Energy use for electricity generation

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Contents

• The first Revolution
• The second Revolution
• The missing Revolution
The Economist preaches the Revolution!


Two articles:

The Electric Revolution

The Dawn of Micropower
The revolution in 2000 is caused by three trends!

• Trend in Society:
  – A sustainable society calls for electric energy!

• Trend in Economy:
  – Competition spurs innovation!

• Trend in Technology:
  – Power electronics defeats the 50/60 Hz ban
  – From large scale to small scale production
Towards a sustainable society

More energy per person

Less pollution

Climate change

Providing energy to the poor

Meeting growing demand for fossil fuels, while reducing environmental and social impact

Shifting towards a low carbon energy system

Source: M.J. Groeneveld, Shell Global Solutions
New rules, new players!

figure 1. Electricity market agents.
From Technology to Market
From Digital to Analog!
From centralized to de-centralized
Van large scale to small-scale
From fossile to renewable
**Distributed Generation**

- From top-down to bottom-up
- The network, the technical link, is augmented by the market, the economical link

One-way traffic: top-down

Two-way traffic: also bottom-up!

Power to the people
The grid of the Future

- Smart Grids
- Micro Grids
- Virtual Power Plants
- Self-healing Grids
- Super Grids
Reliable:
- Ring structure.
- All connections are two three-phase circuits

Changing functions:
- Reliability
- Efficiency
- Environment
- Trade
Planned Interconnections

Electricity networks – axes for priority projects

Electricity priority projects already agreed:
1. France–Belgium–Netherlands–Germany
2. Borders of Italy with France, Austria, Slovenia and Switzerland
3. France–Spain–Portugal
4. Greece–Balkan countries–UCTE System
5. United Kingdom–continental and northern Europe
6. Ireland–United Kingdom
7. Denmark–Germany–Baltic Ring

Proposed additional electricity priority projects:
8. Germany–Poland–Czech Republic–Slovakia–Austria–Hungary–Slovenia
9. Mediterranean Member States – Mediterranean electricity ring
UCTE frequency at 8 November 2006

Live at www.ucte.org
Primary Control

- Primary control involves adjusting the system to maintain stability.
- In this diagram, the components include a steam valve, high pressure, low pressure, reheating, and a controller.
- The objective is to ensure that the frequency (f) and power (P) are maintained within specified ranges (Nullast, Produktie, Vollast).
- The diagram illustrates the interaction between these components to achieve a steady state for 50 Hz operation.
1. Vermogensregeling voor alle generatoren (1-2).
2. Generator met frequentieregeling:
   – Karakteristiek verschuiven, generator gaat meer vermogen leveren bij dezelfde frequentie (2-3’).
   – Gevolg: overschot mechanisch vermogen, generatoren gaan sneller draaien.
3. Vermogensregeling regelt weer naar evenwicht (2-3).
New control strategies based at intelligent agents

Figure 2. Agent learning process.
Active control through agent technology (ECN)

- Decentralized control
- Market based optimization algorithm
- Multi-agent technology
- Multiple layers
- Scalable
- Self configuring
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Evolution of Electricity Consumption in the Netherlands
Targets decentralized generation EU in 2020
Increase in sustainable generation in the Netherlands
Evolution of Solar Panels in the Netherlands
The first Revolution

• From top-down to bottom-up
• The network, de technical link, is augmented by the market, the economical link

One-way traffic: top-down

Two-way traffic: also bottom-up!  
Power to the people
Electric cars and the network infrastructure
Available network capacity (I)

Uncontrolled charging

Maximum transport capacity
Available remaining capacity

[kVA]

Daily pattern households on MV level

Source ECN
Electric cars and the network infrastructure
Available network capacity (II)
Electric cars and the network infrastructure
Available network capacity (III)

Uncontrolled charging
5 hours charging

[Graph showing uncontrolled charging over 5 hours with a note on reinforcement of transport capacity and about 25 cars per 100 dwellings]

Source ECN
Electric cars and the network infrastructure
Available network capacity (IV)

Controlled charging
5 hours charging

Maximum transport capacity
About 25 cars per 100 dwellings

Source ECN
Electric cars and the network infrastructure
Available network capacity ($V$)

