AI for Hydropower Scheduling

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Western Norway University of Applied Sciences (HVL)

01 Mar 2023, Data Science Meetup

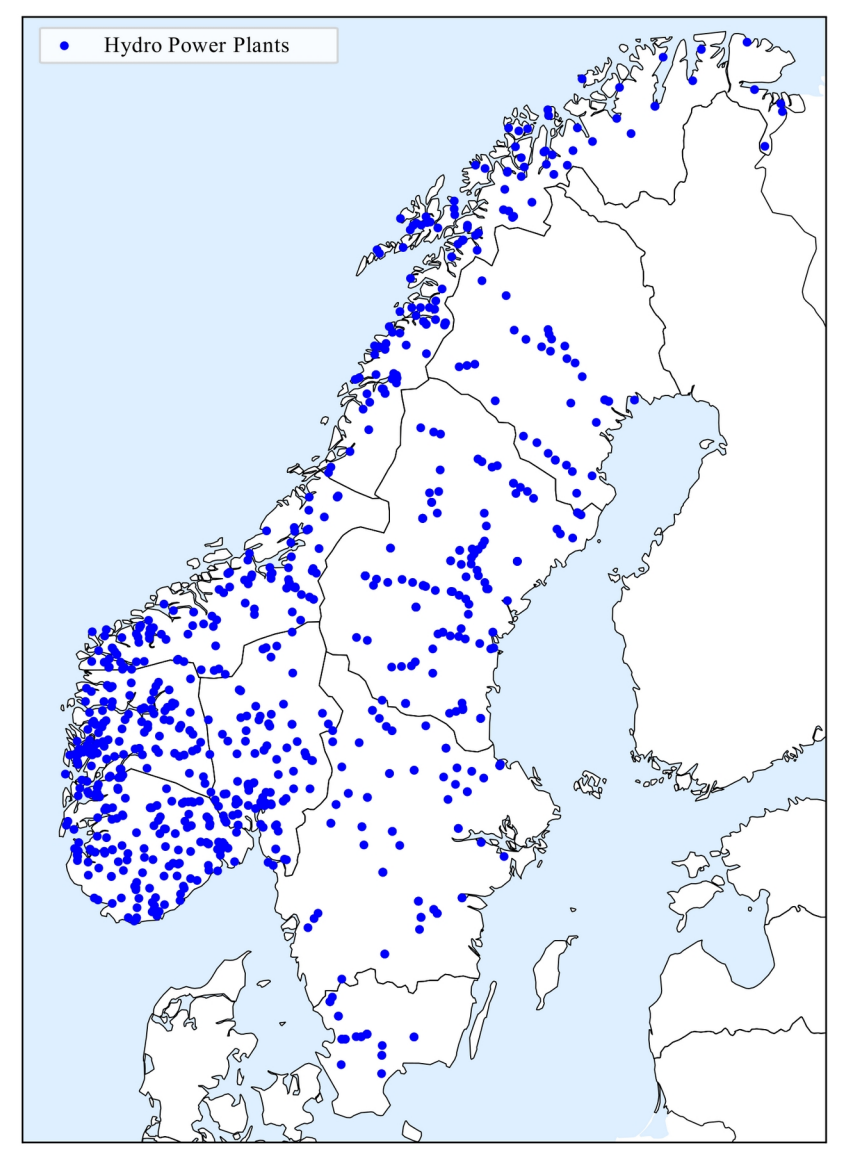
Connectivity, Information & Intelligence Lab

Ci2

We use AI to understand how infrastructure networks shape our lives and impact our environment.

www.ci2lab.com

Norway’s Hydropower



https://www.mdpi.com/1996-1073/14/5/1425

- Hydropower’s share of Norway’s electricity production is about 95%.
- Hydropower is a clean and flexible source of energy for Norway and Europe.

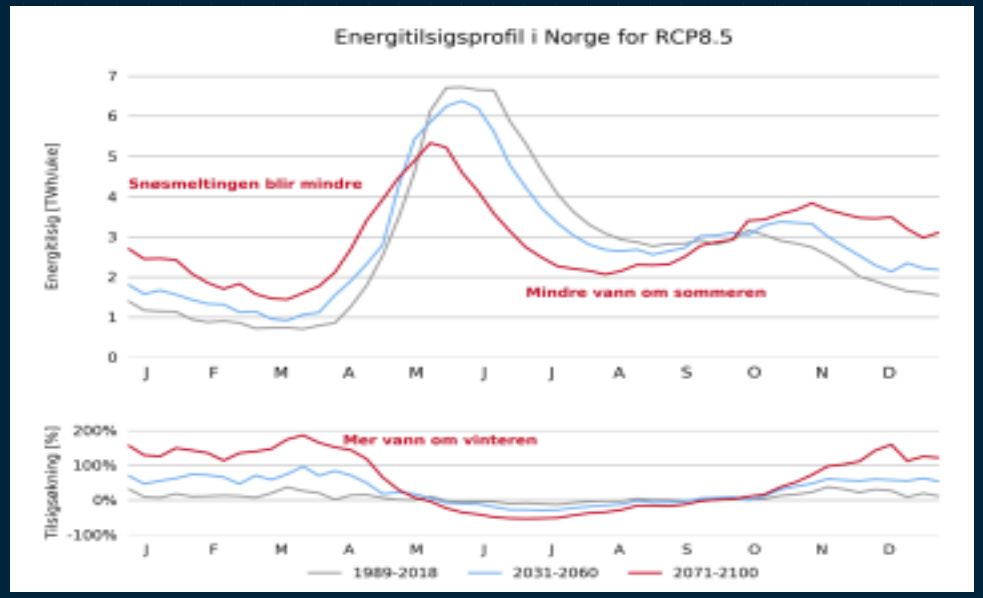
Forecasting water behind dams is complex!

