Institute of Information Systems

Energy Turnaround
National Research Programme NRP 70

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School of ...anagement & Tourism

Configuration of Hydro Power Plant Mathematical Models

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SCCER CREST

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SWISS COMPETENCE CENTER for ENERGY RESEARCH
SUPPLY of ELECTRICITY

Valais excellence

HP-Future

- HP is important in CH
  - Approx. 56% of Swiss Energy comes from HP
  - The Energy Strategy 2050 expects an increase in HP production

➔Investments are needed

  - **BUT:**
    - Average price to produce electric power **5** rp. per kWh
    - Price level to sell electric power **3** rp per kWh

Watching out of the office…

Axpo nach Milliardenabschreiber mit 730 Millionen Franken Verlust

Alpiq macht nach Abschreiber 902 Millionen Franken Verlust

Die Schweizer Grosswasserkraft ist akut bedroht

David Thiel, IWB 13.3.2015, 05:30 Uhr

Empfehlen 0 Twittern 5 g+1 0

Where is the problem?

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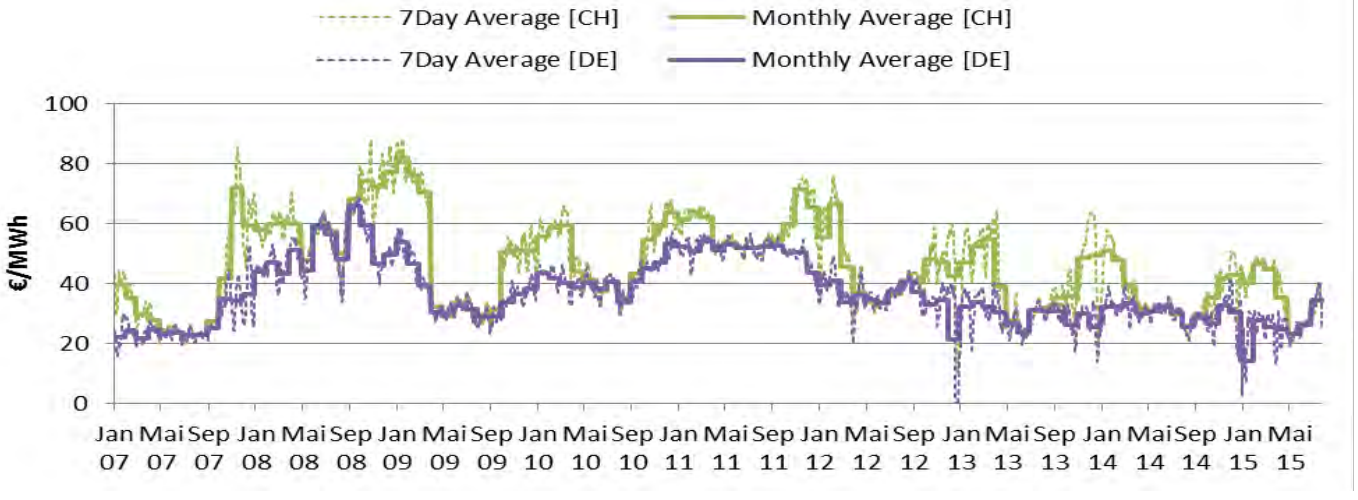
- HP is well established technology
- Operation Planning is well established in HP

- Why revisit problem?
  - Less time
  - Larger problem
  - Smaller margin of error
  - Model maintenance / extension

Current Methods

- Static
- Inflexible
- Domain Specific
- High maintenance cost
- Barely adaptable for for current market



Modular approach

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$$\max. \sum_{i,m} P_{i,m} Q_{i,m}$$

$$Q_{i,m} = R_{i,m} \alpha$$

$$S_i = S_{i-1} + I_i - \sum_m R_{i,m}$$

$$S_i \leq S_{\max}$$

$$S_i \geq S_{\min}$$

$$\sum_m Q_{i,m} \leq Q_{max}$$

- Francis Turbine
- Pelton Turbine
- Day-ahead Market
- Intraday Market
- Env. Constraint
- ...

