Assessment of the economic viability of balancing from Norwegian hydro from the perspective of a single power producer

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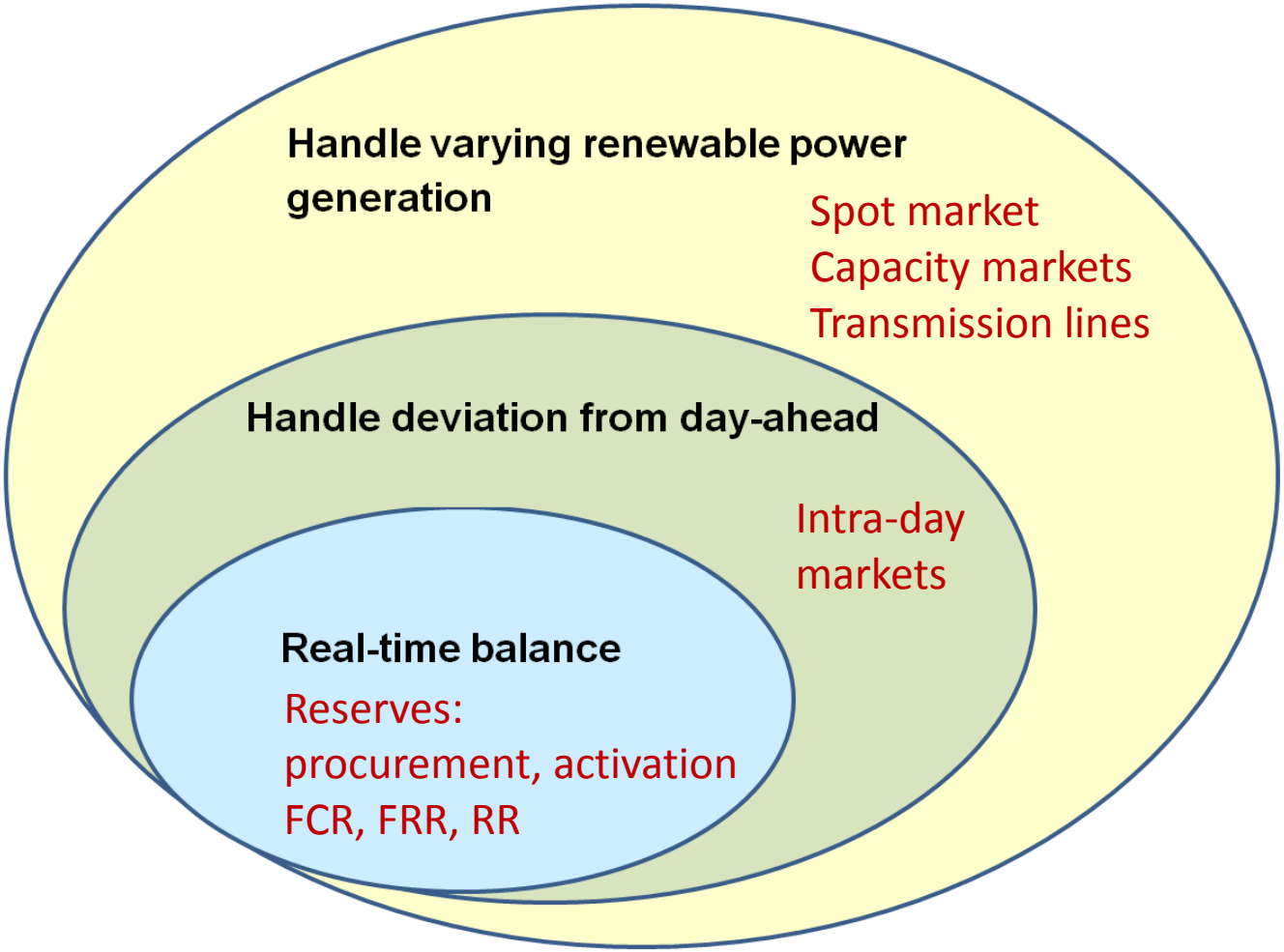
HydroBalance User Meeting, 18-19 November 2014

What is ment by "balancing"?