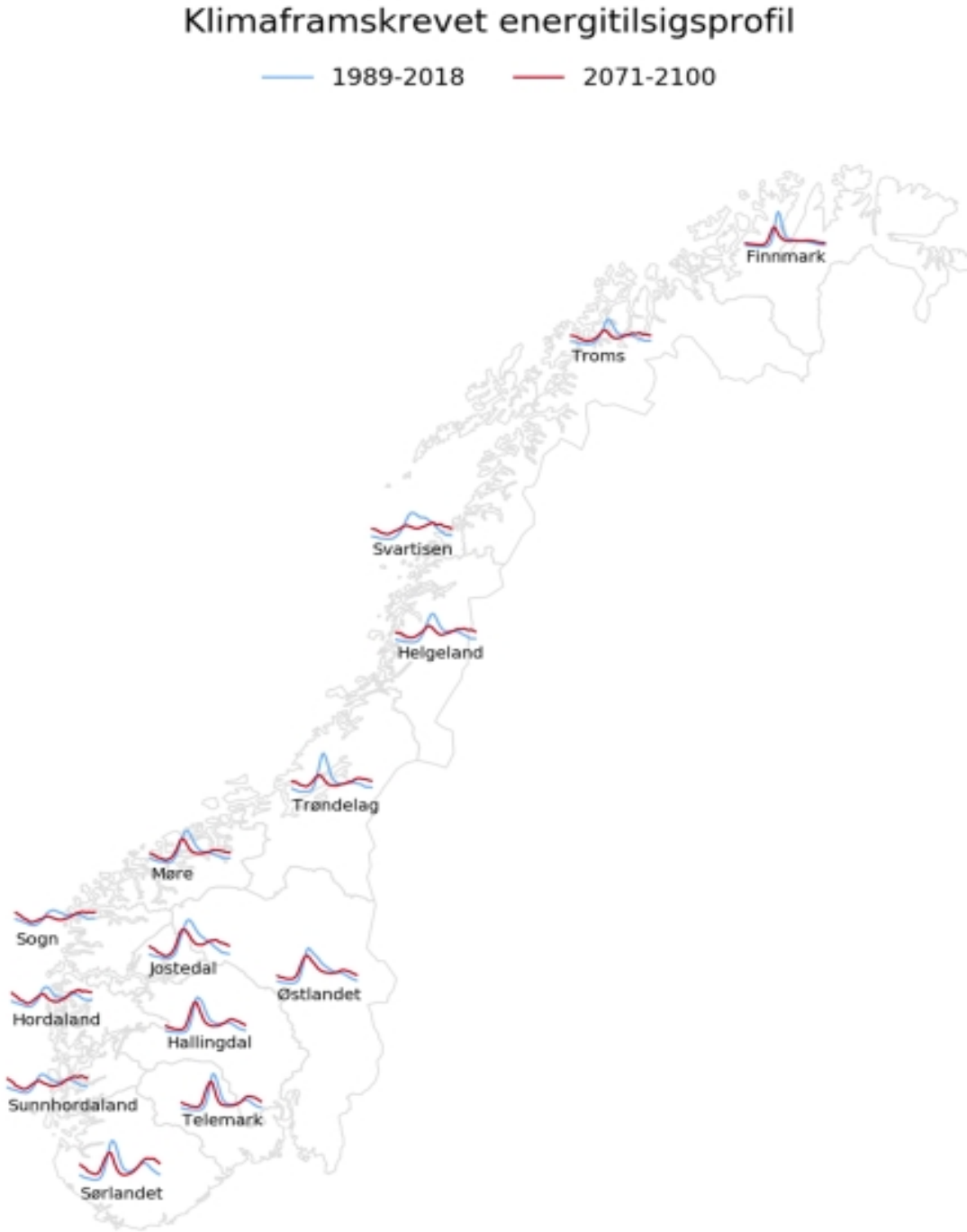
- More connection to Europe and the UK electric grids and their electricity markets.
- The recent energy crises in

https://blog.sintef.com/sintefenergy/nordic-power-system-hvdc/

Forecasting water behind dams is complex!

- Climate change (historical meteorological and hydrological data are not valid anymore!)

