NTNU – Trondheim
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Introduction to the Unit Commitment Problem in Electric Power Production

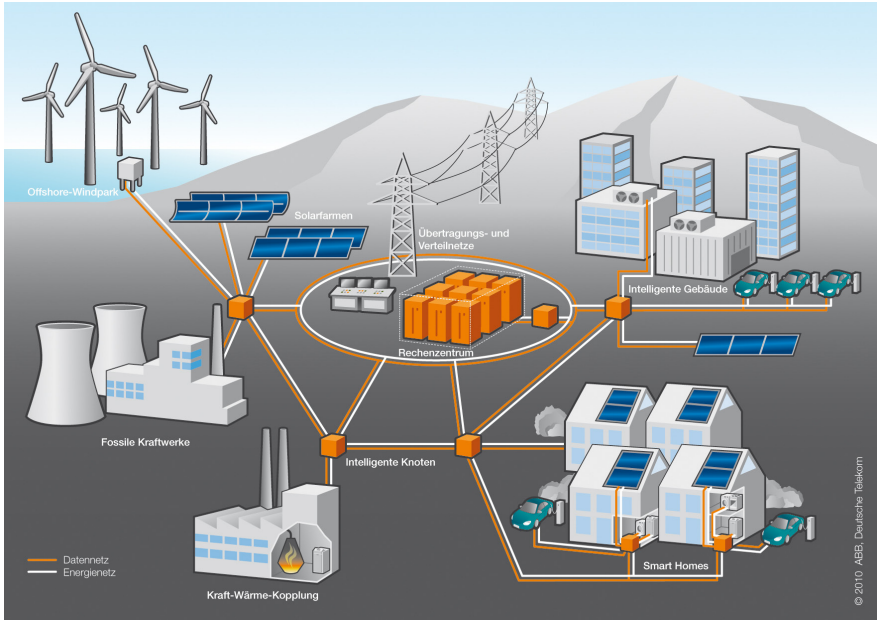
Outline

1. Problem defintion.
2. The structure of electric power generation
   1. Norway.
   2. The US.
3. The unit commitment and economic dispatch problem.
   - Various extension.
4. Solution approaches.

Unit commitment

Basic definition:

To find the least cost dispatch of available generation resources to meet an estimated electric power demand over a given time horizon.



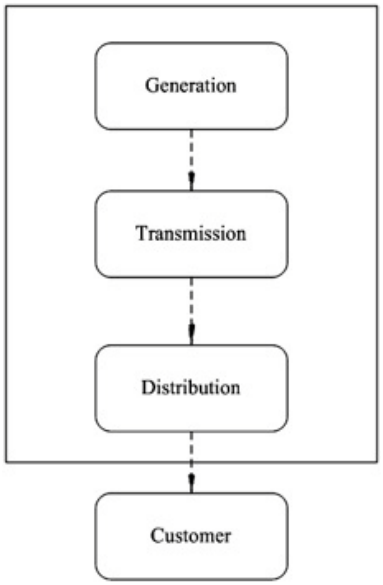
Source: abb.de

A variety of versions: integration, constraints, emissions, cost, profit etc.

Trading power

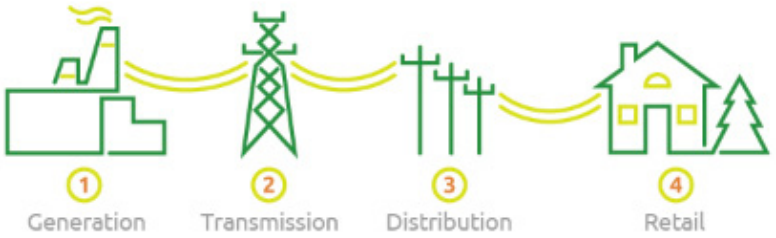
Regulated markets

- **One** utility controlling the power production for a whole region.
- Minimizing cost = maximizing profit.
- Vertical integration (monopoly)



