Recent development and research LTM models

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Agenda

- Simulator
- Recent development
- Overview FoU activities
- MAD project
- FME HydroCen

Simulation/simulator

- Simulation
  - Simulation as in the existing models (e.g. Vansimtap, ProdRisk, Samkjøringsmodellen, osv)
- Simulator
  - A software model that automatically simulate in principle all tasks in the decision process.

Simulation/simulator (simple examples)

- Simulation
  1. Price and inflow forecast (scenarios) for whole planning period
  2. Statistical models for price and inflow
  3. Optimization (calculate the strategy, water values)
  4. Simulating the strategy for scenarios
- Simulator
  - For a given stage (e.g. week)
    1. Price and inflow forecasts (scenarios) for whole planning period
    2. Statistical models for price and inflow
    3. Optimization (calculate the strategy)
    4. Simulate optimal decision for first stage
  - Move to next stage

Why simulator

- Importance of different input
  - Short and long-term price forecasts
  - Snow storage information
  - Short-term inflow forecasts
- or models/methodologies
  - Different types of models/methods at different decision stages

Recent developments

- Version 9.9 of software
  - Parallel processing version of Kopl (EMPS)
  - Time dependent calibration factors (EMPS)
  - ProdRisk – new implementation of parallel processing
  - More details on LTM poster
- Market simulation and optimization
  - EMPS API and calendar data (own presentation)
- Local hydro optimization
  - Vansimtap/ProdRisk API
  - Benchmarking using simulator (presentation by Gunnar Aronsen)
    - Simulator using Vansimtap API
- Prototype ProdRisk with binary startup costs

API results

- API development, code restructuring and improvements include substantial financing from maintenance.
  - Therefore, freely available to all users

- Calendar functionality will be licensed

Research projects

- Market simulation and optimization
  - SOVN (IPN) – just finished (own presentation)
  - **MAD (IPN)**
  - PRIBAS (KPN) (own presentation)

- Local hydro optimization
  - **HydroCen (FME)**
  - Integrated Balancing Markets (KPN) (own presentation)

SOVN –Quantifying the yearly value of snow storage information in Norway (MEUR)

		Prod. surp	Con. Surp	TSO surp	SUM
With snow	Norway	5439.5	83443.9	238.8	89122.1
	Rest	9399.3	2000307	641.4	2010348
	Sum	14838.8	2083750.9	880.2	2099470
Without snow storage information	Norway	5452.6	83425.4	238.3	89116.3
	Rest	9450.6	2000264	629.4	2010344
	Sum	14903.2	2083690	867.7	2099460.3
Difference	**Norway**	**-13.1**	**18.5**	**0.5**	**5.8**
	Rest	**-51.3**	**43**	**12**	**4**
	Sum	**-64.4**	**60.9**	**12.5**	**9.7**

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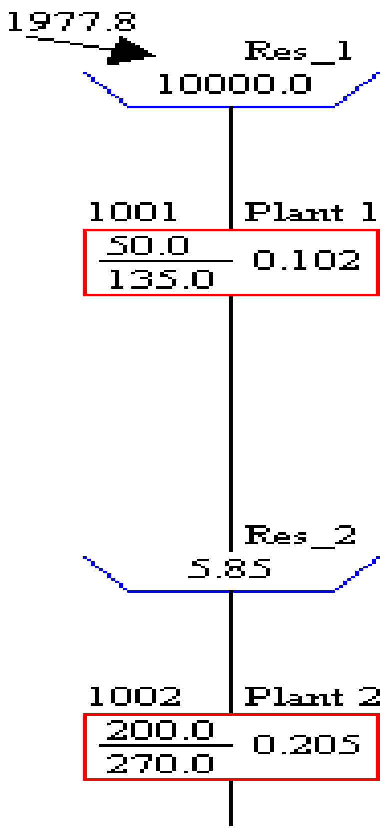
MAD – motivation- objectives

- Develop a new/improved EMPS with regard to known weaknesses
  - Optimal utilization of serial water courses within week, including pumping
  - Aggregate water value for each area
    - Smooths individual variation
  - Difficult to further develop heuristic
  - Training of new employees