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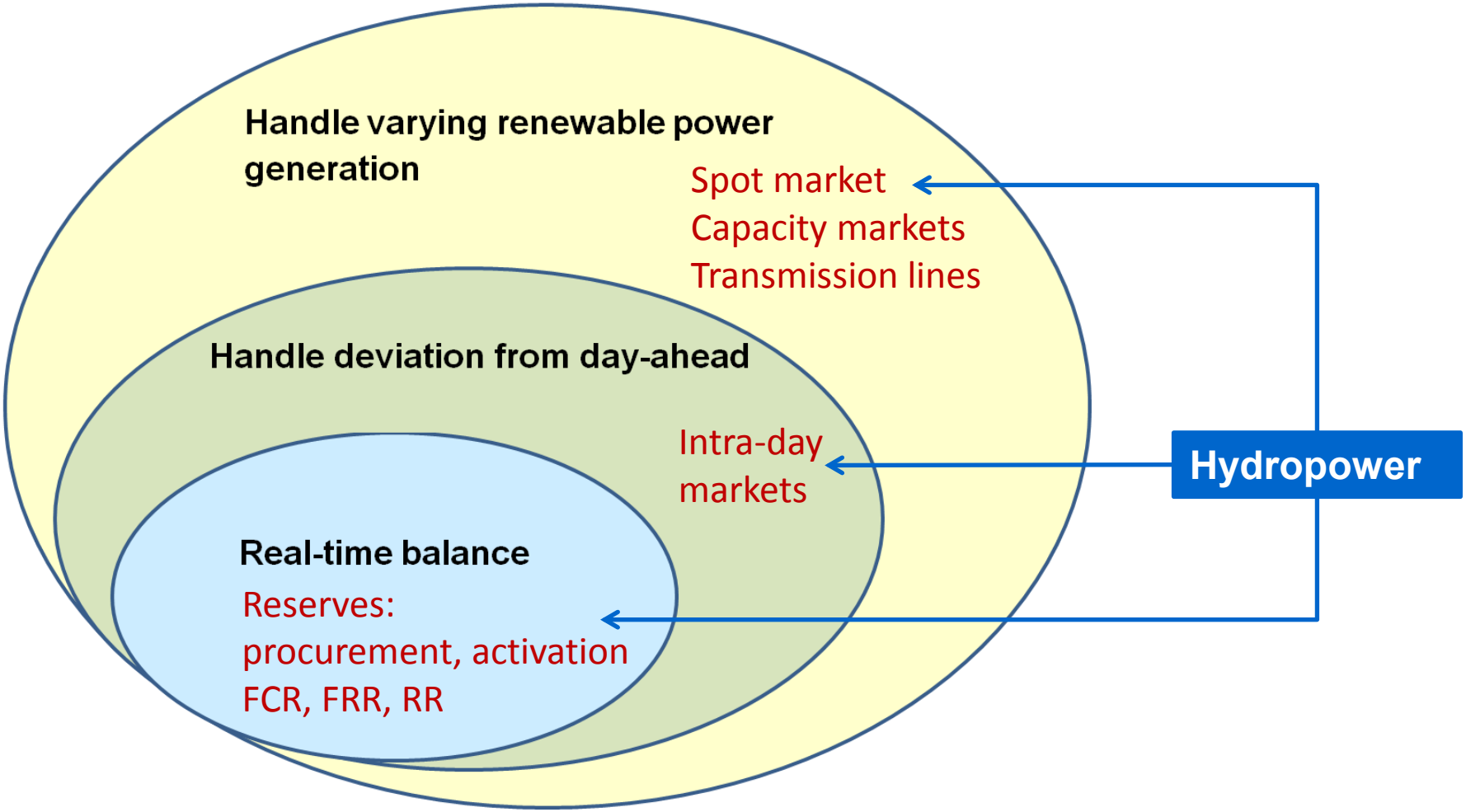
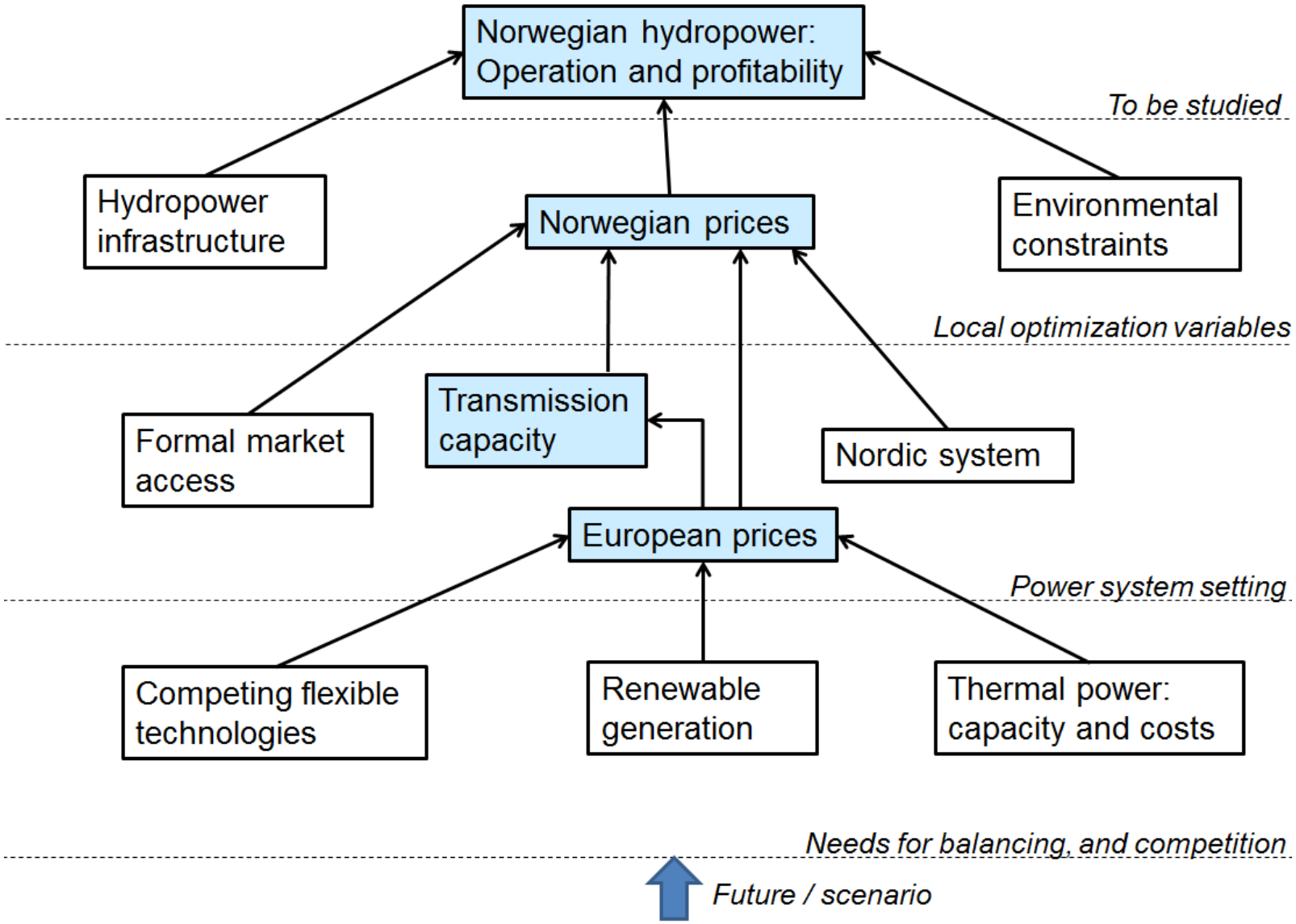


Research questions

1) Will investments in Norwegian hydropower be profitable?
   - New/upgraded facilities, pumped storage
   - Share of income in different markets?
   - Bilateral arrangements?

2) How will hydropower be operated in the future?