Deregulated markets

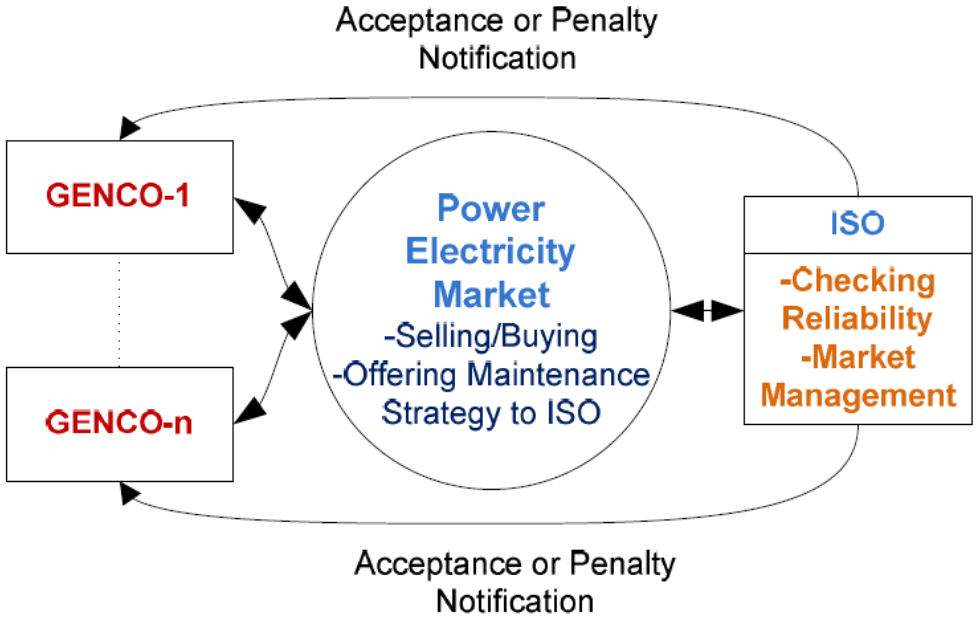
- **Several utilities** competing of being the most attractive provider of electricity.
- Different providers for different services.
- Generating companies (GENCOs) try to maximize their profit: revenue from sales minus generation cost.



Source: xenogyre.com/

Partly deregulated markets

- Some of the energy production is controlled by governmental regulations.
- Independent system operators (ISO) coordinate, control and monitor the operations of the electrical power systems.
- Many variants in integration of ISOs and GENCOs:
  - Bid and auction system.



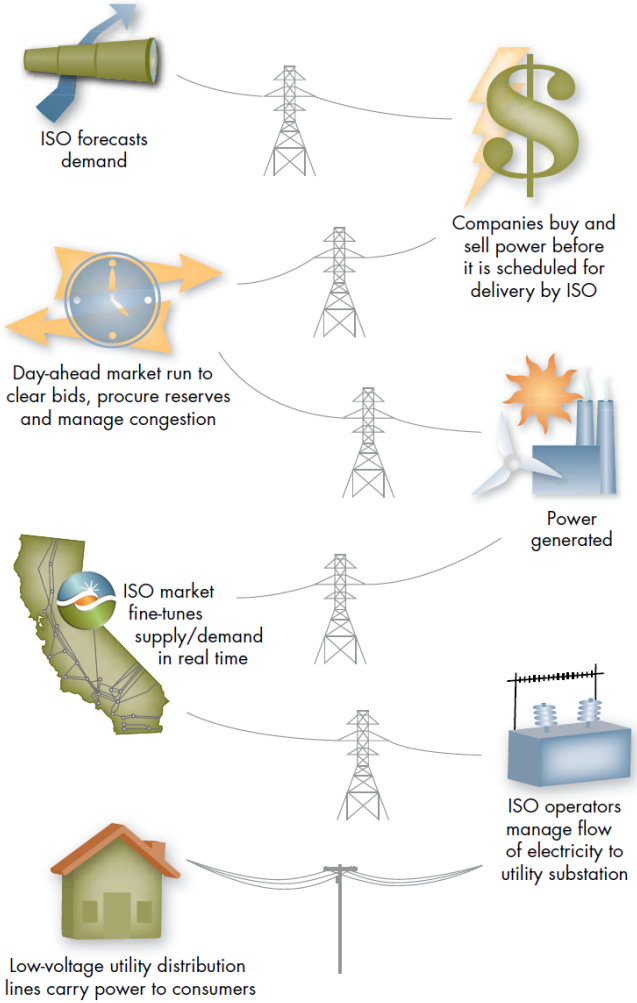
Source: Manbachi et.al 2010

Different horizons – different markets

1. Day ahead market
   - 24 hours – hourly dispatch plans.

The need for adjustment of power levels and units committed:
   - Consumption differs from forecasted demand.
   - Intermittent, stochastic resources (wind mills, solar cells etc.)