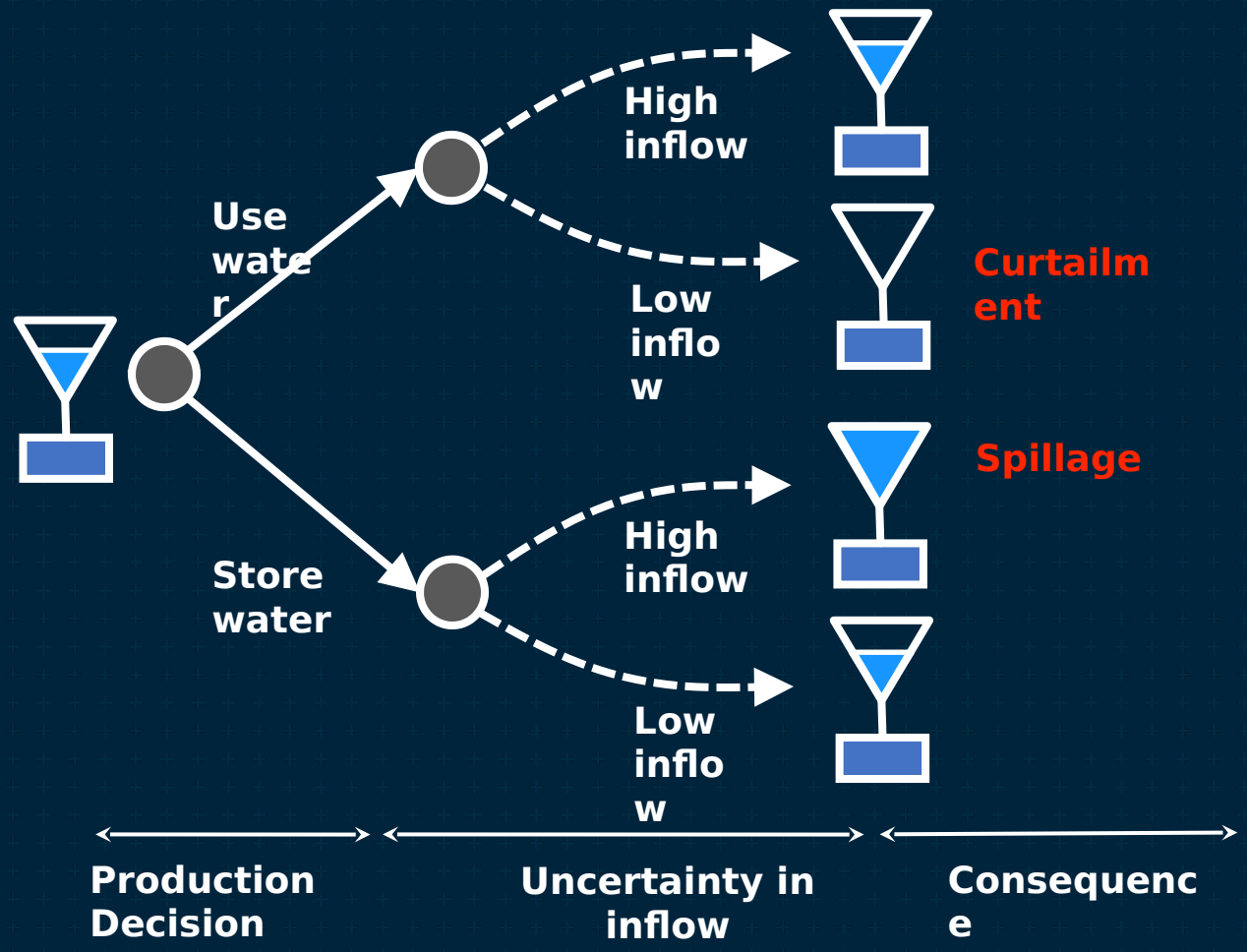




Forecasting water behind dams is complex!

- Integration of intermittent offshore wind energy (Norway plans 30GW by 2040).

Where and when do we have water?



- 1% improvement in inflow forecasting values billions of NOK

Power Generation Market Size 2022

Scale	B NOK
Global	16603.07
Europe	6827.62
Norway	306.00

Source: https://www.reportlinker.com/p06193685/

[1] Hamlet, A.F.; Lettenmaier, D.P. Columbia River Streamflow Forecasting Based on ENSO and PDO Climate Signals. J. Water Resour. Plan. Manag. 1999, 125, 333–341.

Classical hydropower Scheduling

Optimization of available hydropower generation resources to fulfill the electricity demand considering various constraints and uncertainties.

Solving this stochastic and dynamic optimization problem is complex, and time consuming.