A possible mind-map



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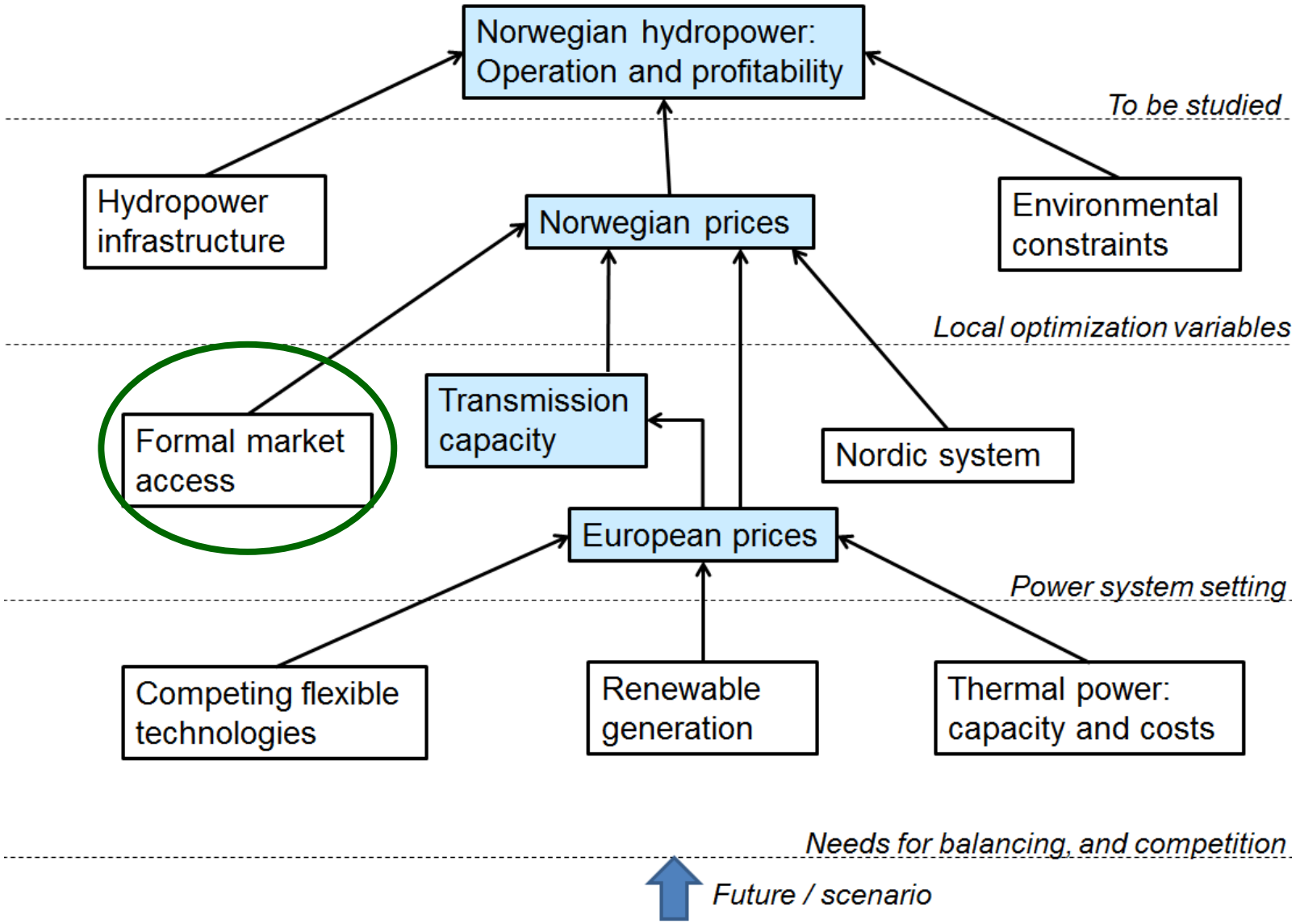


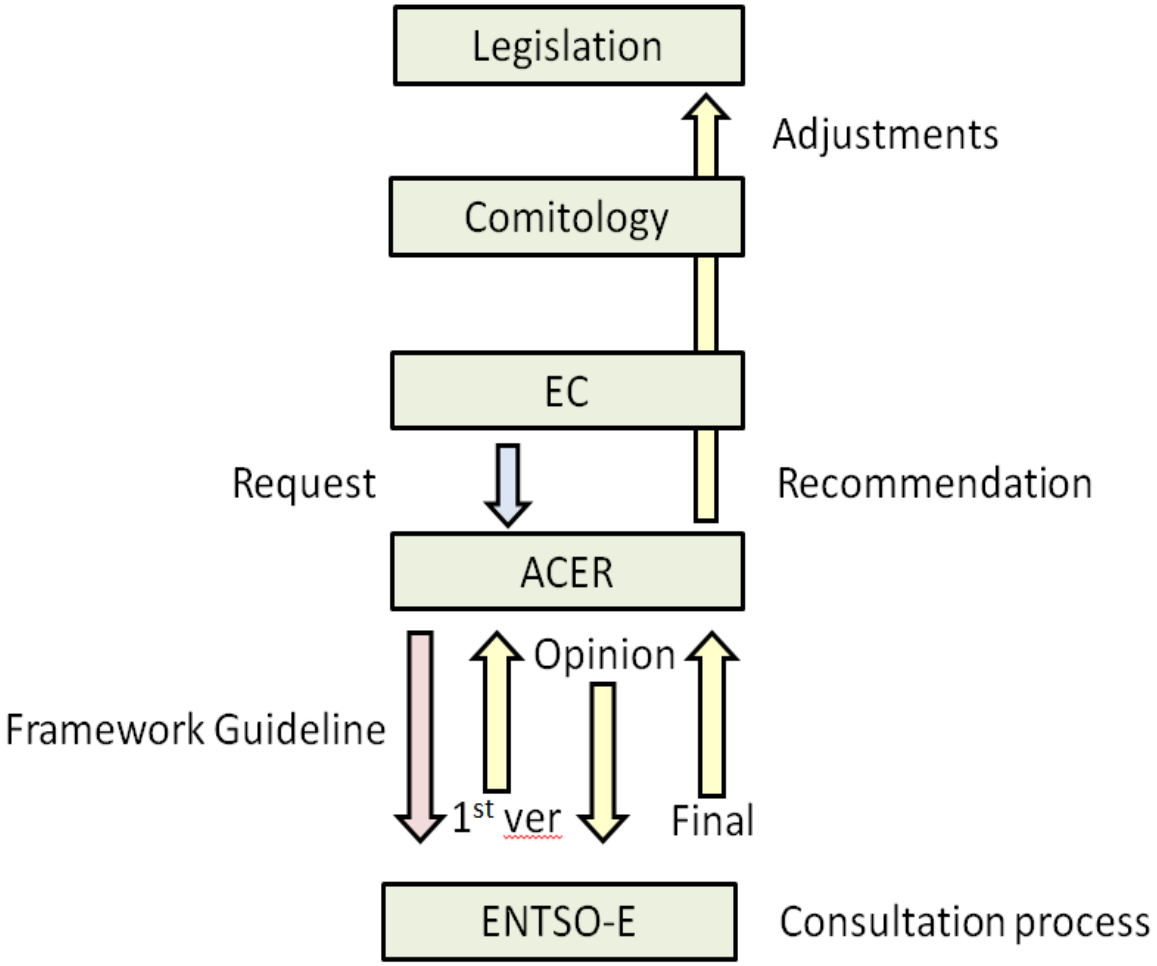
Market access

- Today
  - Nordic market (spot, Elbas, balancing energy)
  - European day-ahead price coupling (75% of total)
  - Elbas (intraday): Nordic + Baltic + NL + GE

- European integration process
  - Florence Forum for regulators (2008), TM/roadmap
  - Day-ahead, intraday, balancing, capacity allocation, connections
  - Ongoing process: EC / ACER / ENTSO-E / …
  - Network codes

- Forward-looking: 2030, 2040, 2050
  - Difficult to foresee
  - Best guess: Full integration in the long run?