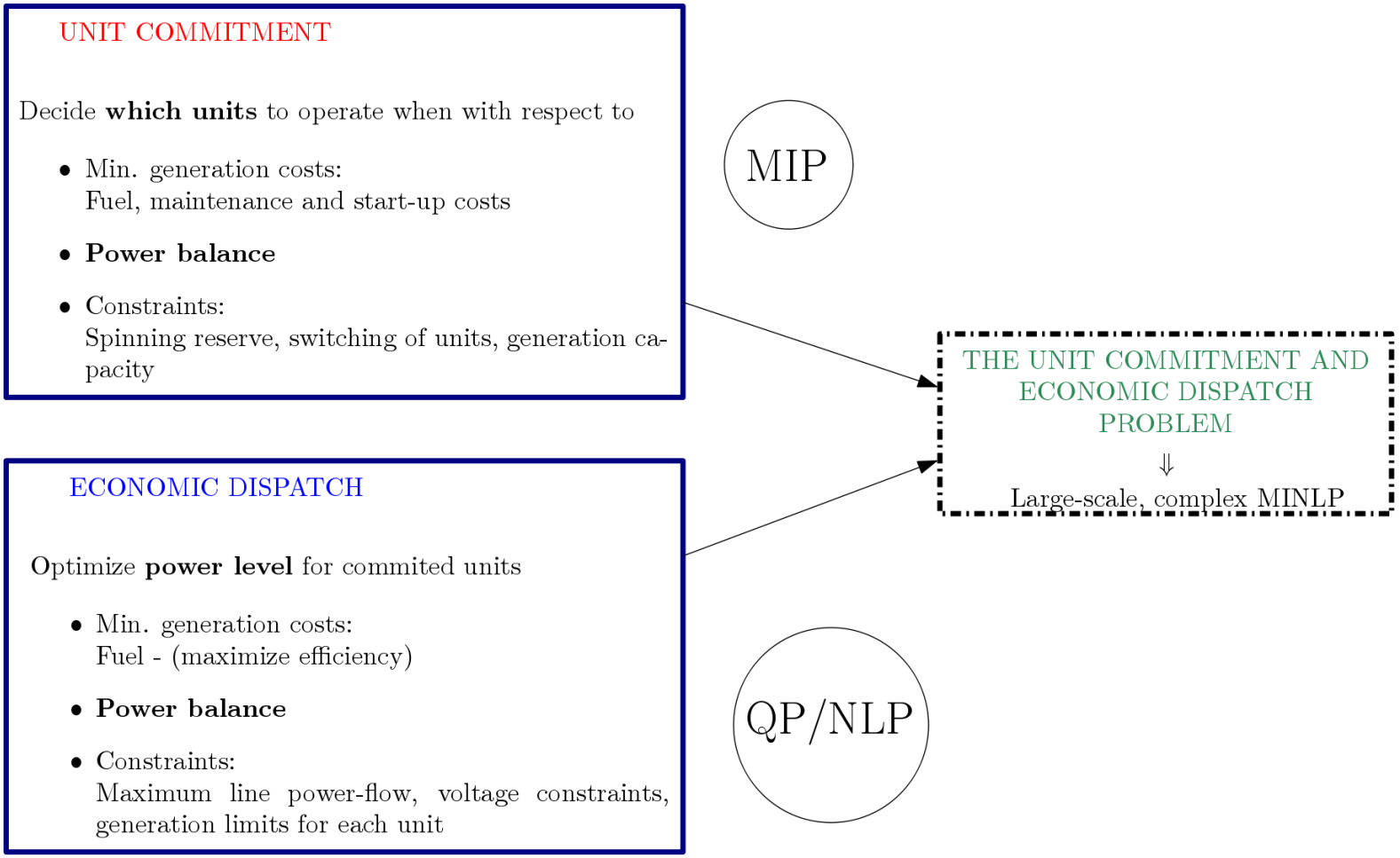
2. Look-ahead unit commitment
   - Adjust status of fast-starting units to meet system changes within the next 3-6 hours.
3. The real-time market:
   - Recommit very fast units (water, natural-gas) based on actual system operating conditions.
   - Time frame: 15 minutes to 2 hours.



Source: caiso.com

Unit commitment and economic dispatch

Given a forecasted demand d_k from an independent system operator (ISO)



The conventional unit commitment problem

- Objective function: minimize total costs.
- Constraints shared by all units (global constraints):
  - Power demand.
  - Spinning reserve.
- Constraints for each unit:
  - Power capacity (min/max).
  - Minimum up down-time constraints.
  - Ramping constraints.

Extension of the unit commitment problem 1:

Emission-constrained unit commitment

1. Hard upper bound (constraints) on allowed emissions.
2. Penalty/cost on emissions in the objective function.
3. Emission allowance system (cap and trade).

Source: pennenergy.com

Extension of the unit commitment problem 2:

Stochastic unit commitment:

1. Uncertainty in demand.
2. Intermittent renewable generation resources.
3. Capacity of generators
   - Generators dropping out.
4. Varying fuel prices.

Extension of the unit commitment problem 3:

Security-constrained unit commitment

- Sufficient spinning reserves:
  - Abrupt changes in load.
  - Units dropping out.
- Transmission capacity.
- Natural-gas availability.

Source: http://buildipedia.com/

Source: forbes.com