Hydropower Scheduling & AI

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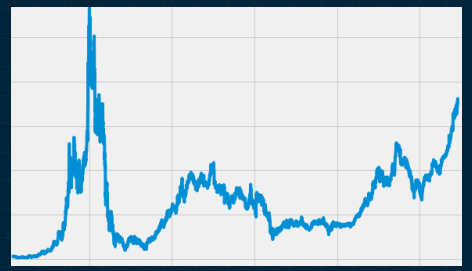
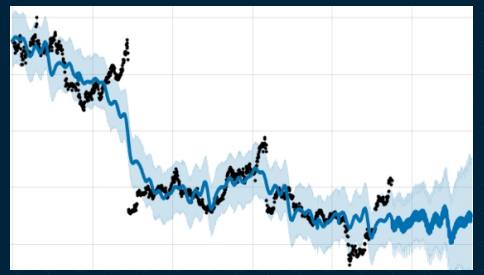
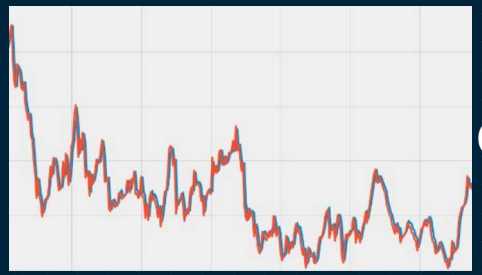
AI **Water Inflow**



AI **Market Price**

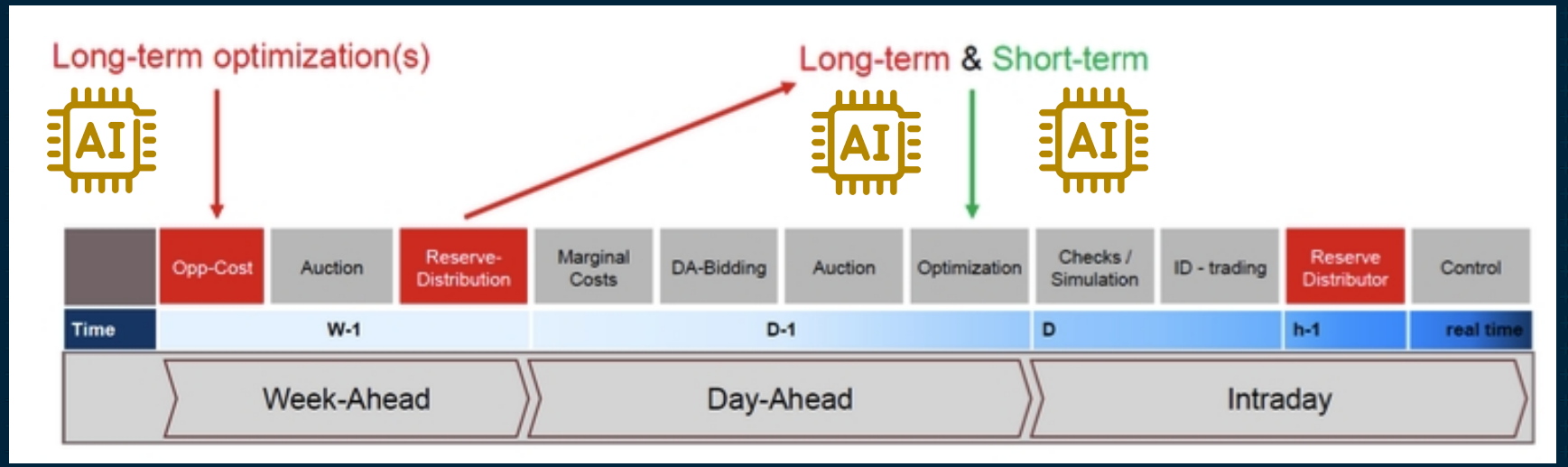


AI **Electric Demand**



Other Data (Weather,...)

AI



Hydropower Scheduling & AI

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digi.no Innhold Ekstra IT-jobber Tips oss

Mener AI kan holde strømprisen nede: – Kan spare milliarder av kroner

Norske strømselskaper tester allerede ut teknologien ved flere kraftverk.

10. jan. 2023

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ARTIKLER (2 TREFF)

Tror ikke AI-hype er løsninga på strømkrisa: – At det gir milliard-sparing over natta, er ikke realistisk

Sintef mener AI har sin plass, men at det er andre ting som er viktigere for å holde prisene nede.

17. jan. 2023

NRK Logg inn

Vestland Snakk med oss Vestlandsrevyen P1 SF P1 H

Vil la kunstig intelligens ta kraftavgjerder: – Kan spara milliardar av kroner

Styring av vasskraftproduksjonen er blitt så komplisert at vi bør ta i bruk nye metodar med kunstig intelligens, meiner forskar. Det kan bidra til at straumprisen ikkje blir høgare enn naudsynt.