Network code development process



NC on markets

CACM
- Day-ahead
- Intraday
- Capacity calculation

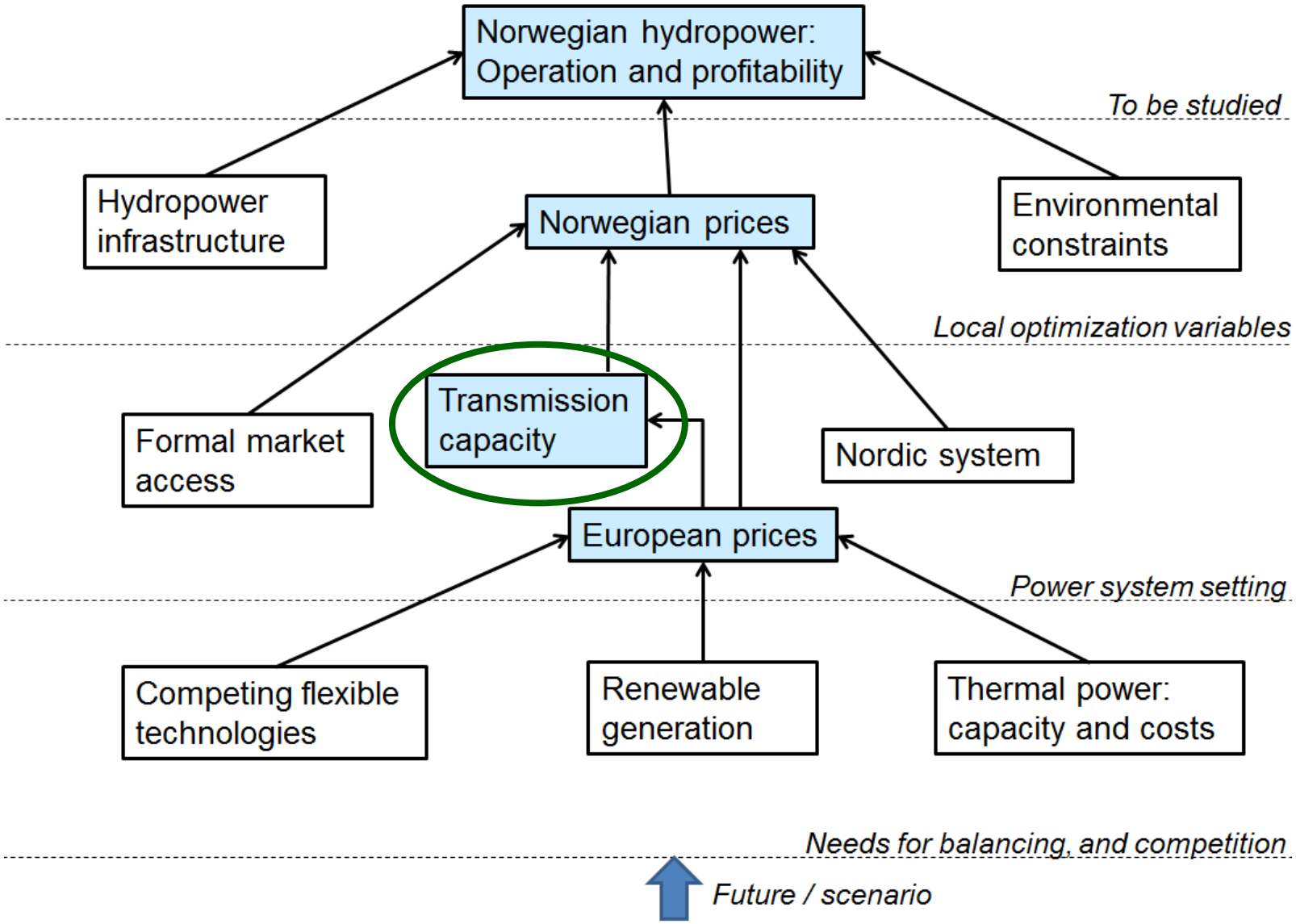
EB
- TSO cooperation
- Balancing energy
- Procurement reserves
- Netting

FCA
- Forward capacity calculation

Figure

https://www.entsoe.eu/major-projects/network-code-development/updates-milestones/Pages/default.aspx

A possible mind-map



Figure

http://www.statnett.no/Global/Dokumenter/Prosjekter/Nettutviklingsplan%202013/Nettutviklingsplan%202013.pdf