- New model should be much faster than the SOVN model

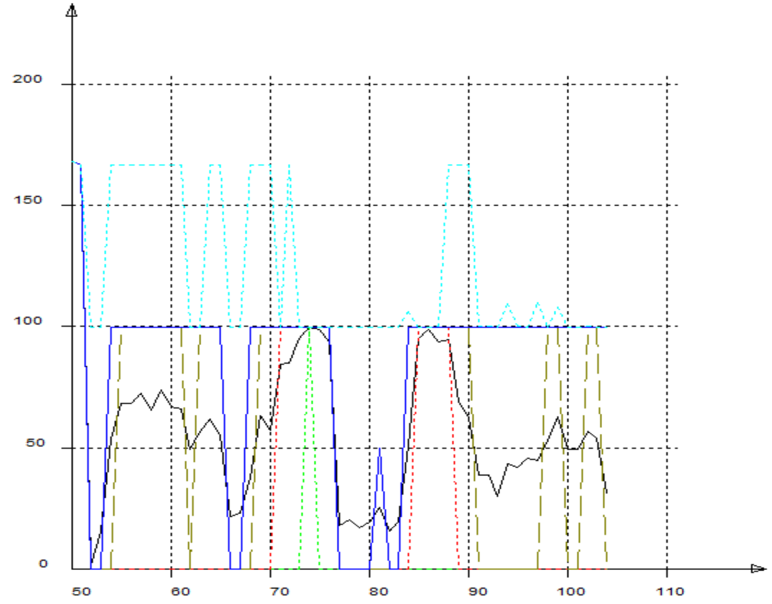
- Project period: 2015-2018

Optimal production in serial water courses

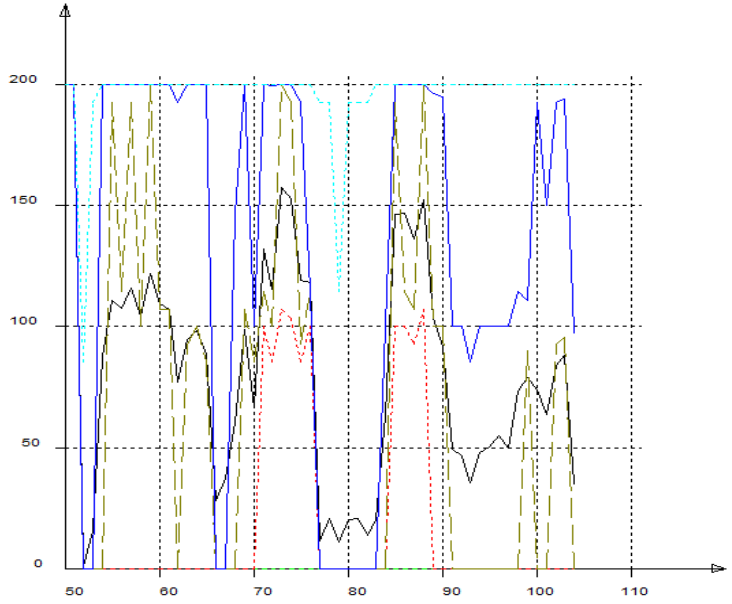


Production in high price period (plant two in example)