Åge Algerøy
Journalist

Publisert 3. jan. kl. 13:15
Oppdatert 3. jan. kl. 16:22

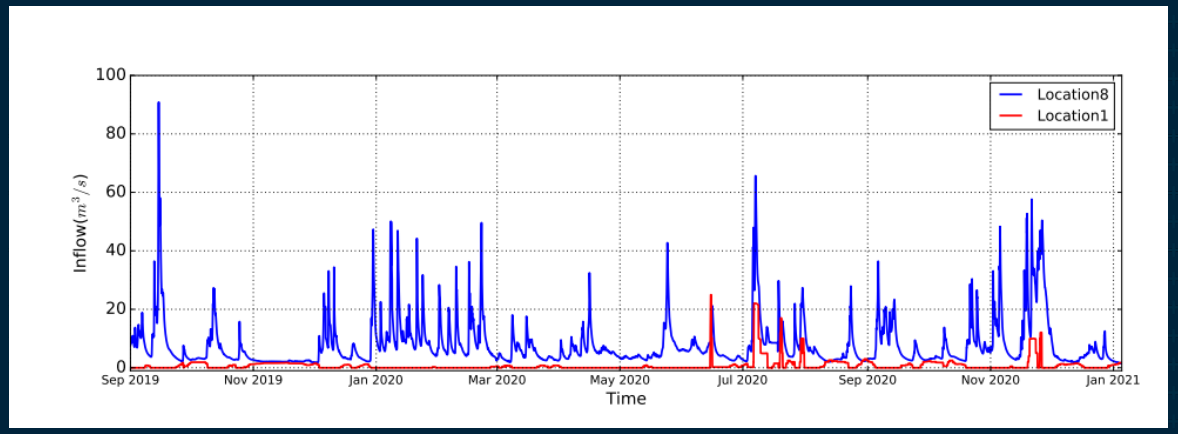
NYE METODAR: Professor Reza Arghandeh ved Høgskulen på Vestlandet har saman med andre forskarar utvikla nye metodar for å produsera straum på ein mest mogleg effektiv måte.

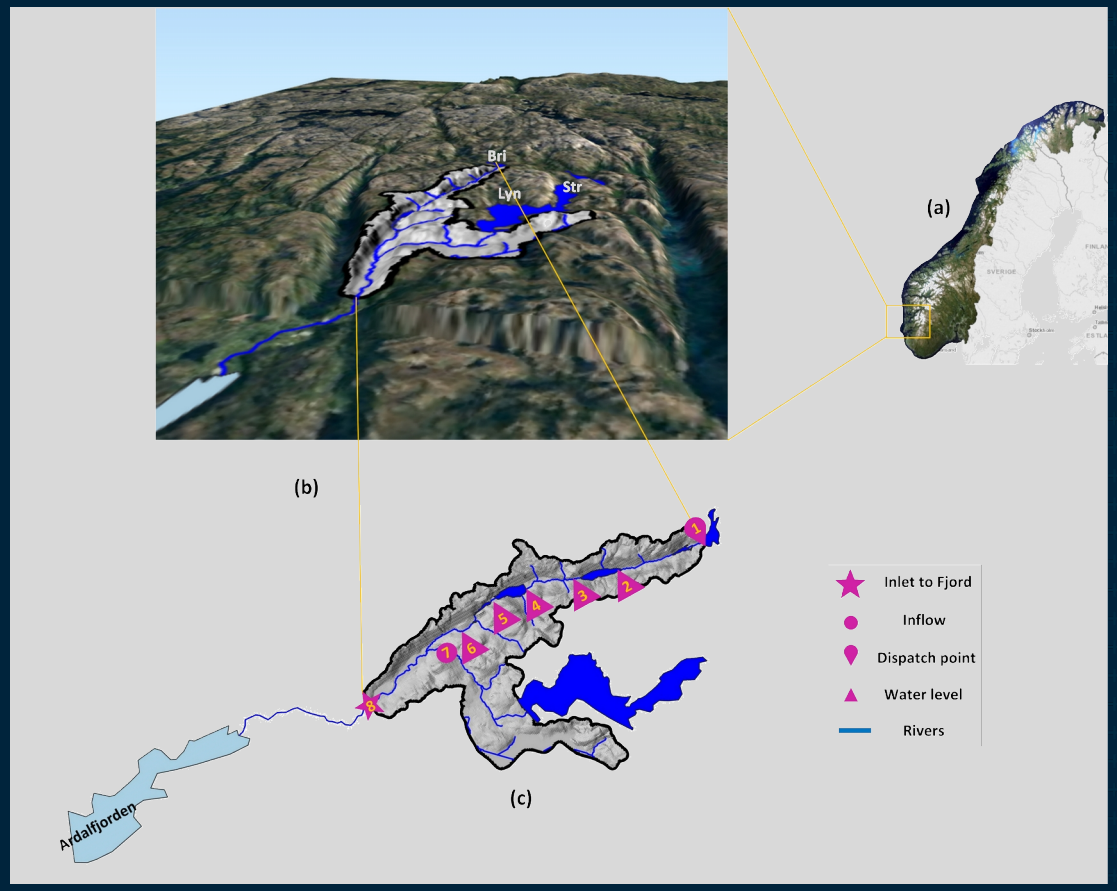
FOTO: ÅGE ALGERØY / NRK

Example of AI Application : Inflow Forecasting

Use Case

- Storåna river in Hjemland, Rogaland
- Lyseboten I and Lyseboten II Hydropower stations
- Data includes Meteorological and Hydrological parameters

