POWEL
The future is bright

Hydroelectric Generation DSS in Deregulated Markets

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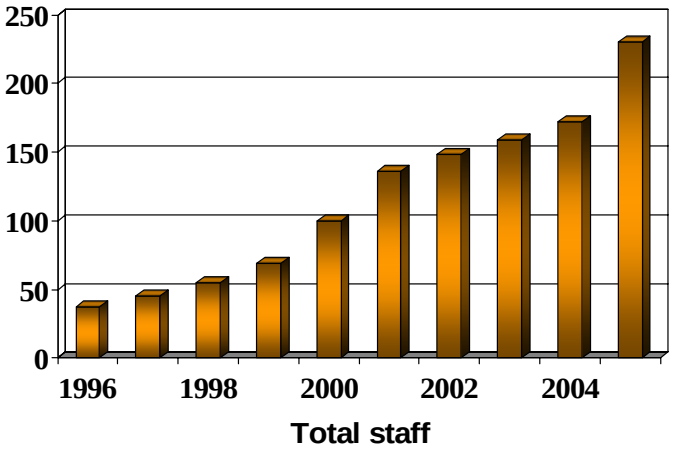
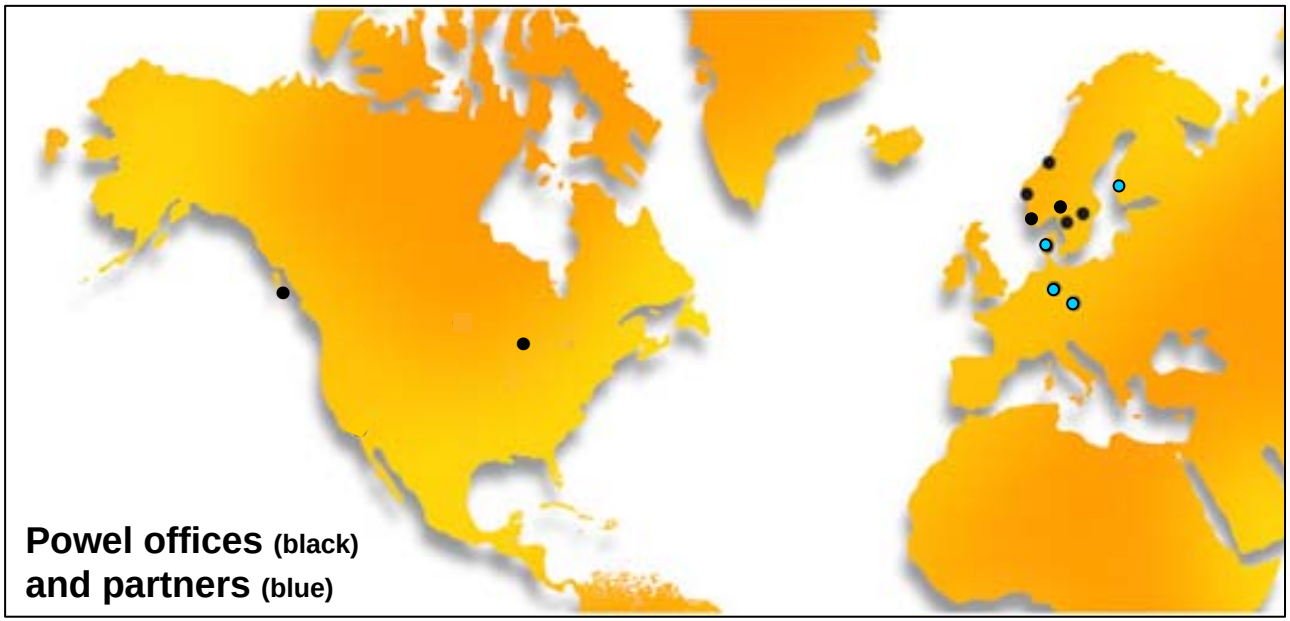
Satisfied Powel ICC Customers

- Statkraft Energy AS (34 TWh/year)
- Fortum Corporation (21 TWh/year)
- E.ON Sweden (11 TWh/year)
- E-CO Energy (7 TWh/year)
- Hydro Oil and Energy (7 TWh/year)

About Powel

- Software company - focused on the Energy Market
- Started in 1996 as a spin-off from the Norwegian University of Science and Technology
- Approx. 240 employees worldwide
- Offices in U.S.A, Canada, Norway, Sweden
- More than 30 software modules are used by 1000 customers worldwide





A Powel/Sintef Energy Research User Group Meeting

Powel Customers Provide a Total of

50,000 MW

Hydro Generation

The Powel ICC Solution in Brief…

- Generation and Water Management
  - Long- and mid term planning
  - Short-term planning:
    - Powel Sim – hydropower simulator
    - Powel Shop – hydropower optimizer
    - Powel Inflow – inflow forecaster
    - Powel Availability – constraint management
- Demand and Price Forecasting
- Power Trading