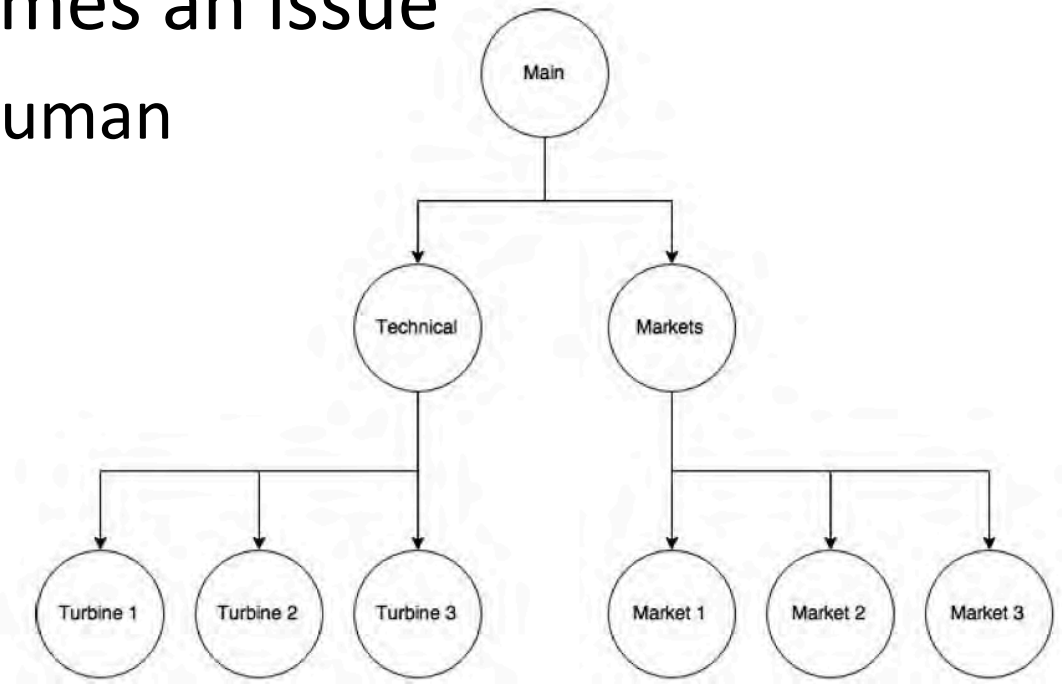
Model 1
- Francis Turbine
- Day-ahead Market
- Env. Constraint