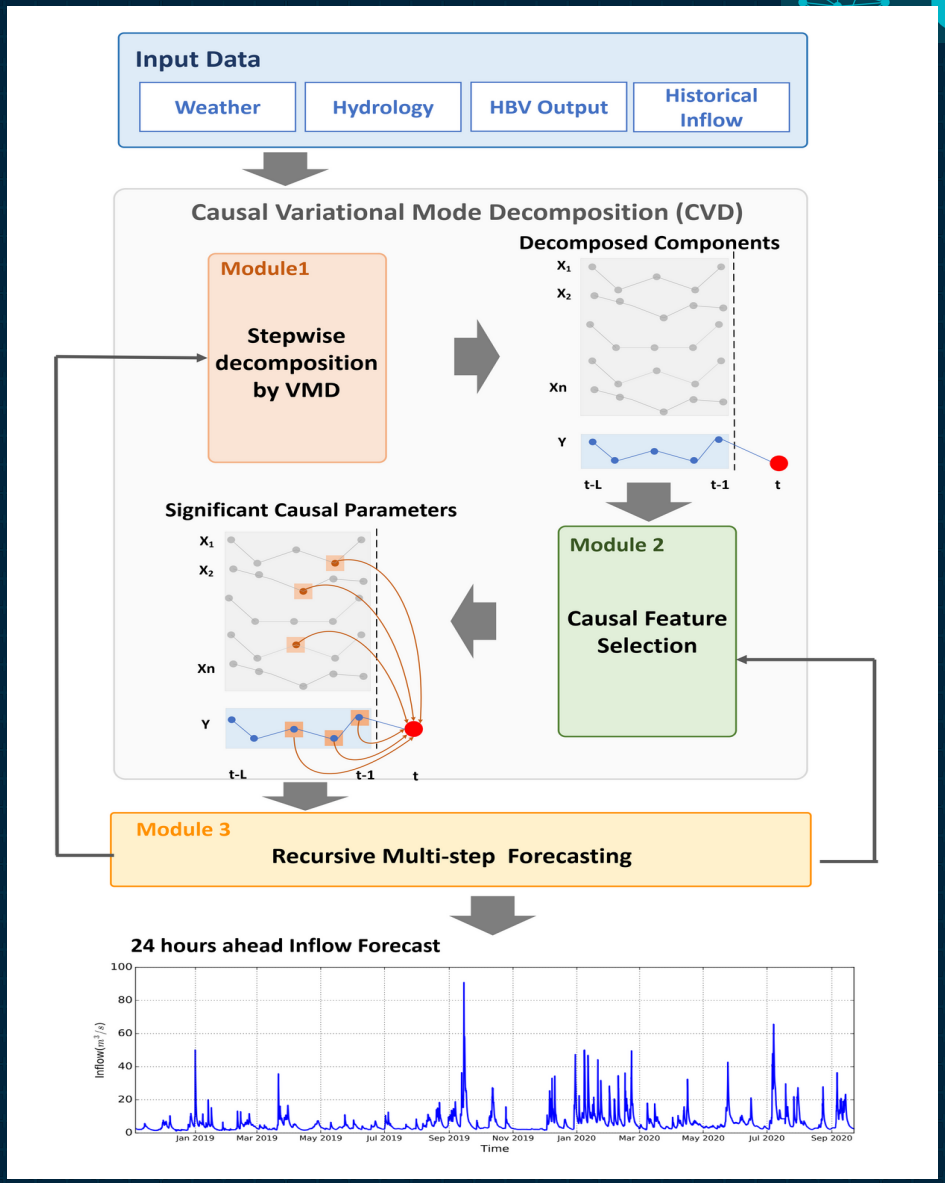




Example of AI Application : Inflow Forecasting

Methodology

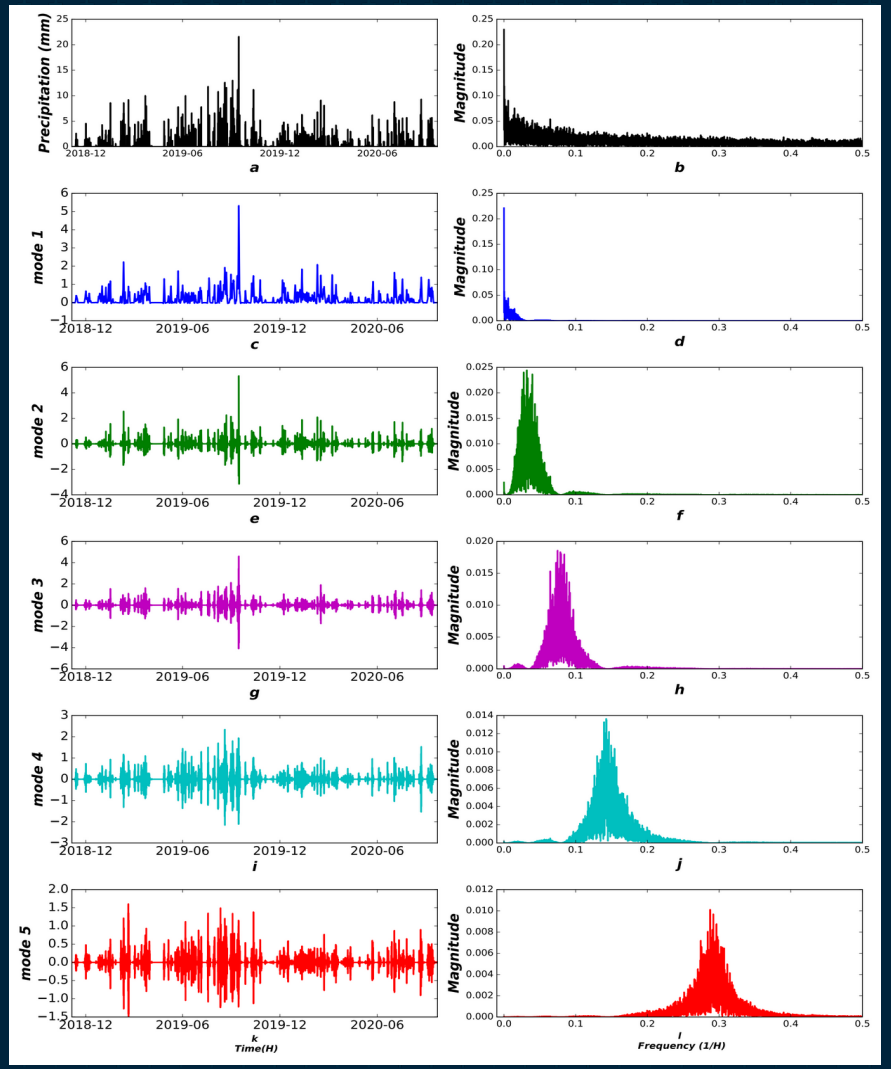
- We developed the Causal Variational Mode Decomposition (CVD) method for inflow forecasting.