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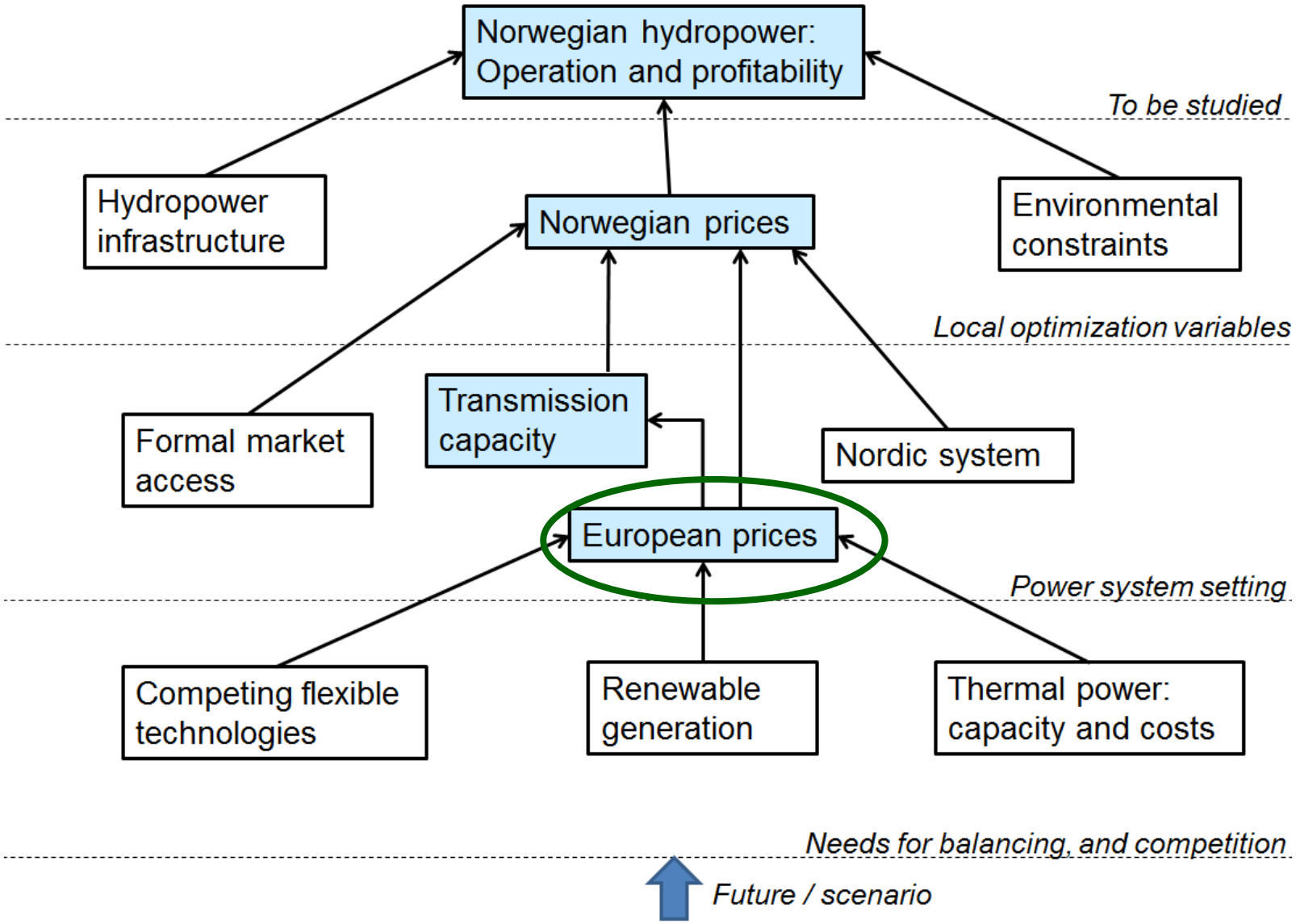
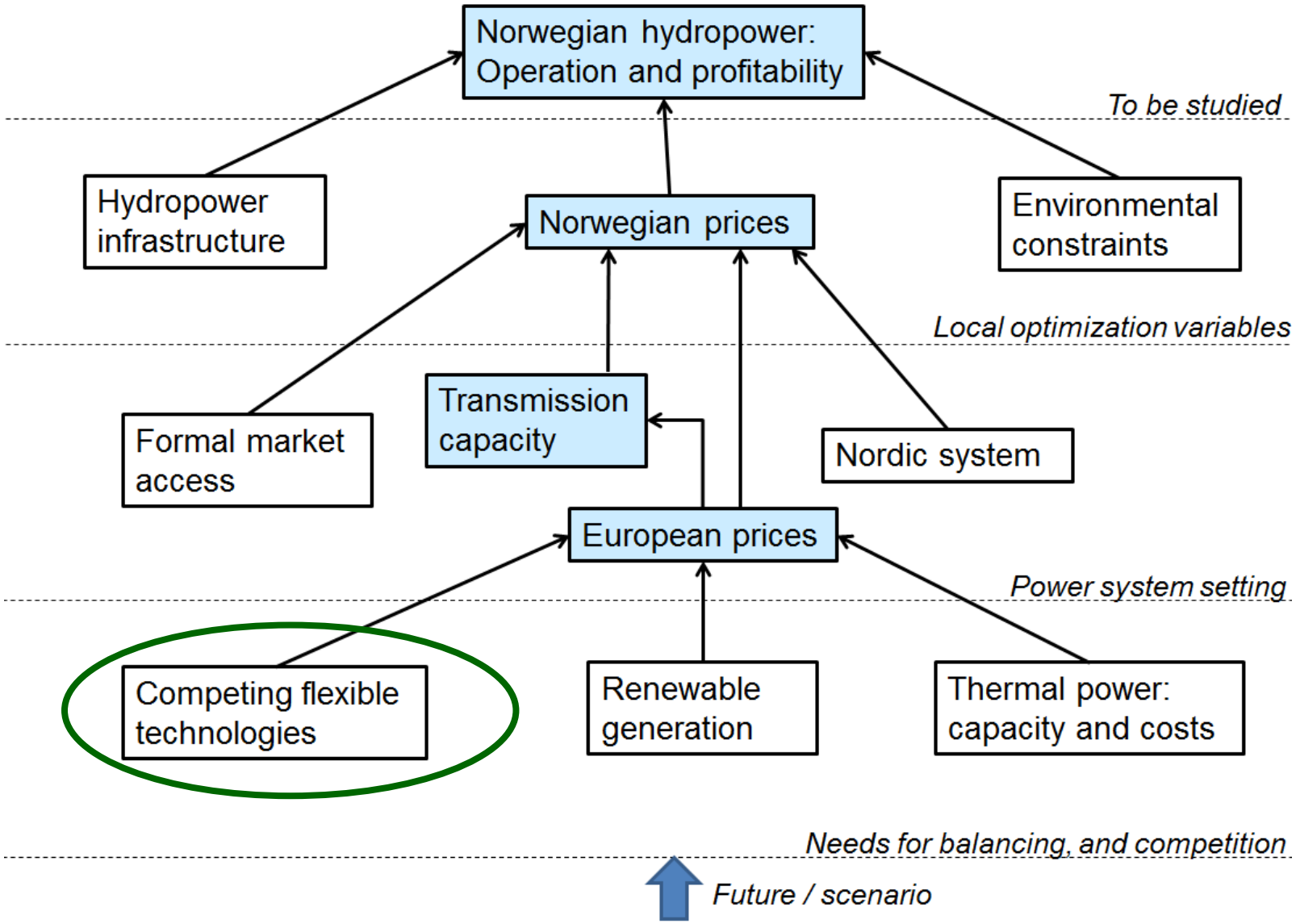
A possible mind-map



European prices 2030 and beyond

- Affected by many factors
  - Thermal power capacity and costs
  - Renewable generation
  - Prices for fuel prices and CO2
  - Nuclear power policy
  - Flexible technologies
  - …
- Several markets: day-ahead, intraday, balancing energy, …
- In project
  - WP1: Different Scenarios for 2050
  - IAEW (European day-ahead prices, more markets for Germany)
  - ECN