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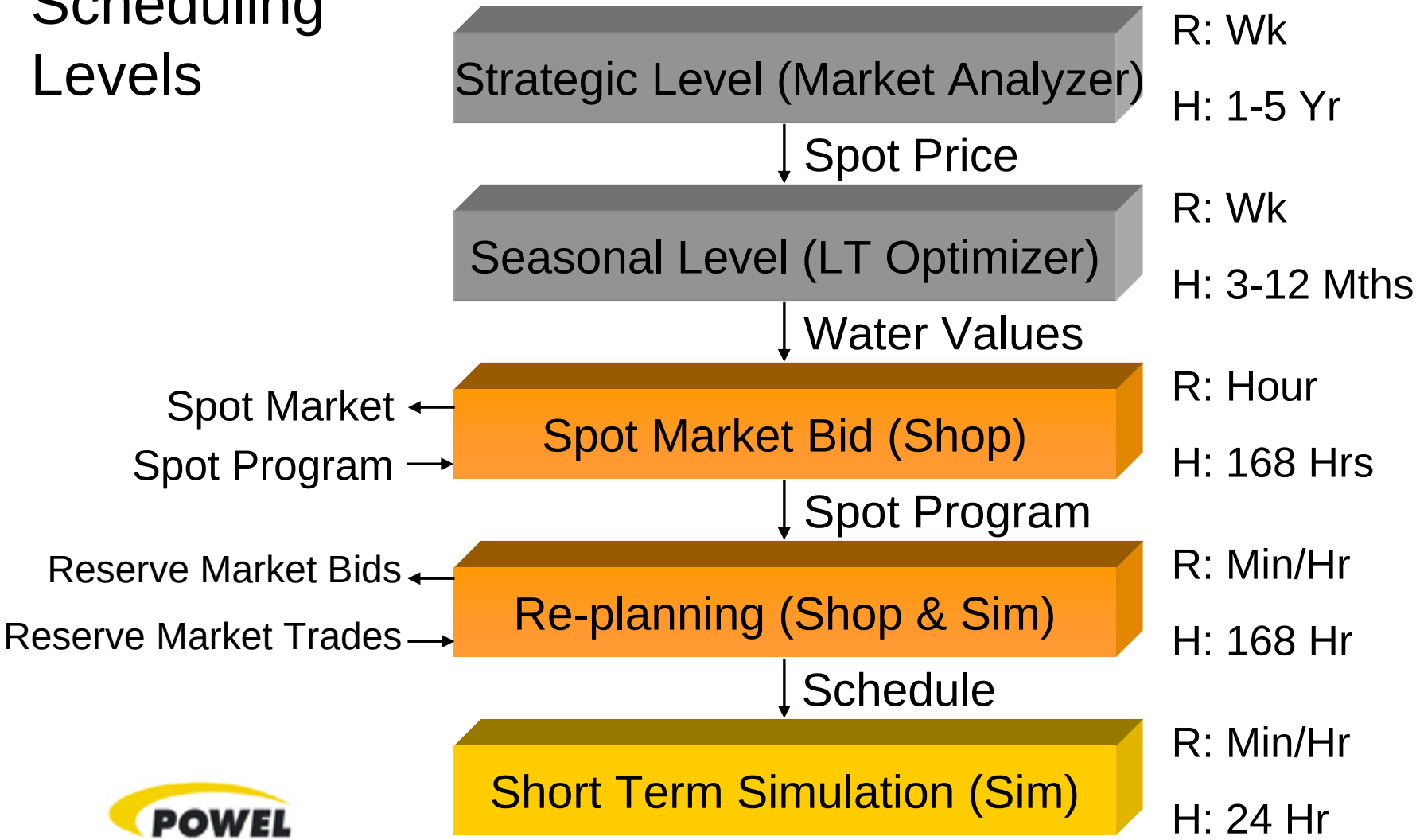
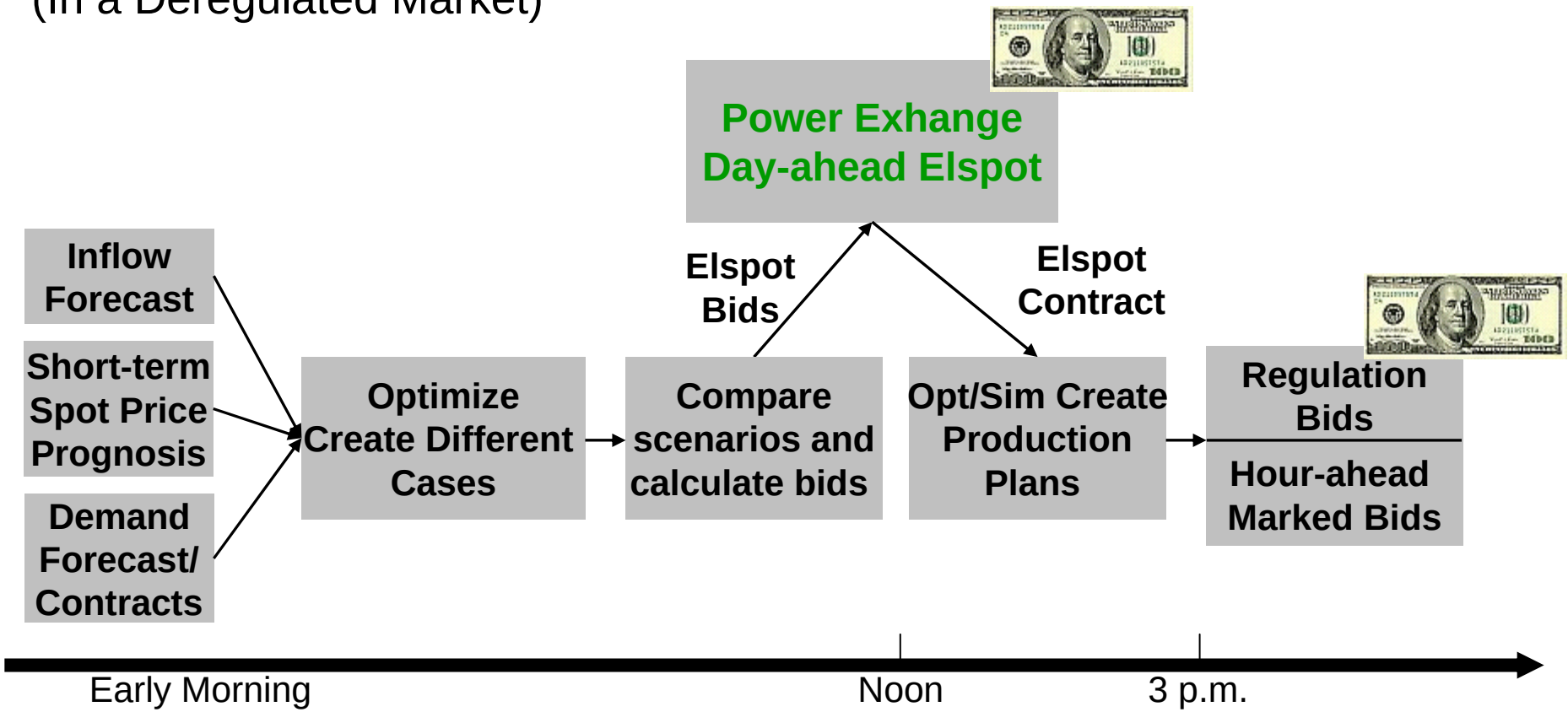
Scheduling Levels



Power Utility Day-ahead Work Process

(In a Deregulated Market)



One Day

Ensuring That Input Data is Correct

- Text alarm when input data is missing:
  - No weather forecast received!
  - Metered reservoir level is missing!
- Validation
- Correction
  - Smooth calculated inflow
  - Correct reservoir levels
- This input data preparation is a typical routine job that needs to be automated

Short-term Planning “Modes”

- Every morning, Powel Shop/Sim is used to prepare a price dependant generation bid for the Power Exchange
- Every afternoon, Powel Shop/Sim is used to plan next days’ generation to operate at lowest possible generation cost
  - By using the “cheapest” water and by minimizing start/stop costs
  - By maximizing head
- The “Available Capacity and Marginal Cost Matrix” can be used as decision support for reserve market bidding
- Powel Shop/Sim may be used to **replan** the current day at any time if changes occur (e.g. unexpected inflow, or request for regulation power)