Model 2
- Pelton Turbine
- Intraday Market
- Day-ahead Market

- Create the specific model at runtime

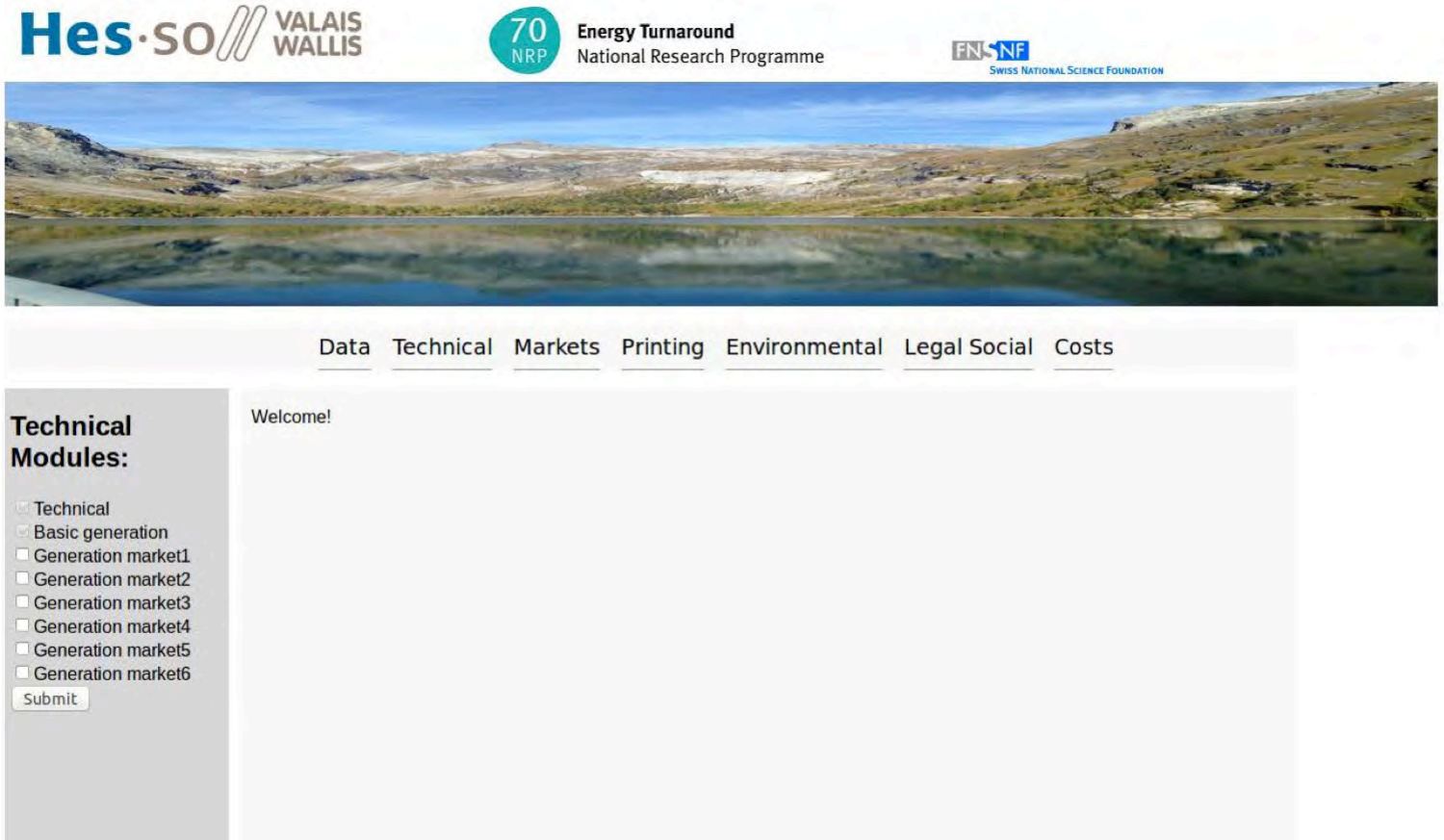
Configuration

- How to combine the modules?
  - To create a valid model we have to consider a number of constraints.
- Configuration becomes an issue
  - Can be done by a human
  - Can be automated