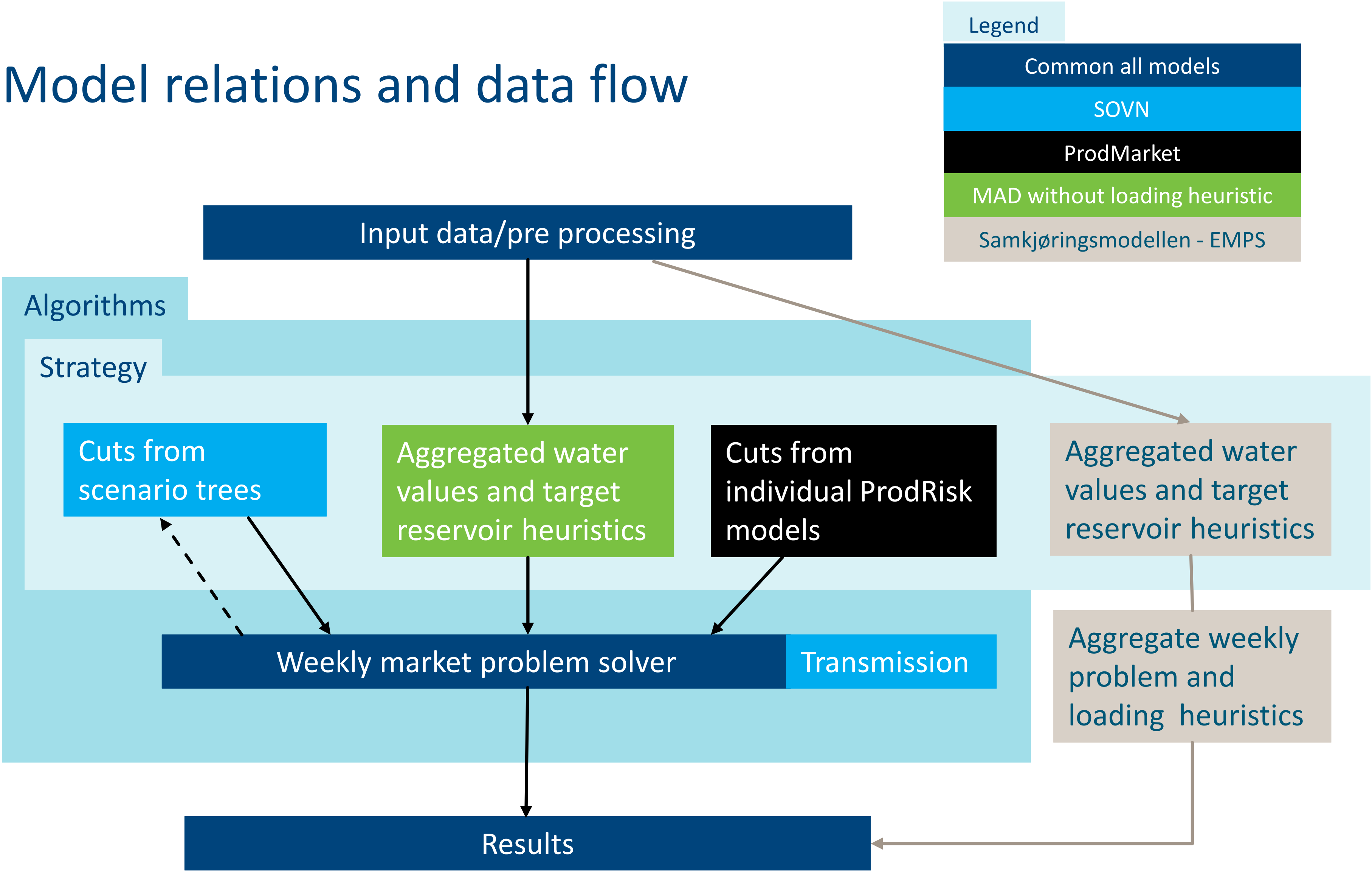
Drawdown heuristic (Vansimtap)



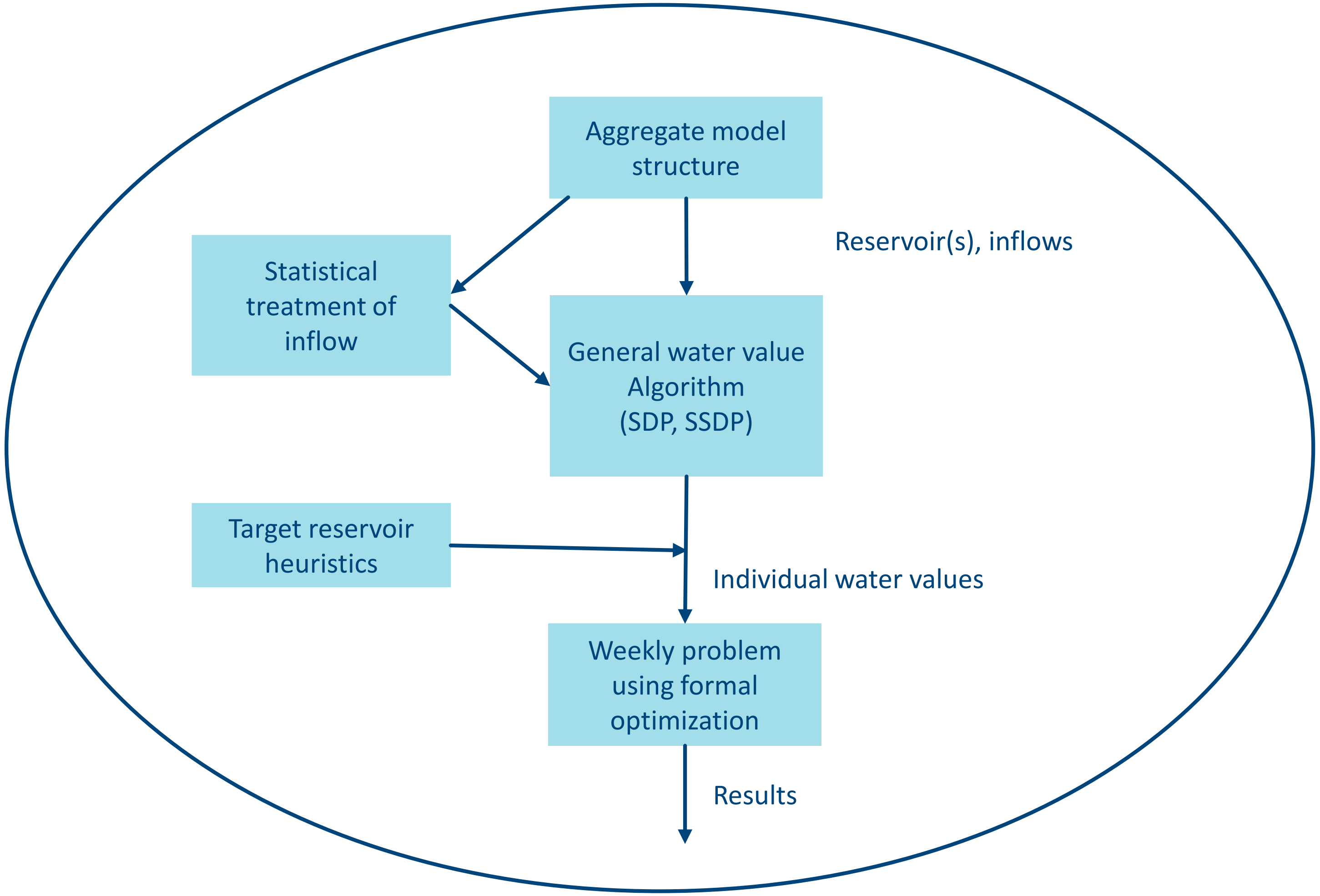
Optimization (ProdRisk)