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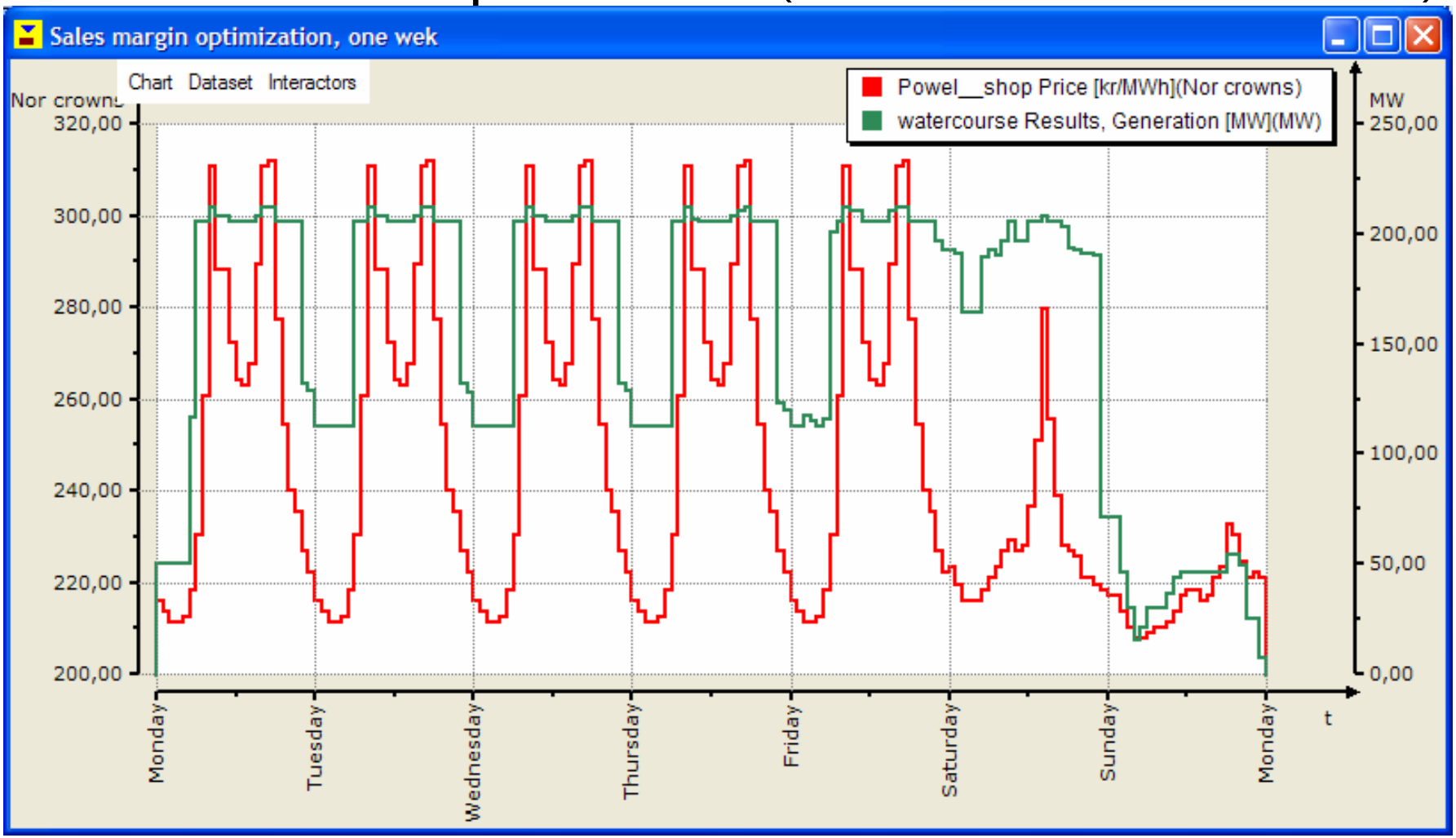
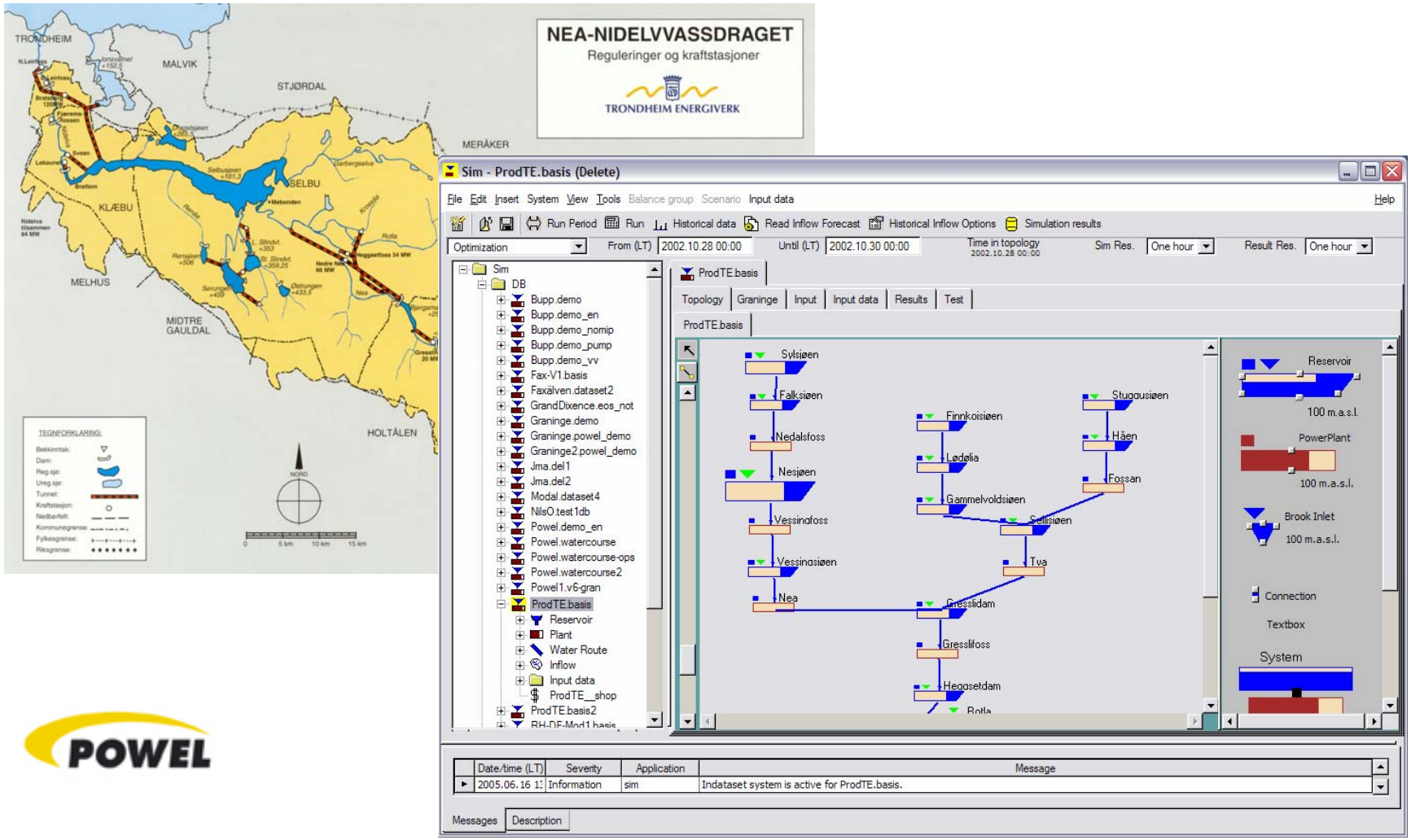
Typical “Before Spot” Planning Result
- Market Based Optimization (Price Curve vs. Total Generation)



Decision Support in the Spot Bidding Process



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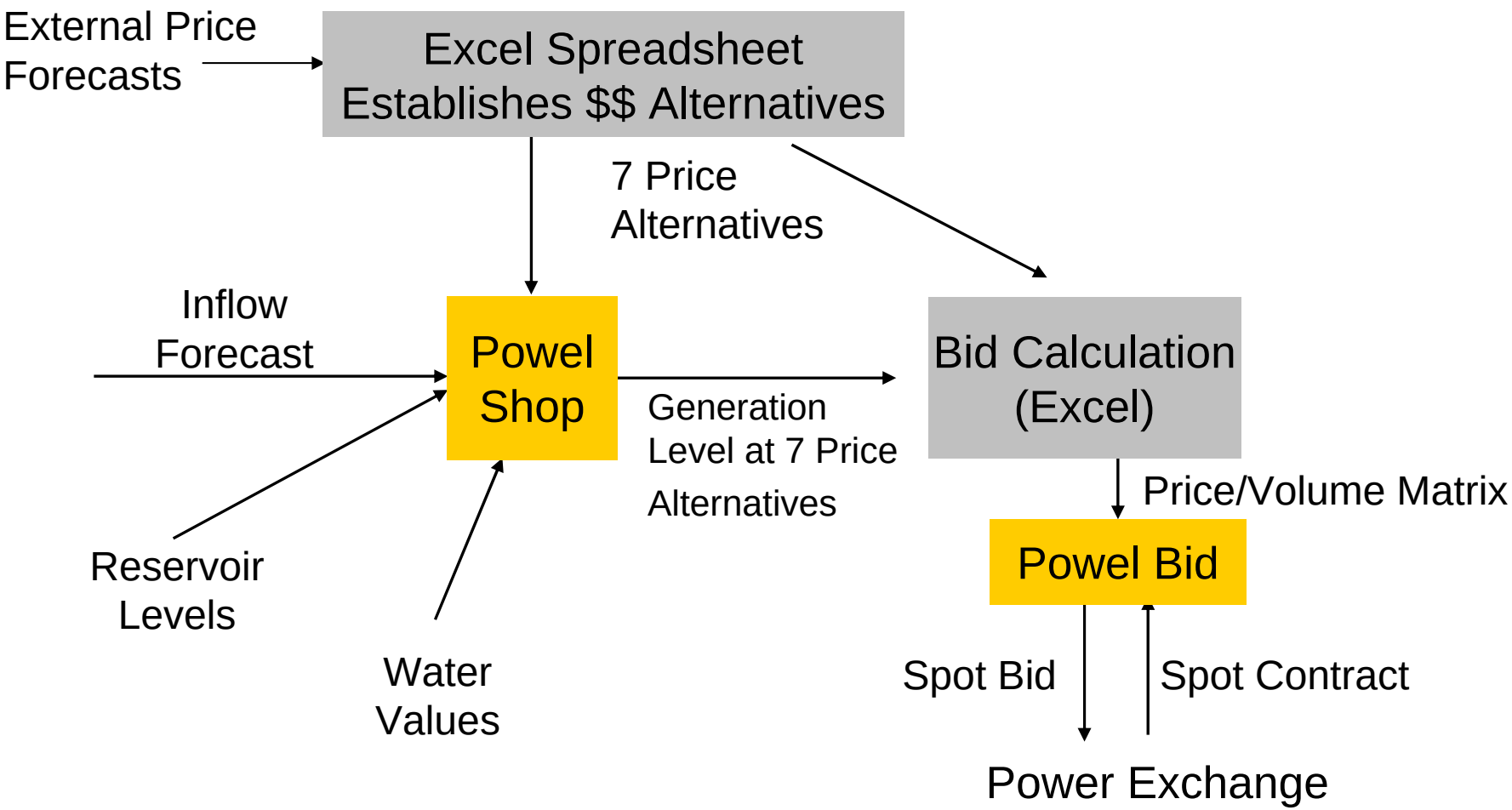
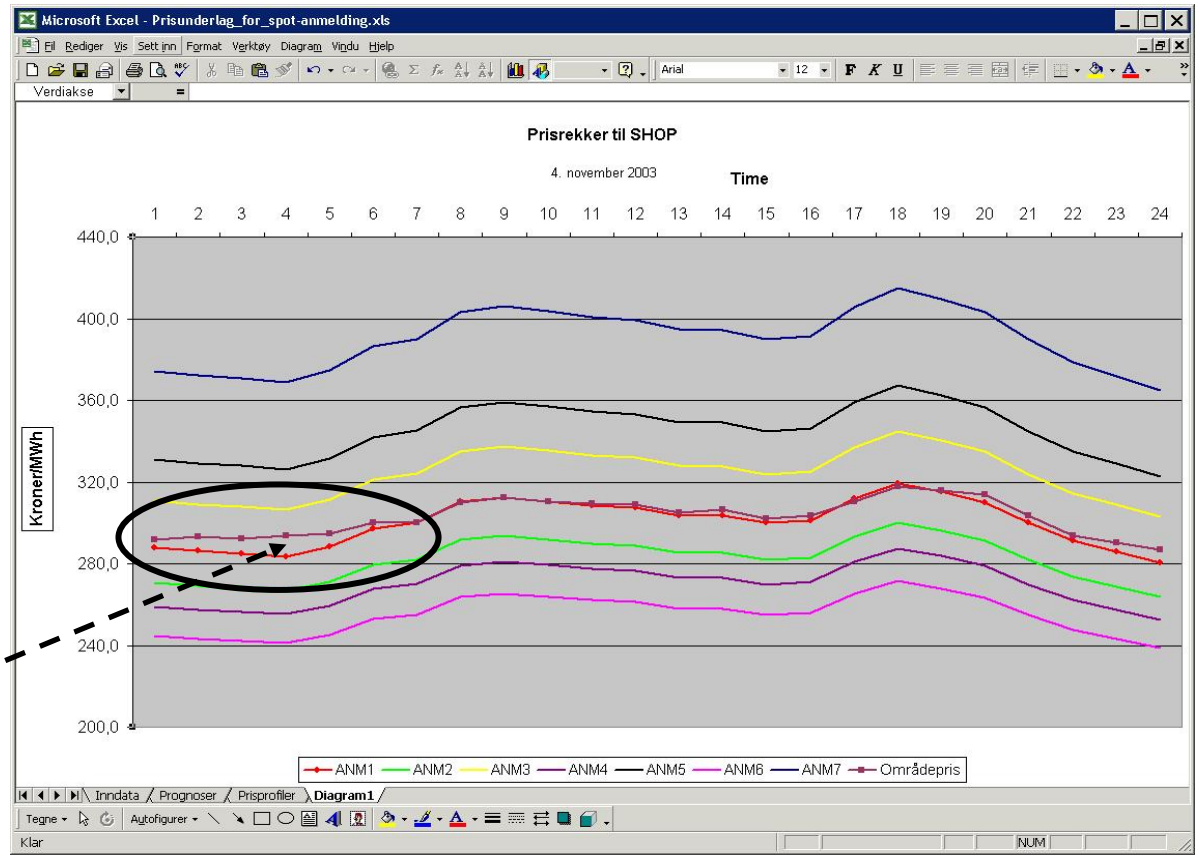
Elspot Bidding Process at TEV