Controlled charging
5 hours charging

Maximum transport capacity
About 75 cars per 100 dwellings
Demand side management
Demand side management
Demand side management

- Micro CHP
- PV panels
- MV grid
- Distribution station
- LV grid
- Electrical heat pump
- Washing machine

Source ECN
Electric cars and the electricity system
What happens with 1000,000 EVs? (I)

- Annual no. of Evs and PHEVs sold in the Netherlands if same introduction speed holds as Toyoto Prius
- Total Evs and PHEVs in the Netherlands including replacement after 10 years
- Action Plan Stichting Natuur en Milieu
- March 2008: 8 years after introduction Toyota Prius 10,000 sold in the Netherlands

Source: ECN
Electric cars and the electricity system
What happens with 1000,000 EVs? (I)

- No mass production of EVs and PHEVs yet
Electric cars and the electricity system
What happens with 1000,000 EVs? (I)

- No mass production of EVs and PHEVs yet
- But, over 1000,000 Toyota Prius on the market
Electric cars and the electricity system
What happens with 1000,000 EVs? (II)

- 1000,000 electric cars
- 20,000 km/year for each electric car
- 5 km/kWh
- 4000 kWh/year per car
- $1000,000 \times 4000 \times 1.1 = 4,400,000,000$ kWh = 4.4 TWh

- Dutch electricity consumption in 2008: 123 TWh

1000,000 electric cars will increase Dutch electricity demand with 3.6%
Electric cars and the electricity system
What happens with 1000,000 EVs? (III)

Day with highest system peak load in 2005 and 2006

Source ECN
Electric cars and the electricity system
What happens with 1000,000 EVs? (III)

Day with highest system peak load in 2005 and 2006

4.4 TWh / 365 = 12,000 MWh

Source ECN
Evolution of Heat Pumps in the Netherlands
The second Revolution

- From Supply follows Demand to
- Demand follows Supply!!
- Enabled through controlled charging of Electric Vehicles and control of Heat pumps
The missing Revolution of 1972

- The Limits To Growth:
- A Report for the Club of Rome Project on The Predicament of Mankind

- What happened ??
Share of total primary energy supply* in 2006

**Germany**

- **Oil**: 35.3%
- **Coal/peat**: 23.5%
- **Gas**: 22.7%
- **Nuclear**: 12.5%
- **Hydro**: 0.5%
- **Comb. renew. & waste**: 4.6%
- **Geothermal/solar/wind**: 0.9%

**349 Mtoe**

* Share of TPES excludes electricity trade.

Note: For presentational purposes, shares of under 0.1% are not included and consequently the total may not add up to 100%. © OECD/IEA 2008

For more detailed data, please consult our on-line data service at http://data.iea.org.
Share of total primary energy supply* in 2006

Denmark

- Coal/peat: 25.4%
- Oil: 38.4%
- Comb. renew. & waste: 12.6%
- Geothermal/solar/wind: 2.6%
- Gas: 21.1%

21 Mtoe

* Share of TPES excludes electricity trade.

Note: For presentational purposes, shares of under 0.1% are not included and consequently the total may not add up to 100%.
Share of total primary energy supply* in 2006

**World**

- Oil 34.3%
- Coal/peat 26.0%
- Gas 20.5%
- Nuclear 6.2%
- Hydro 2.2%
- Comb. renew. & waste 10.1%
- Geothermal/solar/wind 0.6%

11,740 Mtoe

* Share of TPES excludes electricity trade.
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For more detailed data, please consult our on-line data service at http://data.iea.org.
2000 Fuel Shares of World Total Primary Energy Supply

- Oil: 34.8%
- Gas: 21.1%
- Coal: 23.5%
- Nuclear: 6.8%
- Renewables: 13.8%

Other**:
- Hydro: 2.3%
- Combustible Renewables and Waste (CRW): 11.0%

Other Sources:
- Tide: 0.004%
- Wind: 0.026%
- Solar: 0.039%
- Geothermal: 0.442%
The transport of biomass in India
Conclusions on fuels for electric energy supply

- Oil is depleted, Gas is too precious to burn
- Coal and Uranium are abundant
- Electricity will replace oil as a transport fuel
- Hydro is the forgotten renewable!
- How fast will wind and solar catch up?
- Will wind and solar overtake coal and oil as the major energy source before 2050??