Model relations and data flow



Activities – relation MAD



MAD –deliveries so far

- A prototype model with formal optimization on detailed levels for the weekly market clearing problem
  - Use drawdown heuristics to individualize aggregated water values
  - The construct a LP problem for the week problem

  - Can be hourly resolution
  - Time delays
  - Ramping (transmission and hydro)

  - Computation time is long

- Including avoidable overflow in aggregated inflow used for water (version 9)

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HydroCen

NORWEGIAN RESEARCH CENTRE FOR HYDRO POWER TECHNOLOGY

Vertskap og ledelse	NTNU
Hovedpartnere, FoU	NTNU SINTEF Energi Norsk institutt for naturforskning, NINA
Varighet	5+3 år, totalt åtte år
FoU partnere, utdrag	BOKU, Bologna, CEPEL, Chalmers, CSM, HydroLab, Høgskolen i Sørøst-Norge, IREQ, ITB, KTH, KU, LTU, Lucerne University, Sandia, Sintef Byggforsk, TU Berlin, Uppsala University
Partnere, bransje & myndigheter	Agder Energi, Alstom, Andritz Hydro, BKK, DynaVec, E-CO Energi, EDF, EDR Medeso, Eidsiva Energi, Energi Norge, Helgelandskraft, Hydro Energi, IHA, Lyse Produksjon, Miljødirektoratet, Multiconsult, NTE Energi, NVE, PTM, Rainpower, SediCon, SFE Produksjon, Sira Kvina Kraftselskap, Skagerak Kraft, SKL, Sognekraft, Statkraft, Sunnfjord Energi, Sweco, Tafjord Kraftproduksjon, TrønderEnergi, TTO NTNU, Voith Hydro, Østfold Energi