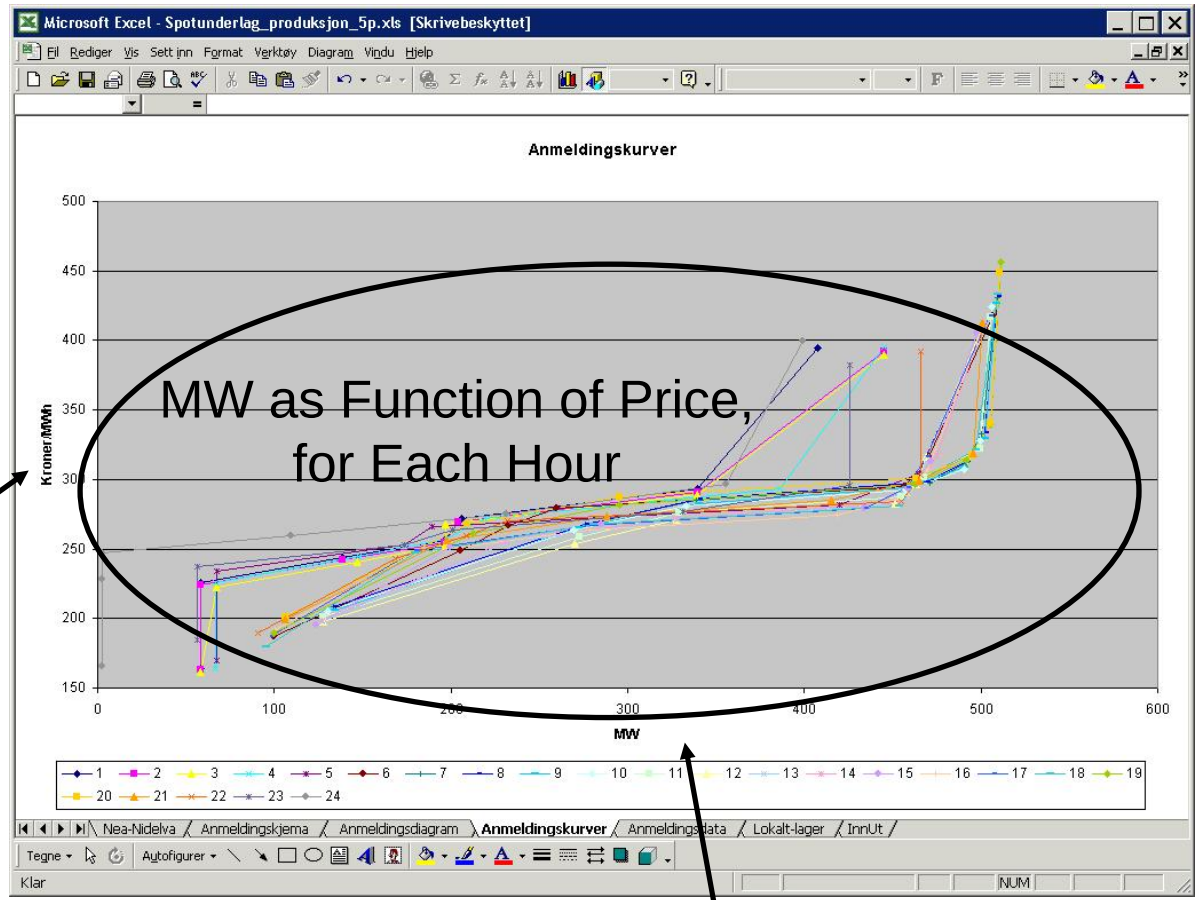


Day-Ahead Price Alternatives

If the price forecast PROFILE is right, bids get very robust and will give a good contract regardless of price level.