Interactive Configuration

- Turn on/off modules
- Check Validity
- Creates the model
- Start CPLEX



Automatic Configuration

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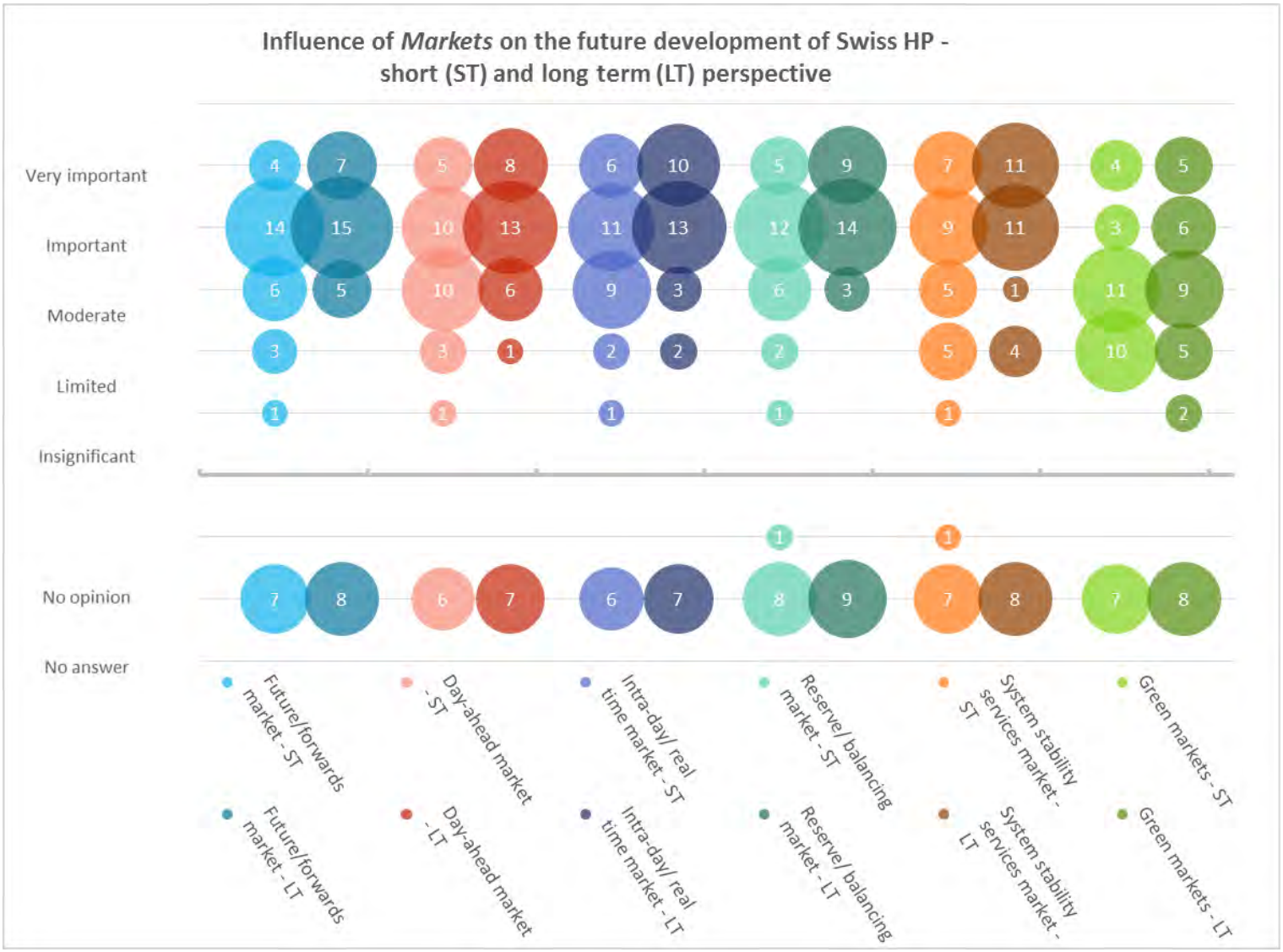
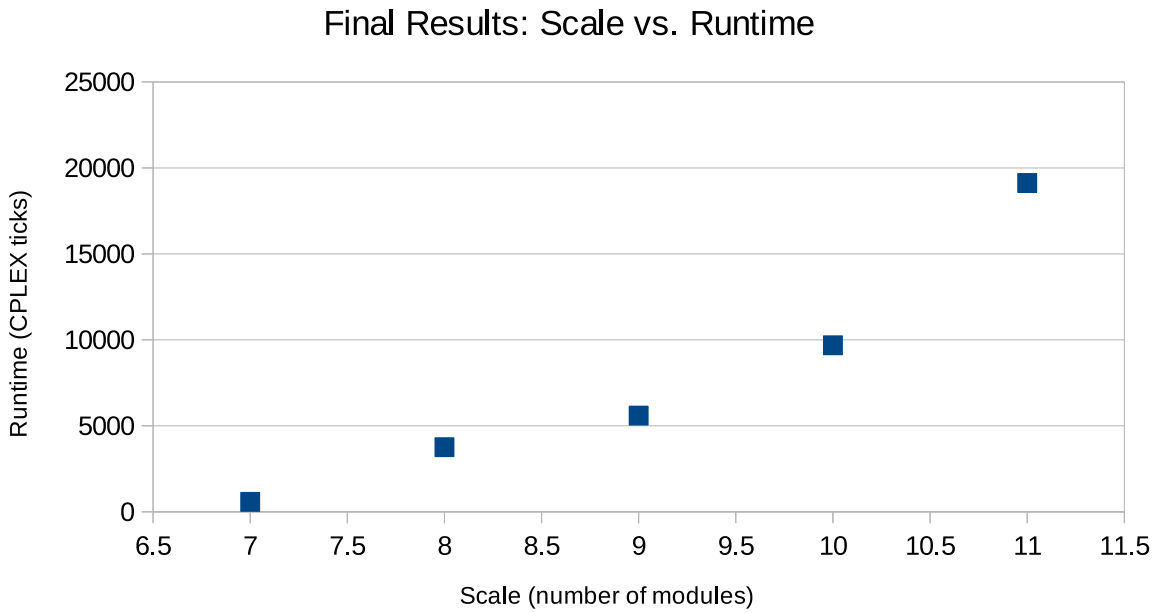
- Configure a model towards different objectives, e.g.
  - Runtime
  - Result quality
- Search for better combination of alternative extensions (extending scenario based manual evaluations)

Proof-of-concept



Proof-of-concept

- 5 different (faked) markets
- The more modules (markets) included, the more complex is the problem
- Find a Pareto front (Runtime / Scale)
- Using a SPEA2



Future work

- Expand mathematical model
  - Apply to real world problems in case studies
  - Compete with industry standards
  - Additional technical/environmental constraints
  - More Sophisticated market models
- Expand interface
- Automatic configuration
- Multi-Site operations
- Model modernization

Acknowledgement

- This project is part of the research project

  The Future of Swiss Hydropower:

  An Integrated Economic Assessment of Chances, Threats and Solutions

- This project is done in co-operation with