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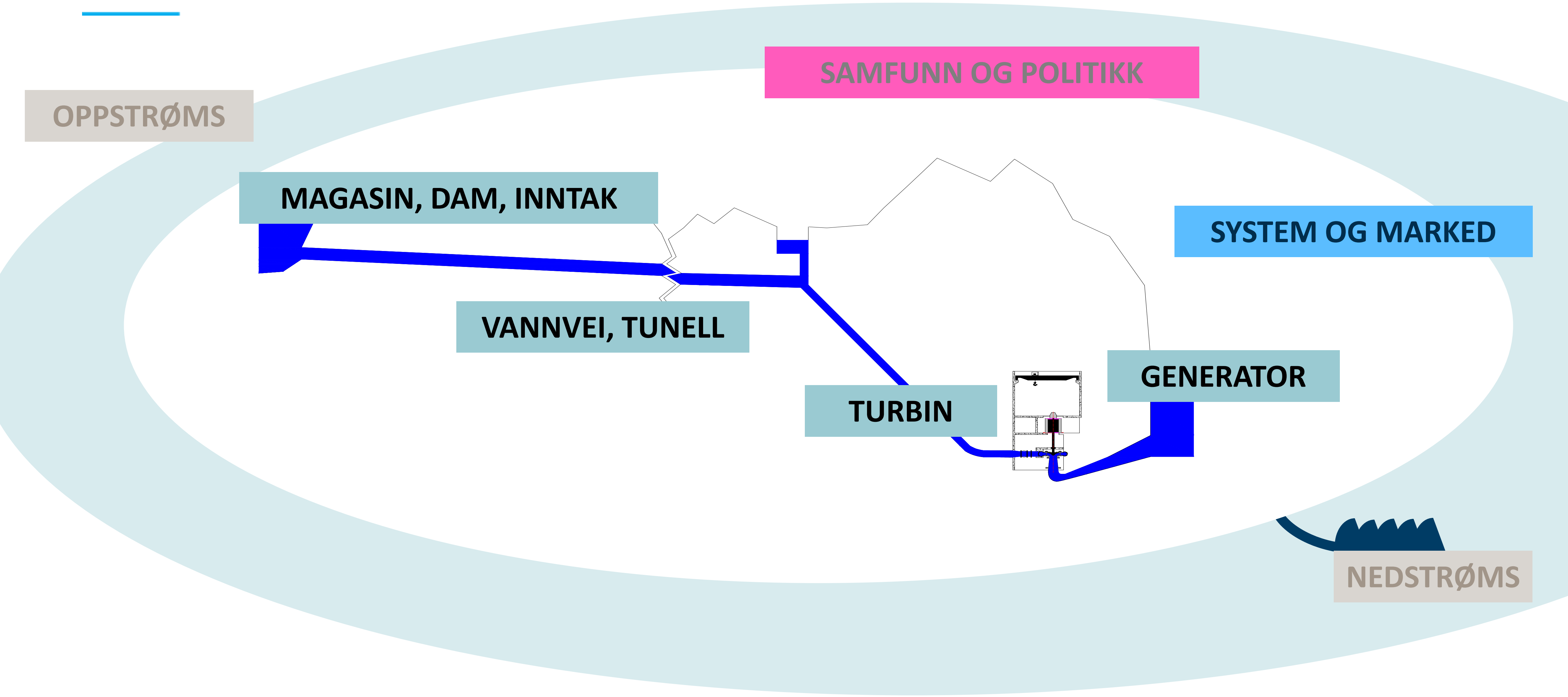
Tverrfaglig fokus



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HydroCEN Research Tasks

- WP1 Hydropower structures
- WP2 Turbine and generator
- ***WP3* Markets and services**
- WP4 Environmental design
- WP5 Management and innovation
- WP6 Open Calls

WP 3 Structure

Task 3.1
Future market structures and prices

Task 3.2
Remaining useful life, failure probability

Task 3.3

Optimal hydro design in the future power

Task 3.4
Environmental constraints and uncertainties – impact on revenues

Task 3.5
Water resources assessment tool

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Task 3.3 Optimal hydro design in the future power system (2017-2023)

- *Methods* and *models* for calculation of future revenues for hydropower
  - Robustness with regard to future market design
  - Importance of different ancillary service products
  - Environmental design
- Develop concepts, methods and tools for optimal investments in upgrading and expansion projects
  - 3-dimentional problem: Type, Size and Timing
  - taking into account all relevant information that affect the investment decision and information from T3.2
- 1 PhD at NTNU is planned within Task 3.3
- **2017: Prototype. Simulation combining SHOP and ProdRisk**

Task 3.4 Environmental constraints and uncertainties – impact on revenues (2018-2024)

- Develop methods and prototype models with the ability to calculate revenues for hydro systems that include complex environmental constraints
  - State-dependent constraints
- Develop prototype simulator(s) to quantify how short-term forecasting uncertainty and model simplifications affect revenue estimates
- 1 PhD at NTNU is planned within Task 3.4

Task 3.1 Future market structures and prices (2017-2017)

- Utilizing models, market simulations and existing literature and data to provide information about future market products, prices and structures to be used in Task 3.3
- **2017: Finalize work related to inflow-price correlation in ProdRisk**

Task 3.2 Remaining useful life, failure probability (2017-2021)

- Develop methods and tools for estimation of component degradation and failure probabilities as function of operating conditions

Task 3.5 Water resources assessment tool (2017-2023)

- Tools to handle multiple water user requirements and constraints, and the impacts on the hydropower production

Budget (Sum mill. NOK for 2016-2024)

		SUM	SINTEF	NTNU	NINA
WP 3	Markets and services	42.8	35.90	6.77	0.75
t3.0	Work package management	6.5	6.50	0.00	0.00
t3.1	Future market structure and prices	3.5	3.5	0.00	0.00
t3.2	Remaining useful life, failure probability	4.7	4.7	0.00	0.00
t3.3	Optimal hydro design in future power systems	12.0	8.6	3.39	0.00
t3.4	Environmental constraints and uncertainties	11.6	8.1	3.39	0.75
t3.5	Water resources assessment tool	4.5	4.5	0.00	0.00

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