Excel Uses Optimal Generation At Each $$ Level

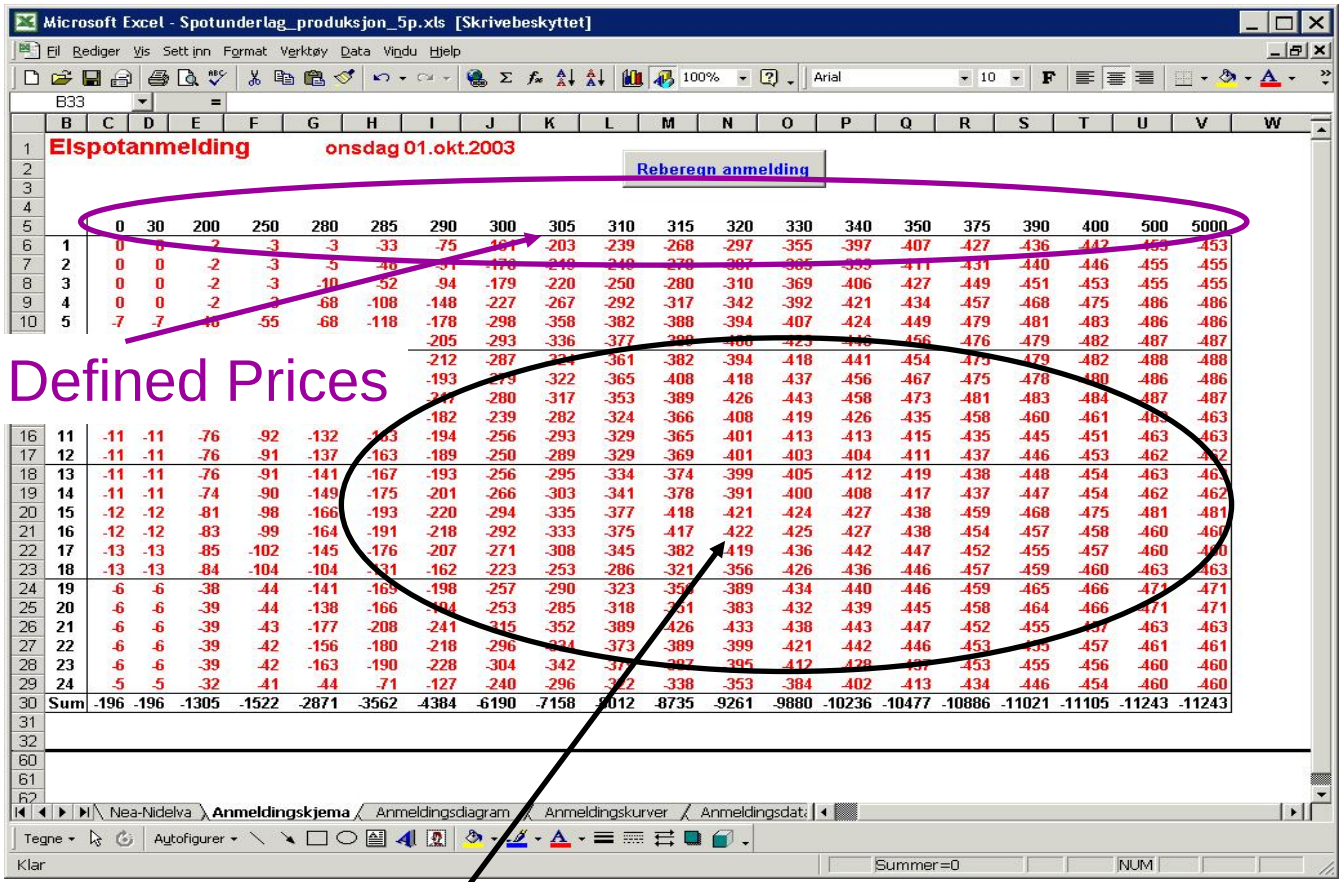


Price

MW

TRONDHEIM ENERGIVERK
Kraft

Bid Schematic

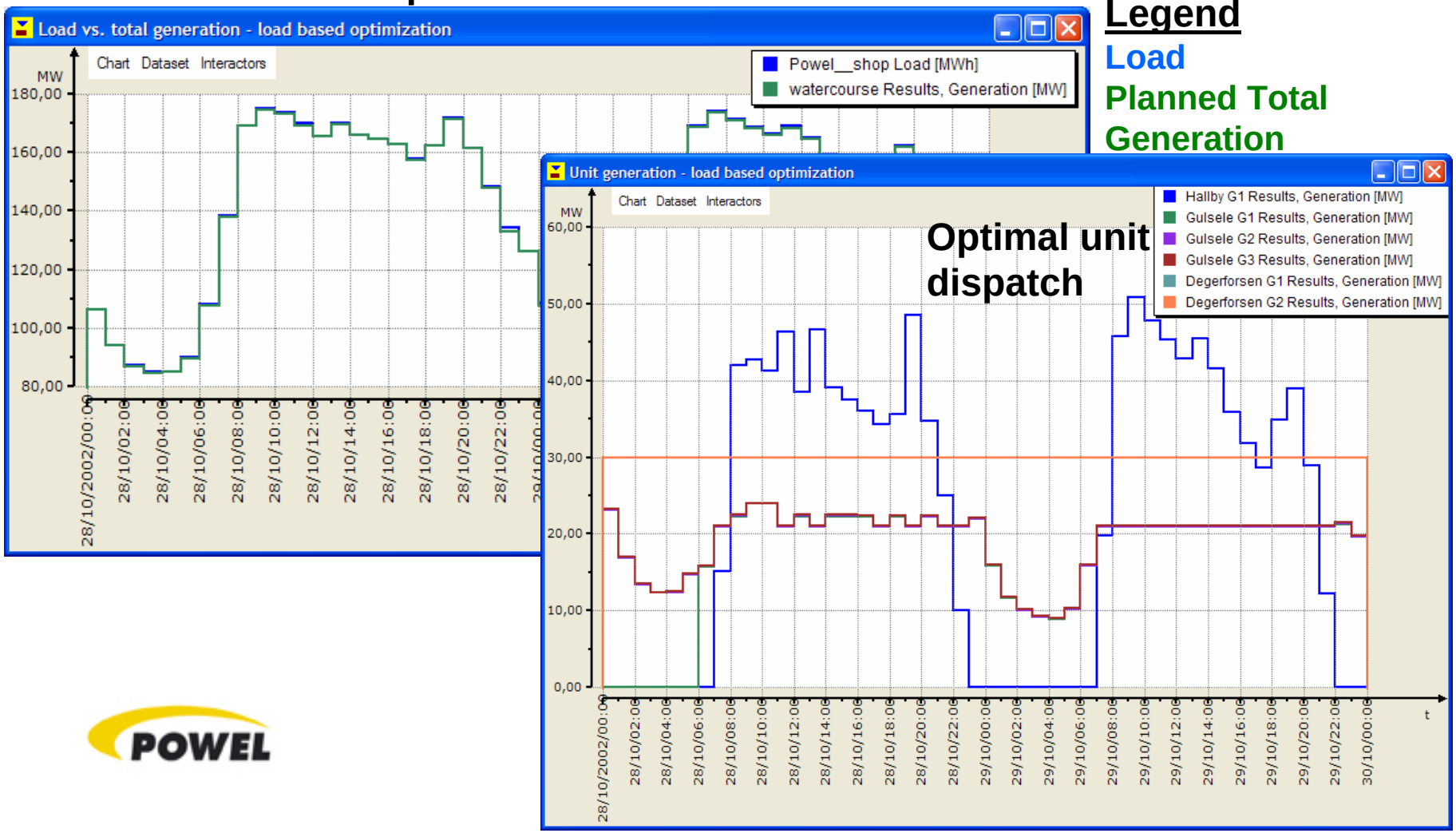


User Defined Prices

Optimal MW/h, at Given Price Level

TRONDHEIM ENERGIVERK
Kraft

Typical After Spot Planning Result
Load-based Optimization



Legend

Load

Planned Total Generation

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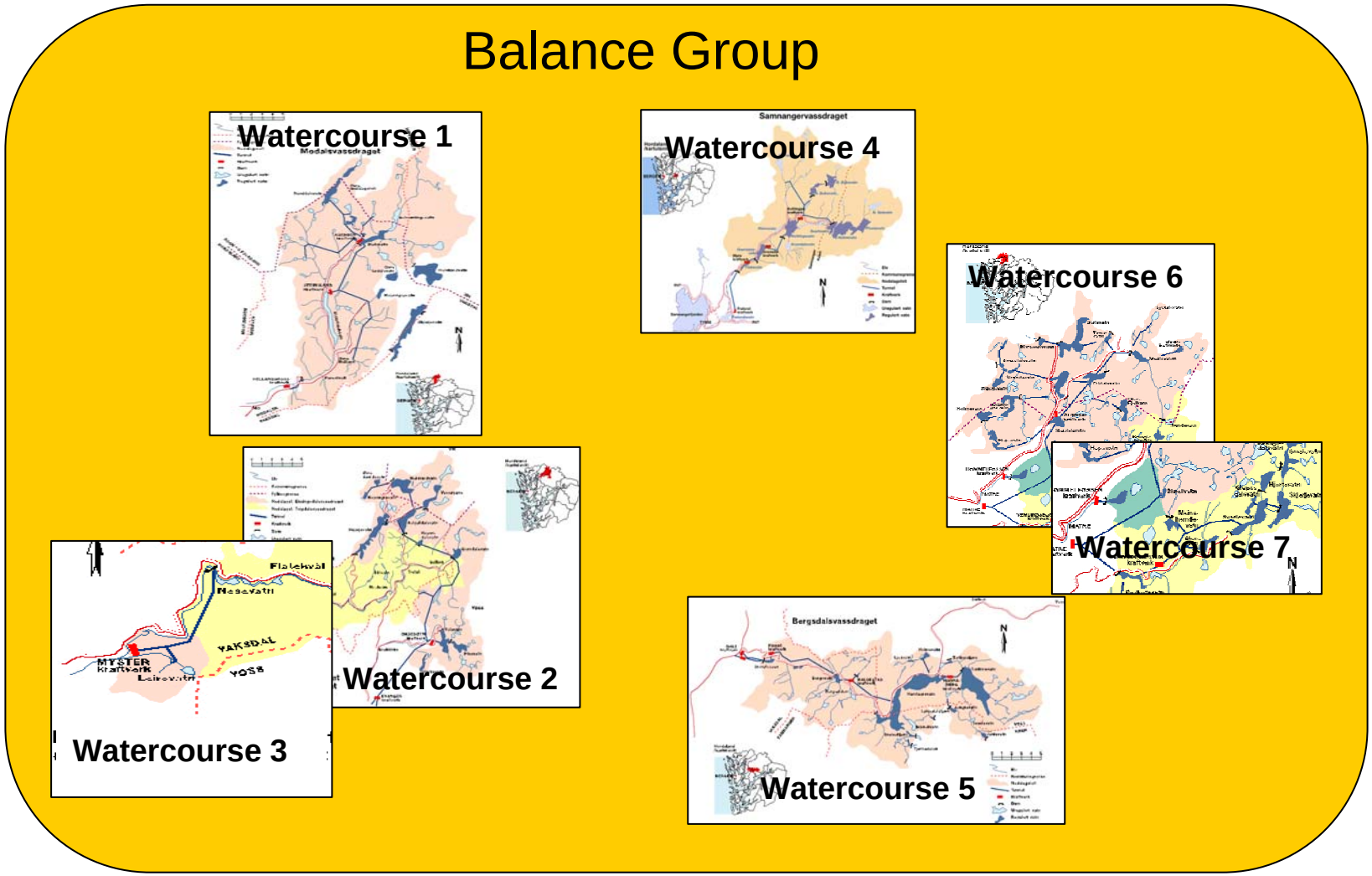