Example of AI Application : Inflow Forecasting

Results

Data Decomposition (Precipitation)



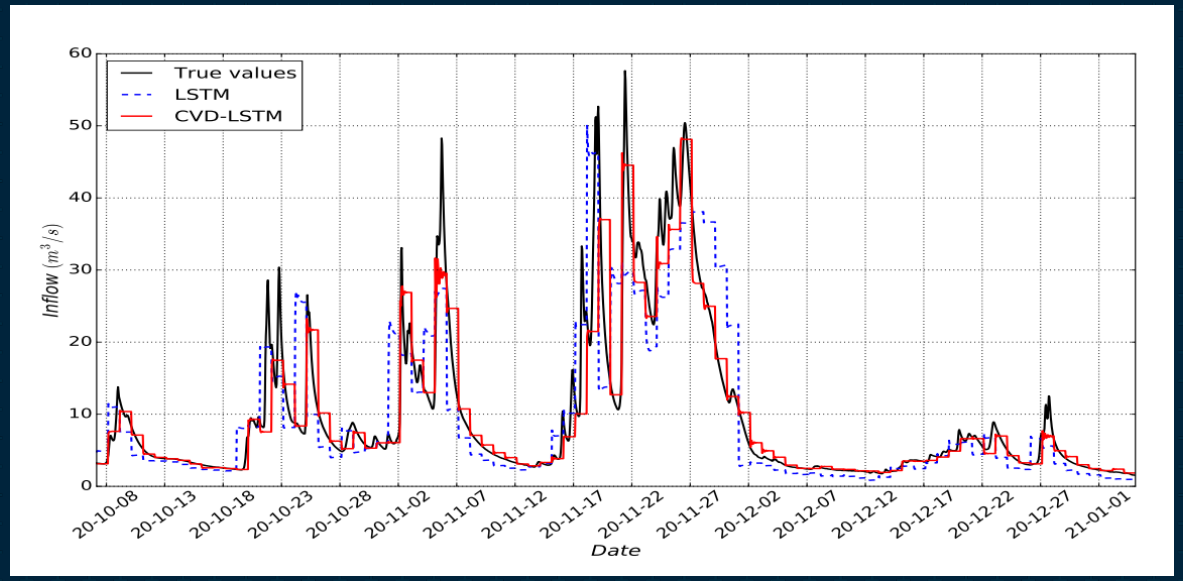
Selected Causal Variabels

SIGNIFICANT SELECTED MODES BY CAUSAL FEATURE SELECTION ALGORITHM

Variable	Location	Mode	Lag
Precipitation	Location 8 Actual (Kalltviet)	3	4
	Location 8 HBV	3 5	2 4
Inflow	Location 7 (Lyngsåna)	3 4 5	1 4 3
	Location 8 HBV	1 4	5 1
Difference Inflow	Location 8-Location 1 actual	1 2 3 4 5	1 1 5 5 1
Water temperature	Location 8 actual	1	1
Water level	Location 3 Actual (Musdalsvatn down stream)	2	5
	Location 7 Actual	1 3 4 5	5 1 1 1
	Location 6 Actual (Hiafossen)	3 4 5	5 3 2
	Location 5 actual (Hiavatn)	1 2 3 4	1 1 5 1
	Location2 Actual (Musdalsvatn)	3	3
	Location 4 Actual (Viglesdalsvatn)	2 5	1 5