A possible mind-map

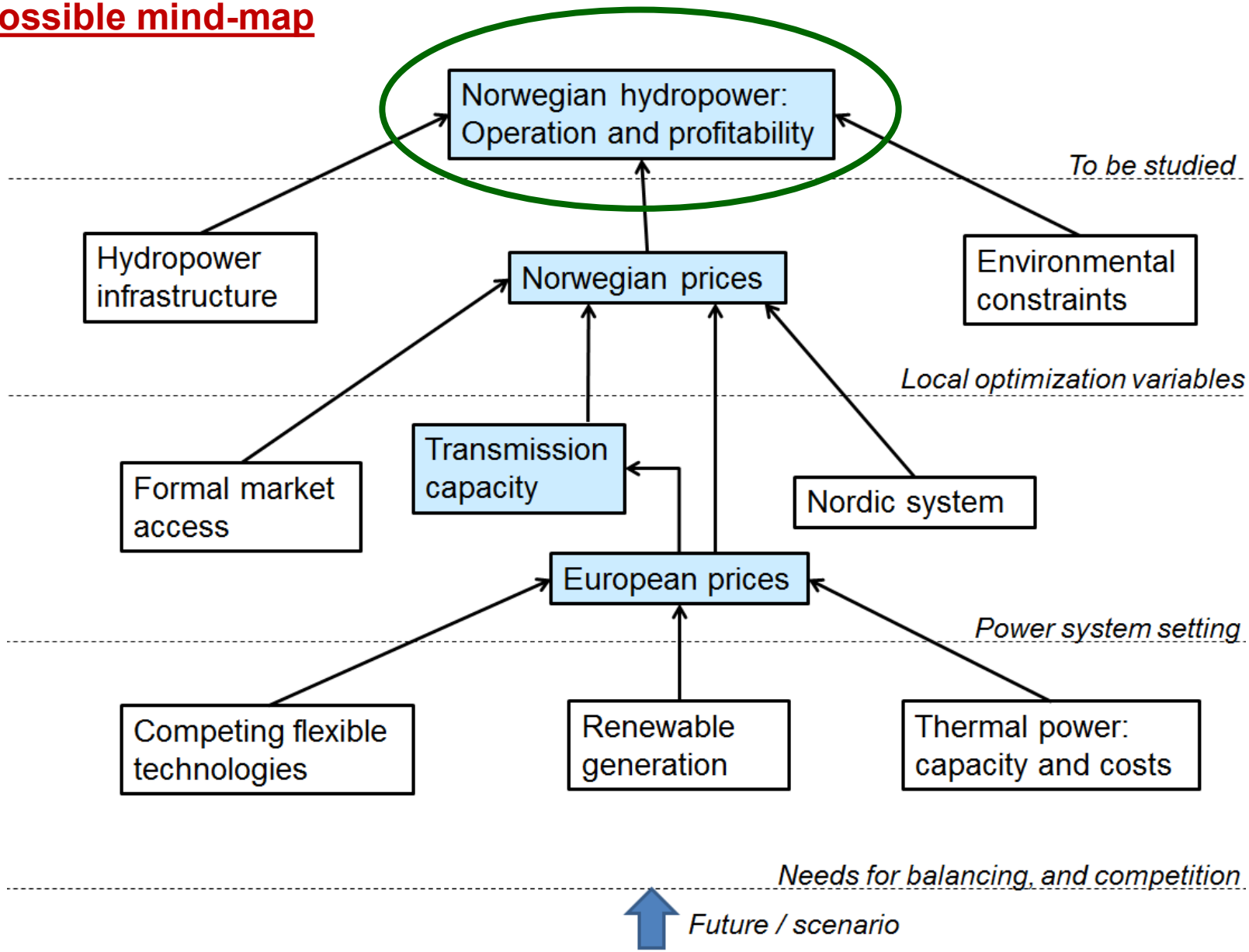


Flexible technologies

(dealing with varying vind/solar)

- Large-scale reservoir hydropower
- Gas-power
- More flexible coal- and nuclear-power
- Netting / transmission grid enhancment
- Storages
  - Local pumped storage
  - Power to gas
  - Batteries
  - Thermal
- Demand flexibility

A possible mind-map



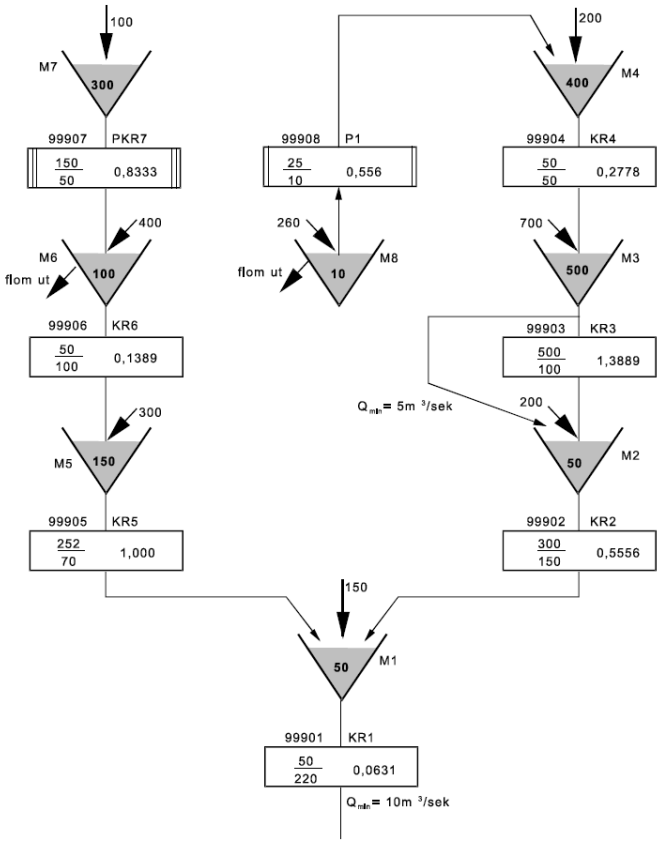
Goals in WP3 of Hydrobalance

- Analyze
  - Expected payback for investors in hydropower capacity
  - Shares from different markets
- Simulate future hydropower operation
  - Design methodology (multi-market)
  - Case-studies of specific water-courses

Plan: Apply the model PRODRISK

(… and possibly SHOP)

- One of SINTEF's optimization tools for hydropower
- Local producer / river system
- Time-resolution: minimum 1 hour
- Horizon: e.g. 1 year
- Prices and inflow are stochastic variables: inputs to model