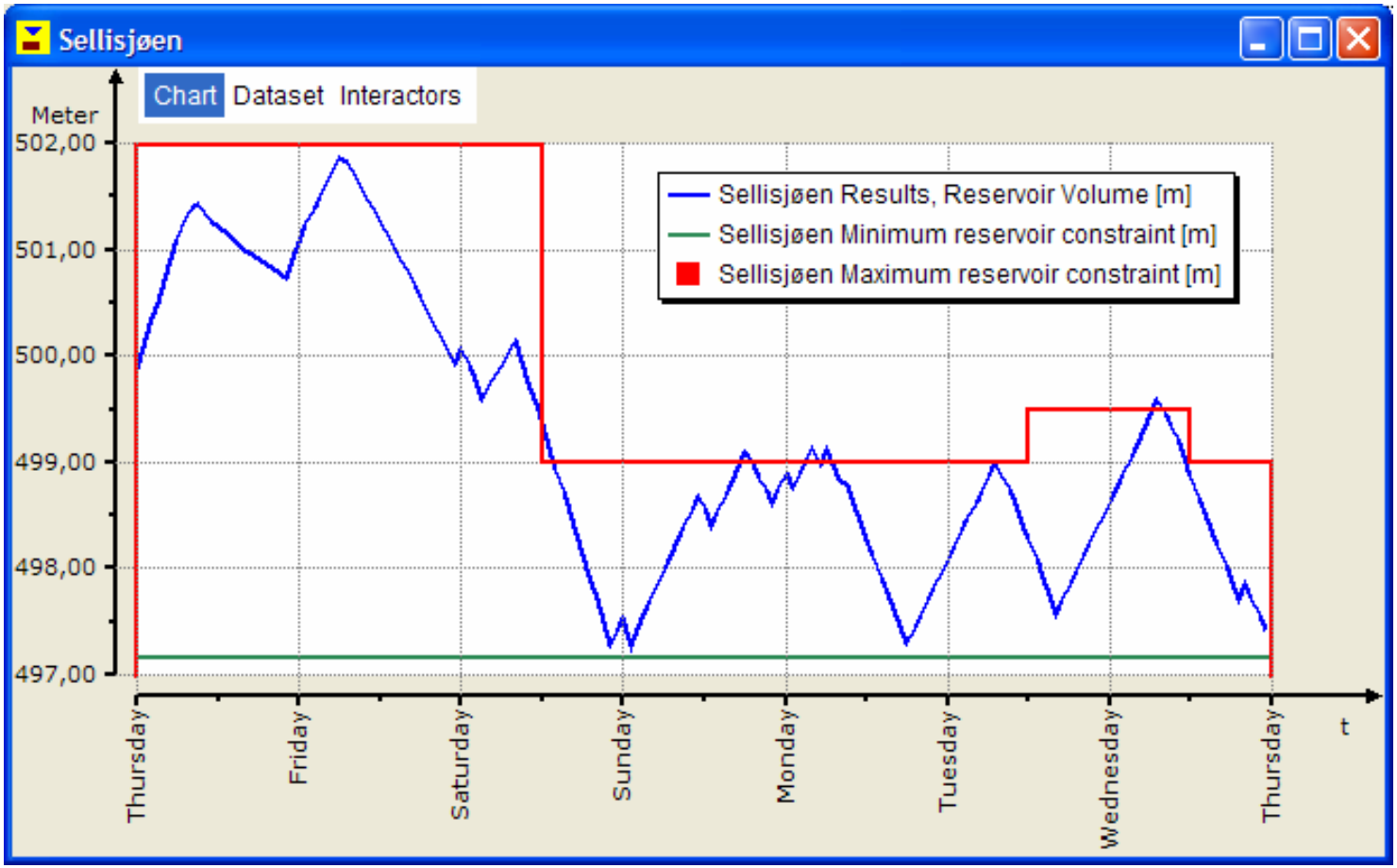
Load-based Optimization can be Done in **Balance Groups** - Containing Several Watercourses



Restriction Management

Time dependant reservoir level restriction shown together with planned reservoir level



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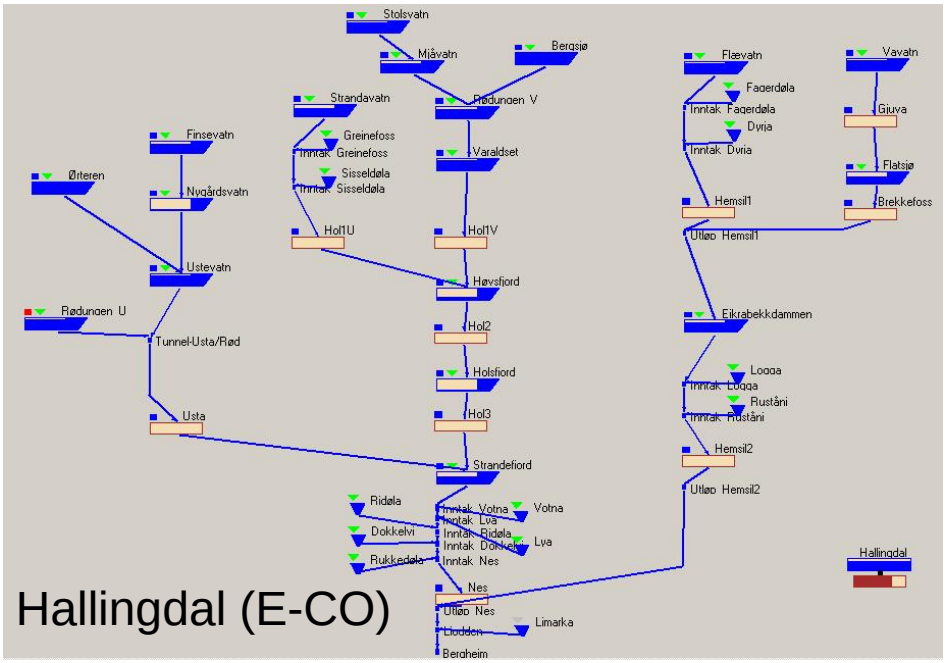
Available Capacity and Marginal Cost Matrix

(Decision Support for Reserve Market Bidding)