Example of AI Application : Inflow Forecasting

Results



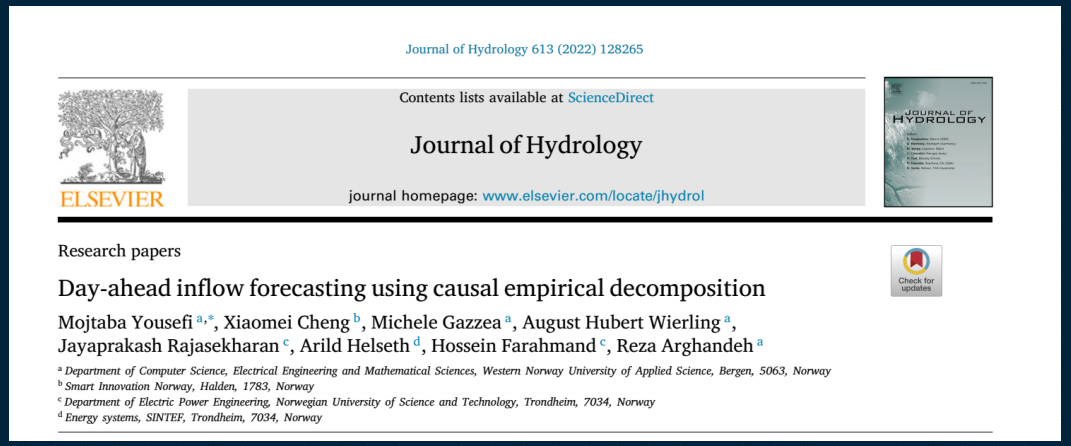
Comparison of input data impact on CVD performance for forecasting 24-hours ahead of inflow

Senarios	Data	Model	period	NRMSE	Computational time (s)
1	Historic inflow	LSTM	t+24	1.7	547
2	Weather	LSTM	t+24	1.66	442
		CVD-LSTM		1.03	80
3	Weather+ hydrological data	LSTM	t+24	1.06	629
		CVD-LSTM		0.8	96
4	Weather+ hydrological+ HBV data	LSTM	t+24	0.68	900
		CVD-LSTM		**0.51**	**76**

70% improvement

25% improvement

More Information:



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Contents lists available at ScienceDirect

Journal of Hydrology

journal homepage: www.elsevier.com/locate/jhydrol

Research papers

Day-ahead inflow forecasting using causal empirical decomposition

Mojtaba Yousefi [a,*], Xiaomei Cheng [b], Michele Gazzea [a], August Hubert Wierling [a], Jayaprakash Rajasekharan [c], Arild Helseth [d], Hossein Farahmand [c], Reza Arghandeh [a]

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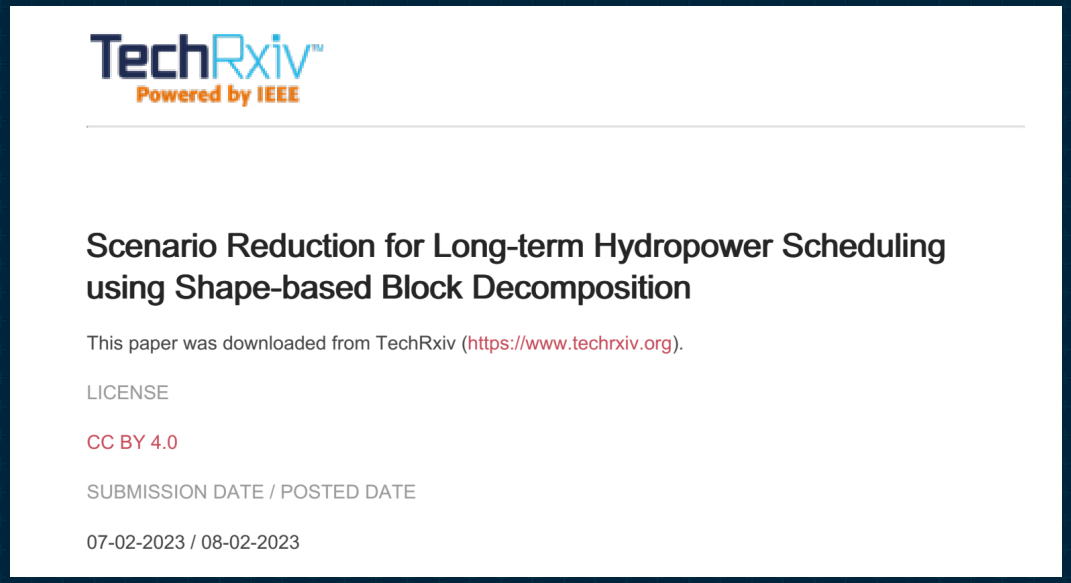
[d] Energy systems, SINTEF, Trondheim, 7034, Norway



Scenario Reduction for Long-term Hydropower Scheduling using Shape-based Block Decomposition

SUBMISSION DATE / POSTED DATE

07-02-2023 / 08-02-2023

Takeaway

- Climate changes, the presence of renewable energy and the complexity of electricity price market have a huge impact on the hydropower scheduling problem.
- AI can improve hydropower scheduling problems by reducing complexity, uncertainties and time consumption.
- An example of using AI for forecasting water inflow for a dam-regulated reservoir is presented

Thank You

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