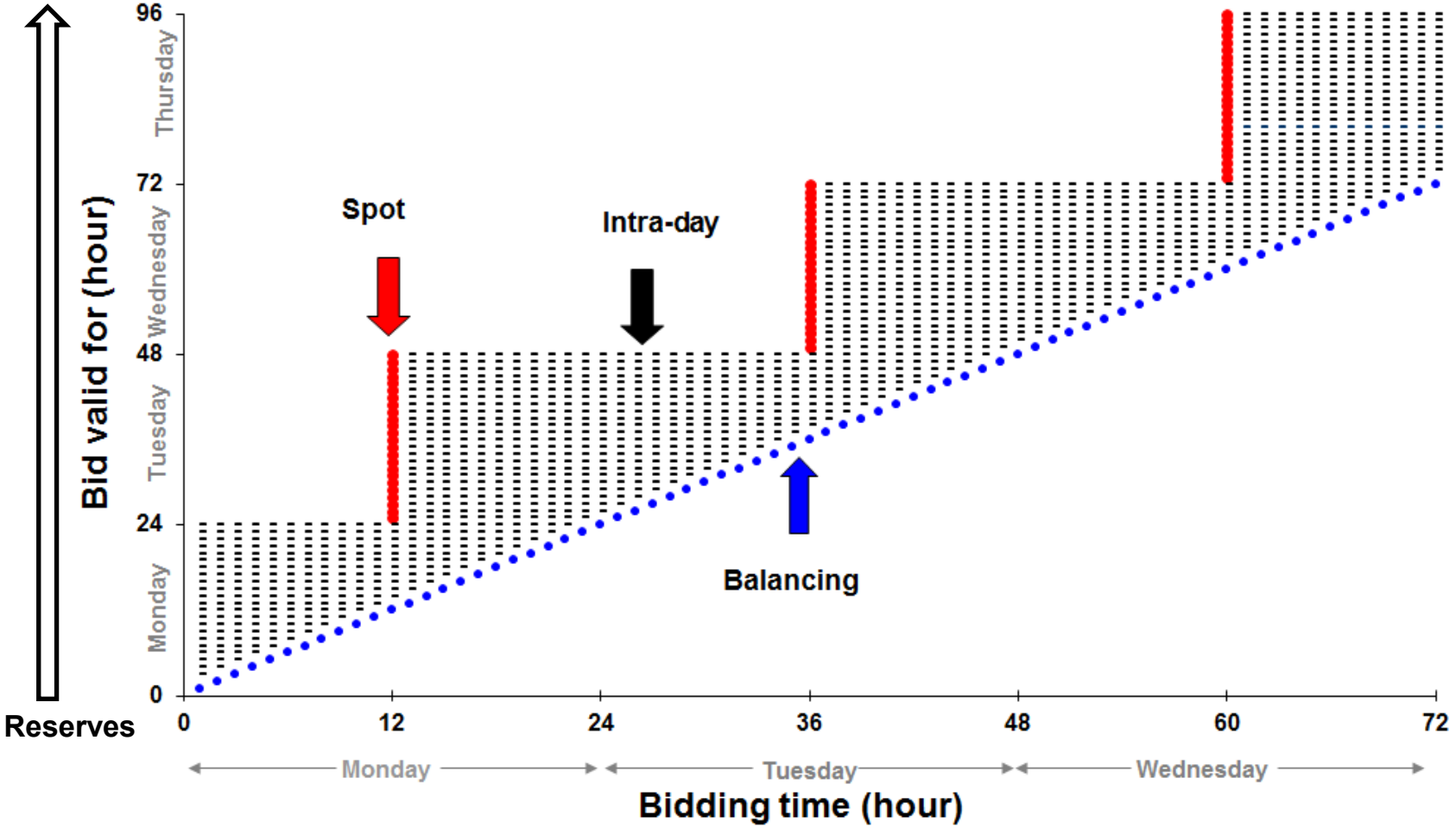


Challenge: Future-year prices

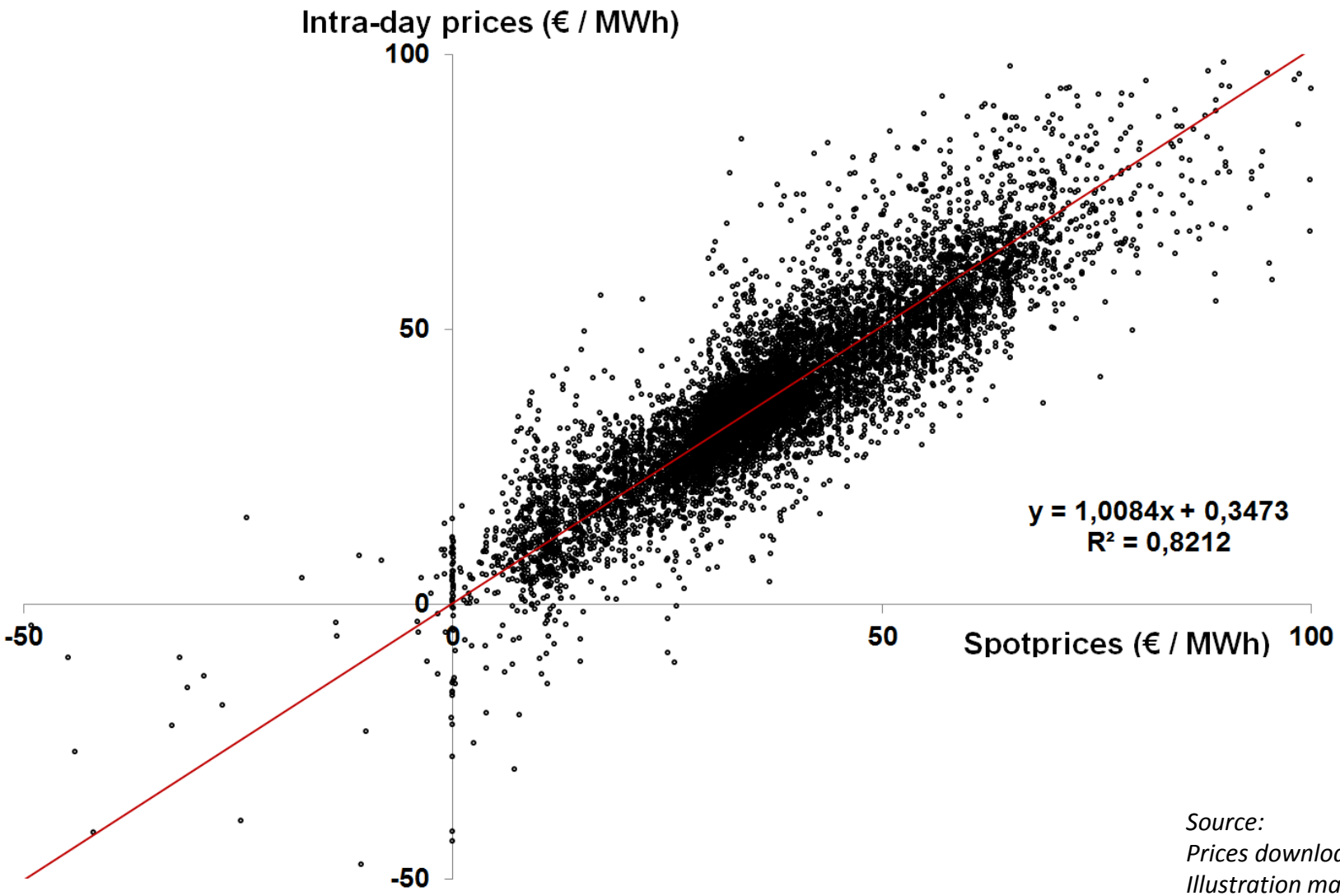
- Spot prices
  - For future year: 2050
  - Several 2050-scenarios
  - Uncertainty and variation for renewable generation

- Prices in several markets
  - Procurement of reserves (several types)
  - Day ahead
  - Intra-day (several trading hours)
  - Activation of reserves / balancing energy (several types)
  - …