Block		Block-1	Block-2	Block-3	Block-4	Block-5	Block-6	Block-7	Block-8	Block-9	Block-10	Block-11
Marginal Cost		0,5 $	15 $	20 $	22 $	23,5 $	23,9 $	24,4 $	26 €	30 $	40 $	200 $
Available capacity per hor	1	-50	-75	-40	-20	-50	0	0	10	0	25	30
	2	-50	-75	-40	-20	-100	0	0	10	0	25	30
	3	-50	-75	-40	-20	0	0	20	0	0	25	30
	4	-50	-75	-40	-30	0	0	20	0	0	25	30
	5	-50	-75	-40	-30	0	0	20	0	0	25	30
	6	-50	-75	-40	-30	0	0	20	0	0	25	30
	7	-50	-75	-40	-20	0	0	20	10	0	25	30
	8	-50	-75	-40	-20	0	0	20	10	0	25	30
	9	-50	-75	-40	-20	0	0	0	0	0	25	30
	10	-50	-75	-40	-30	0	0	0	0	0	25	30
	11	-50	-75	-40	-30	0	0	0	0	0	25	30
	12	-50	-75	-40	-30	0	0	0	0	0	25	30
	13	-50	-75	-40	-30	0	0	0	0	0	25	30
	14	-50	-75	-40	-30	0	0	0	10	0	25	30
	15	-50	-75	-40	-30	0	10	0	20	0	25	30
	16	-50	-75	-40	-30	0	10	0	20	0	25	30
	17	-50	-75	-40	-30	0	10	0	20	0	25	30
	18	-50	-75	-40	-30	0	10	30	20	0	25	30
	19	-50	-75	-40	-30	-40	10	30	20	0	25	30
	20	-50	-75	-40	-30	-40	0	30	40	0	25	30
	21	-50	-75	-40	-30	-40	0	30	30	40	25	30
	22	-50	-75	-40	-30	0	0	30	30	40	25	30
	23	-50	-75	-40	-30	0	50	30	30	40	25	30
	24	-50	-75	-40	-30	0	50	30	30	40	25	30
Sum available capacity		-1200	-1800	-960	-660	-270	150	330	310	160	600	720

Implementations of Powel ICC Systems



Hallingdal (E-CO)

Dalälven (Fortum)

Every watercourse is different. The ability to cope with different topologies robustly is a key issue!

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Calculation Times – Optimization vs. Simulation

- Users make a huge volume of calculations daily in a limited amount of time; hence, calculation times for optimization are critical
- Start/Stop costs must be considered, at least for the 2 days following
- Important to find right balance between model complexity and calculation time
- Continuous effort to reduce calculation times for optimization
  - Powel + Sintef Energy Research + ILOG (CPLEX)
  - faster calculations allow new areas of use, e.g. in after-spot markets
- **Simulation** is fast and can be done at any time

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Operational Challenges

- The short-term planning system must manage
  - multiple sites and multiple, concurrent users
  - continuous stream of input and output data
  - day-ahead planning of large, multi-river systems in a few hours
  - during-the-day re-planning of individual rivers in few minutes
  - users with very different skills
  - users with very different focus and interest

- Plans from the system must easily be activated in SCADA system
  - optimal solutions require frequent change of unit setpoints

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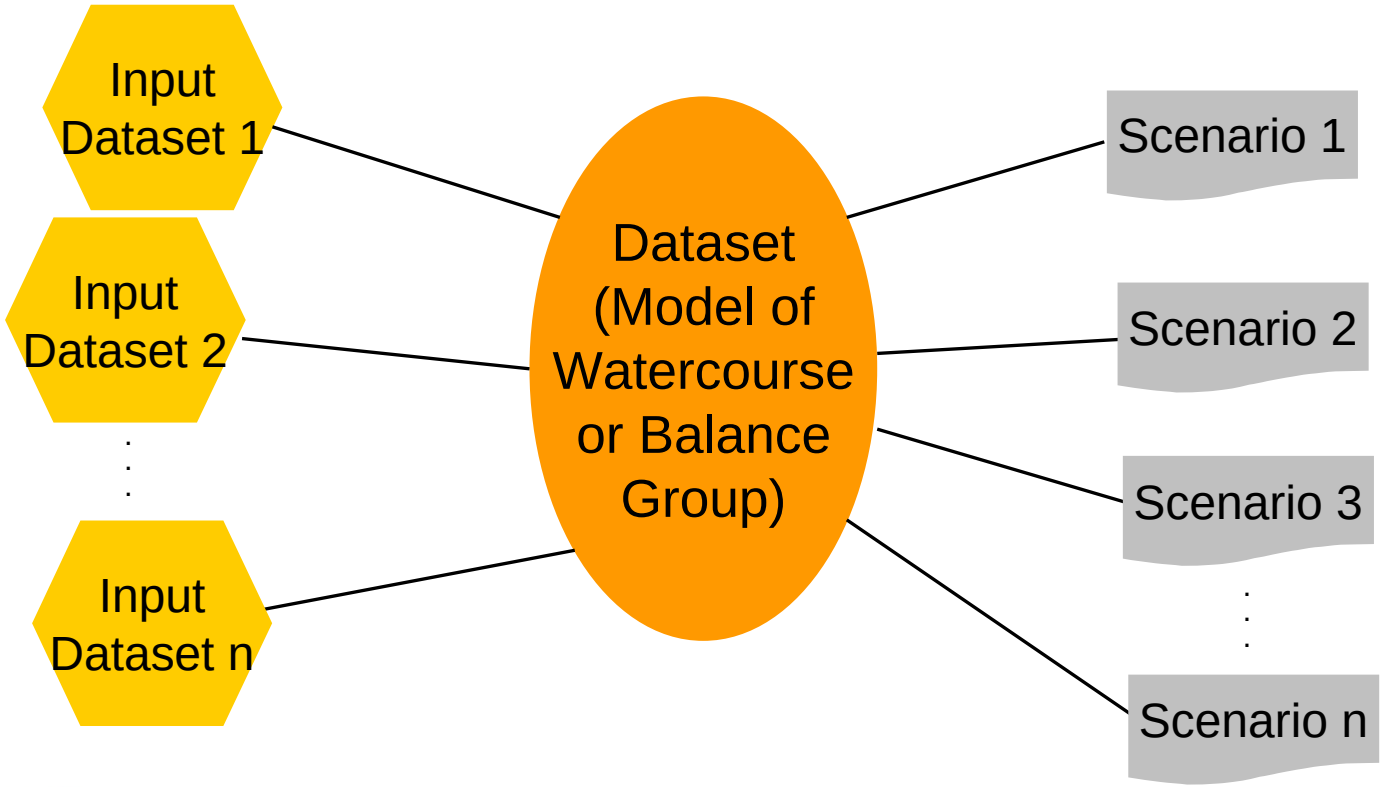
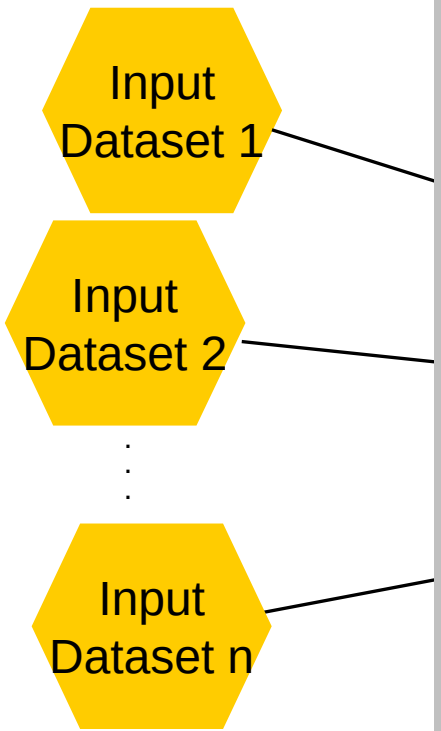
Overview “Powel ICC Model” Concepts



Input Dataset



A collection of time series & parameters defining a complete set of input data. Examples are:

