

Network simulations and analysis results
- Load flow and loss calculations
- Estimation of reinforcements required

Electricity distribution network
- Network topology and customer information
- Feeder and hourly-specific actual load curves
- Network volume
- Replacement value
- Parameters: loss costs, load growth, lifetime, unit price of network components
Case Network – Electric car charging profiles

† Transmission capacity in the network?
† Losses and loss costs?

The same amount of charging energy in each profile!
Intelligent EV Charging

City area feeder:
- Peak load of the day: 6.6 MW
- Minimum load of the day: 4.0 MW
- Number of electric cars: 2000
- Driving distance: 57 km/car, day
- Energy consumption: 0.2 kWh/km
- Charging energy: 11.5 kWh/car, day
  
  \[ 22.9 \text{ MWh/day for all cars} \]
- Charging power: 3.6 kW/car
- Additional power: 0 – 3.5 MW (depending on charging method)
- Charging energy (E) is equal in each charging alternative

- In optimal charging method
  - Customer interfaces discuss with each other and modern DMS system
  - Interfaces time the charging on the basis of existing network capacity
  - Full exploitation of the network’s transmission capacity, and thus, minimisation of the reinforcement needs due to EV load
  - Network losses per transmitted kWh are minimised
Case Network – Reinforcement costs

Network value compared with the peak load in
- low-voltage networks: 320 €/kW
- medium-voltage network: 300 €/kW
- primary substation level (110/20 kV): 100 €/kW

An example of defining required reinforcement investments on the medium voltage feeder

20 kV feeder 1. (densely populated area)
- Peak load of the day: 6.6 MW
- Additional power: + 3.0 MW
- Average marginal cost: 300 €/kW
  → Estimated need for reinforcement:
    \[300 \text{ €/kW} \times 3000 \text{ kW} = 900 \text{ 000 €}\]

‡ Using intelligent charging system (Optimised charging) charging can be adjusted fully into low-load moments
## Air-source heat pumps in Finland

<table>
<thead>
<tr>
<th>Year</th>
<th>Amount</th>
<th>Heating capacity [MW]</th>
<th>Generated heat [GWh]</th>
<th>Consumed electricity [GWh]</th>
<th>Utilized primary energy [GWh]</th>
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<tbody>
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</table>

[http://www.sulpu.fi](http://www.sulpu.fi)
## Ground source heat pumps in Finland

<table>
<thead>
<tr>
<th>Year</th>
<th>Amount</th>
<th>Heating capacity [MW]</th>
<th>Generated heat [GWh]</th>
<th>Consumed electricity [GWh]</th>
<th>Utilized primary energy [GWh]</th>
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<td>2001</td>
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<tr>
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<td>1 402,90</td>
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<tr>
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<td>2007</td>
<td>38 906</td>
<td>831,00</td>
<td>2 815,00</td>
<td>983,00</td>
<td>1 877,00</td>
</tr>
</tbody>
</table>

[http://www.sulpu.fi](http://www.sulpu.fi)
Heat pumps

Penetration level of the heat pumps [%]

Detached houses: 11% (2010), 48% (2020)
Attached houses: 3% (2010), 61% (2020)
Apartment houses: 1% (2010), 12% (2020)
Public service: 1% (2010), 19% (2020)
Private service: 2% (2010), 30% (2020)
Industry: 0% (2010), 19% (2020)
Summer cottages: 2% (2010), 53% (2020)
Agriculture: 1% (2010), 38% (2020)
Heat pumps

Impacts of the heat pumps for the electrical energy

-14,0 %
-12,0 %
-10,0 %
-8,0 %
-6,0 %
-4,0 %
-2,0 %
0,0 %
2,0 %

Detached houses
Attached houses
Apartment houses
Public service
Private service
Industry
Summer cottages
Agriculture
In total

- Heating
- Cooling