Trading in multiple markets

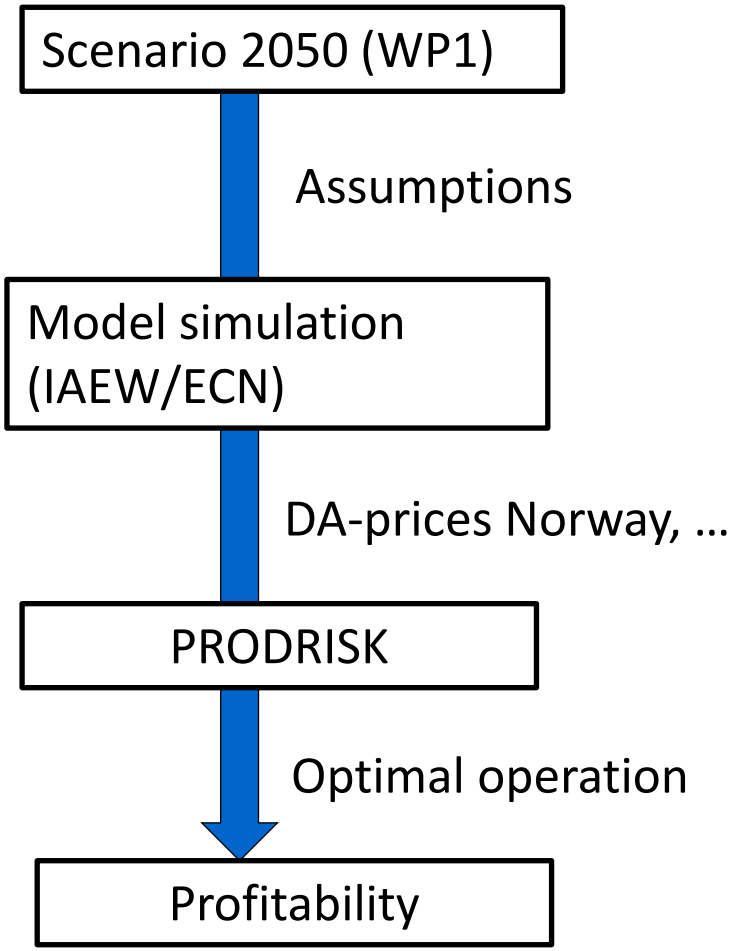


2013-prices in German market



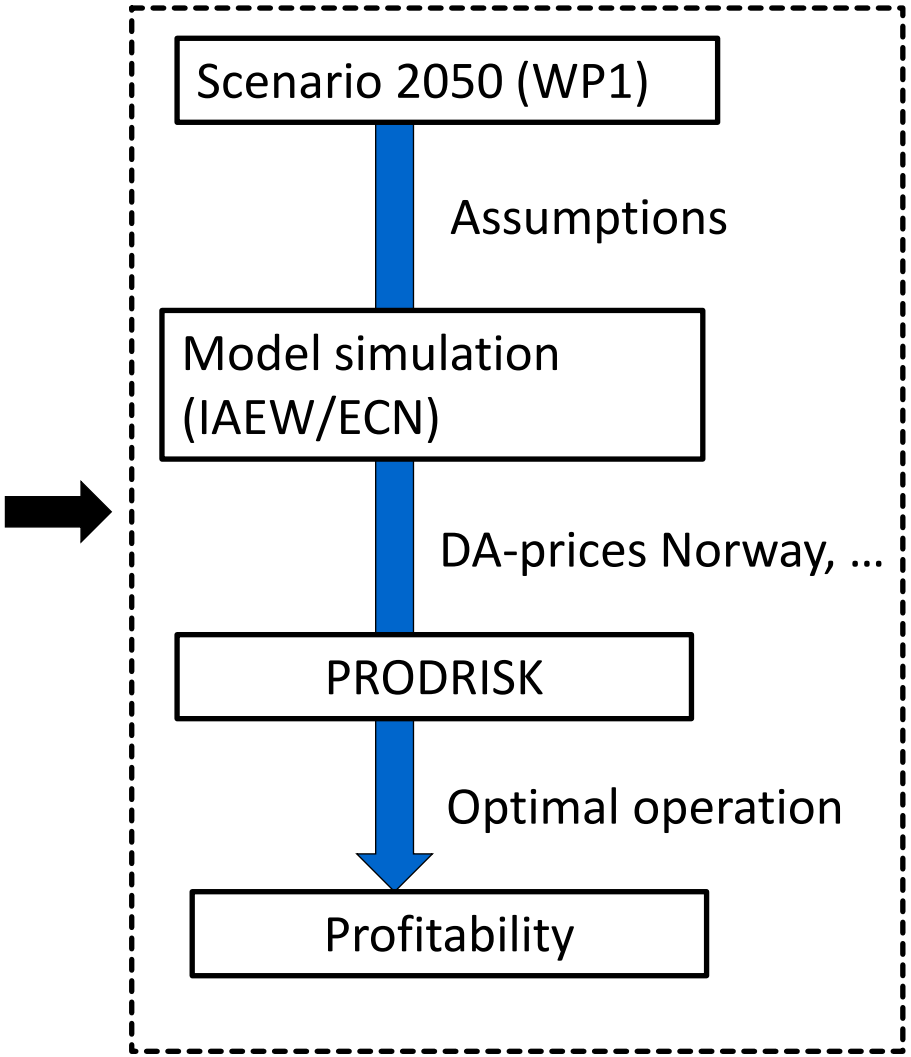
Source:
Prices downloaded from EPEX
Illustration made by SINTEF

Analyze future year profitability in DA

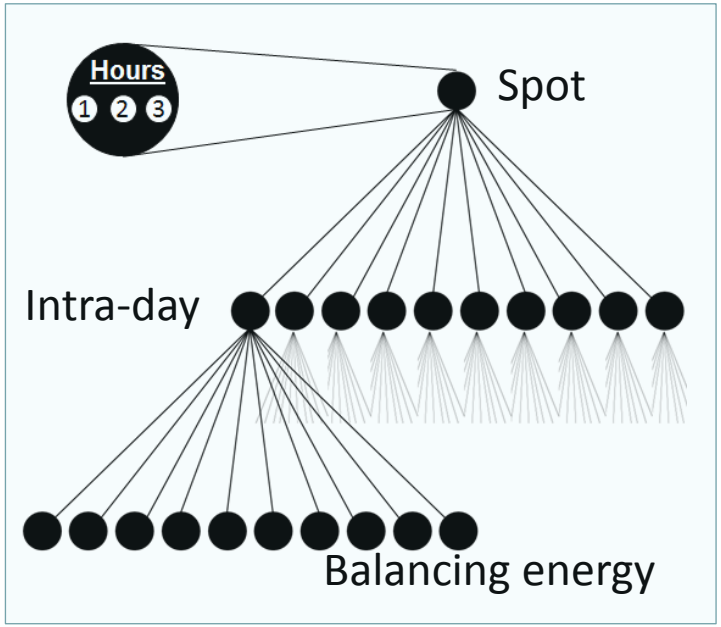


Analyze profitability for investment

Investment in pumped storage



Challenge: Multi-market optimization



- Prices
  - One per hour in PRODRISK
  - Several for each hour in reality
- Presently, we do not have the multi-market optimization tool for hydropower
- A set of strategies can still be evaluated

Strategies to be evaluated

- Analyze operation towards
  1) Spot-market prices $X^{PRO}\left(p_t^{spot}\right)$
  2) Prices in other markets (intra-day, balancing) $X^{PRO}\left(p_t^{intra}\right)$ $X^{PRO}\left(p_t^{bal}\right)$

- Sequential sub-optimal approach
  - Simulate participation in all markets
  - As difference between solutions for each market

Spot (main market): $X_t^{\text{spot}} = X^{PRO}\left(p_t^{spot}\right)$

Intra (adjustment): $X_t^{\text{intra}} = X^{PRO}\left(p_t^{intra}\right) - X^{PRO}\left(p_t^{spot}\right)$

Balancing (adjustment): $X_t^{\text{bal}} = X^{PRO}\left(p_t^{bal}\right) - X^{PRO}\left(p_t^{intra}\right)$

  - Reserve capacity (MW): parameter, try different values
  - Reservoir content updates needed

Next steps in WP3

- Finalize review on markets
- Calculate future prices (cooperation)
  - Scenarios
  - Markets
- Calculate optimal operation (PRODRISK, SHOP)
  - Design/test methodology
  - Case study; site
- Evaluate profitability of investment for different scenarios