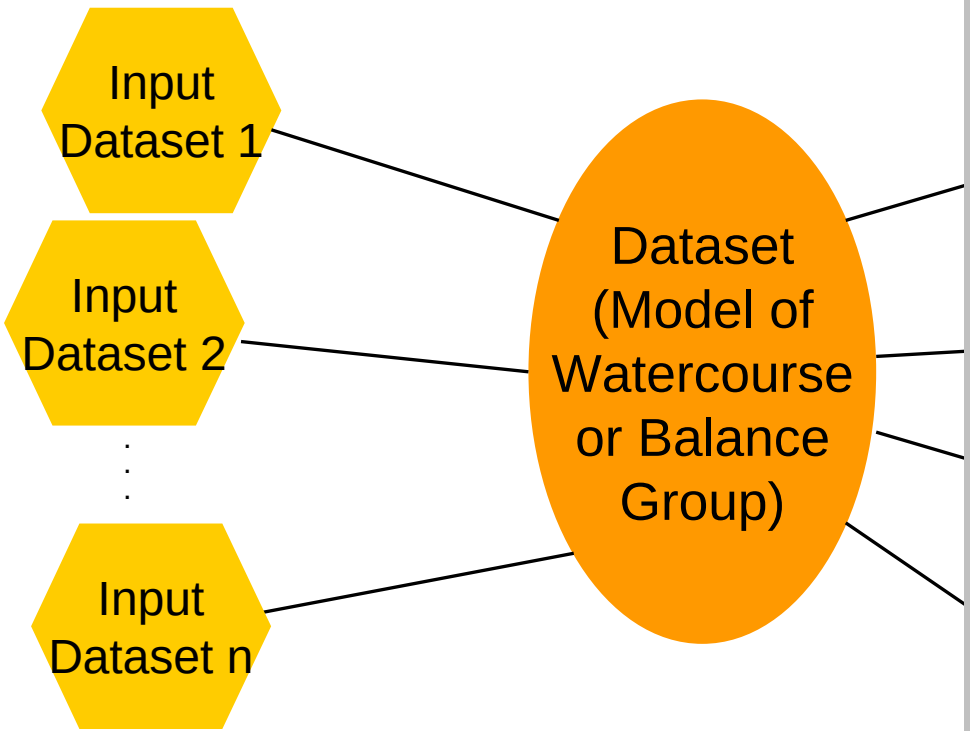
- Start reservoir
- Availability
- Restrictions
- Reservoir and plant/unit plans
- Inflow prognosis (multiple)
- Price prognosis (multiple)
- Load (sales obligations)
- Start- and end simulation/optimization period
- Different strategy flags

Typical use: different input dataset for different roles and work processes

Every user may define own input datasets

Privileges managed by security system

Watercourse Model



- Topology description
- Description of all objects in model
  - Reservoirs
  - Plants
  - Rivers/tunnels
  - Brook inlets (creeks)
- Object attributes, like
  - Reservoir curves
  - Efficiency curves
- Operational tasks should not include changing the model
- Privileges managed by security system

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Scenario

- Collection of time series related to the model – both input data and results. Examples of Input Data:
  - Load (sales, obligations)
  - Price, prognosis
  - Production plans
- Examples of results
  - Production results
  - Reservoir levels
  - Dispatch
- Content and design is configurable by user
- Usually containing enough information to repeat simulation /optimization for a specified period
- Every user may define his own scenarios
- Privileges managed by security system

Scenario 1

Scenario 2

Scenario 3

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Scenario n

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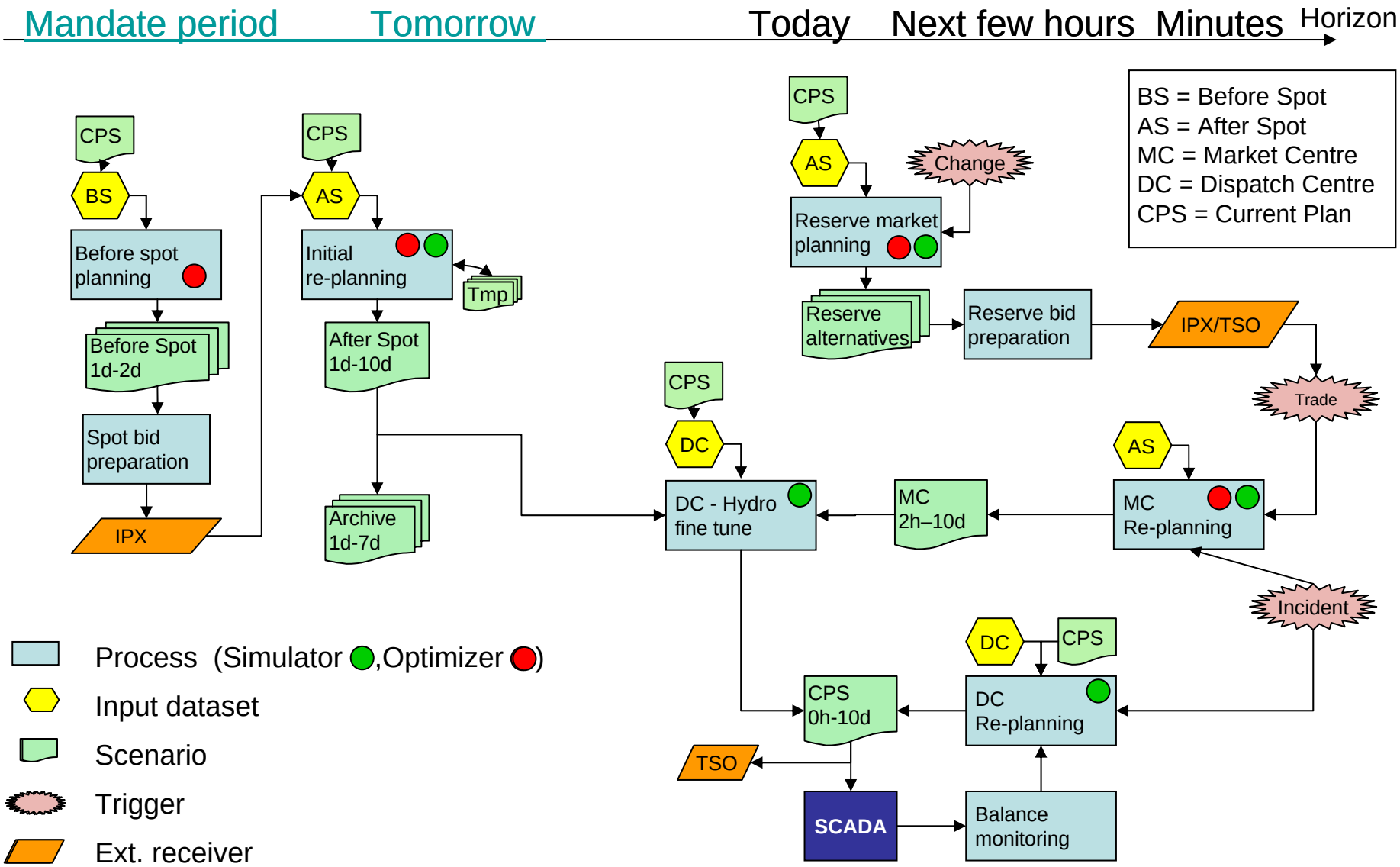
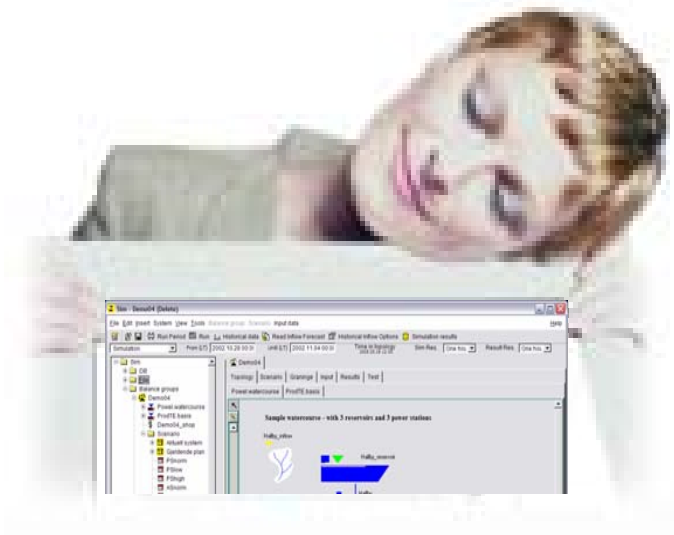
Example - Operative Use of Optimizer/Simulator



Summary - Key Factors for Success

- Efficient user interface and data flow is extremely important
  - must be tuned for operative use
- Robustness
  - managing model complexity and input data problems
- Speed
  - Finding balance between level of accuracy and calculation times
- Trust
  - Make users trust the results suggested by the system



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Thank You for Your Attention!

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