Outline

1. Problem definition.
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.

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.
Unit commitment and economic dispatch

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

**UNIT COMMITMENT**

Decide **which units** to operate when with respect to

- Min. generation costs:
  Fuel, maintenance and start-up costs

- **Power balance**

- **Constraints:**
  Spinning reserve, switching of units, generation capacity

**ECONOMIC DISPATCH**

Optimize **power level** for committed units

- Min. generation costs:
  Fuel - (maximize efficiency)

- **Power balance**

- **Constraints:**
  Maximum line power-flow, voltage constraints, generation limits for each unit

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**THE UNIT COMMITMENT AND ECONOMIC DISPATCH PROBLEM**

Large-scale, complex MINLP

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**MIP**

**QP/NLP**
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:

Safety-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