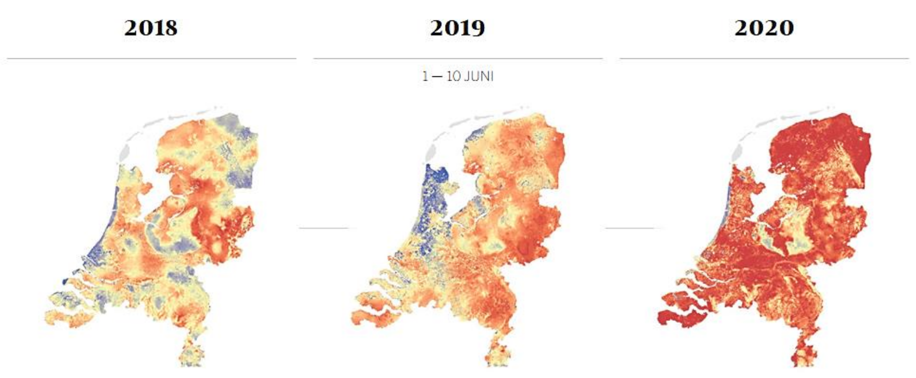
WP6.2: Real-time Monitoring and Model Predictive Control of Smart Water-Grids

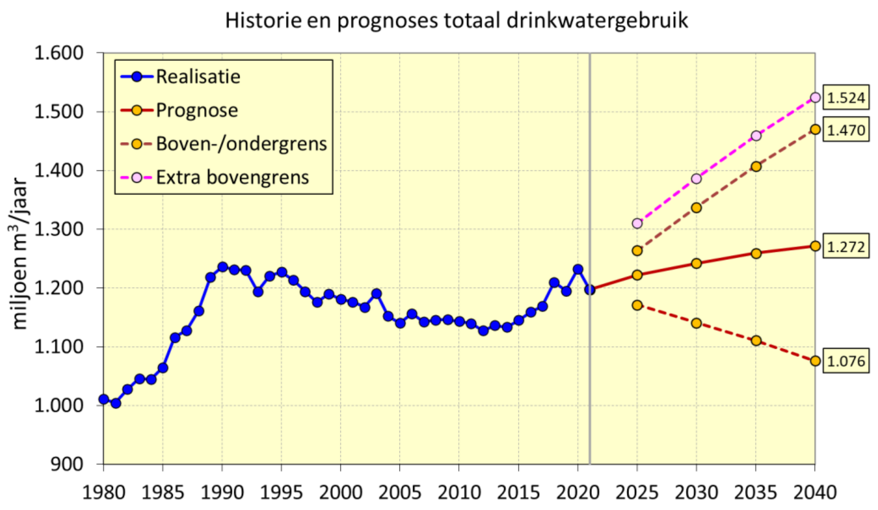
Peter Verheijen – Mircea Lazar – Dip Goswami – Jeroen Voeten

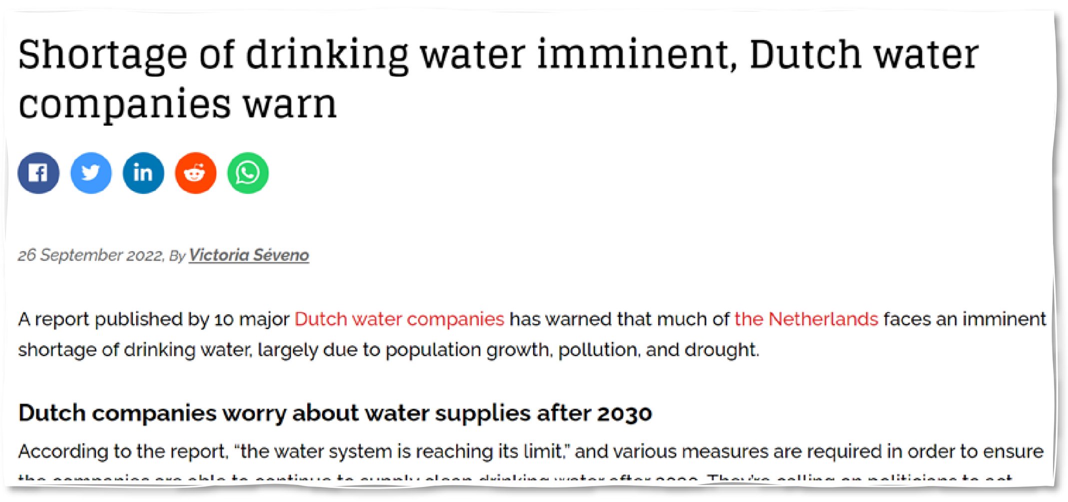
contact: p.c.n.verheijen@tue.nl, Linkedin

Problem



Modern water grids in the Netherlands are subject to increasing uncertainties due to growing demand, changing electricity tariffs, and climate change. In the future, this will put an increasing strain on the robustness of the water supply and the network. Currently, the resilience of the water networks is achieved through buffer reservoirs. The underlying control strategies ensure that a sufficient volume of water is available. However, under harsh demand/supply mismatches, this can fail.





Shortage of drinking water imminent, Dutch water companies warn

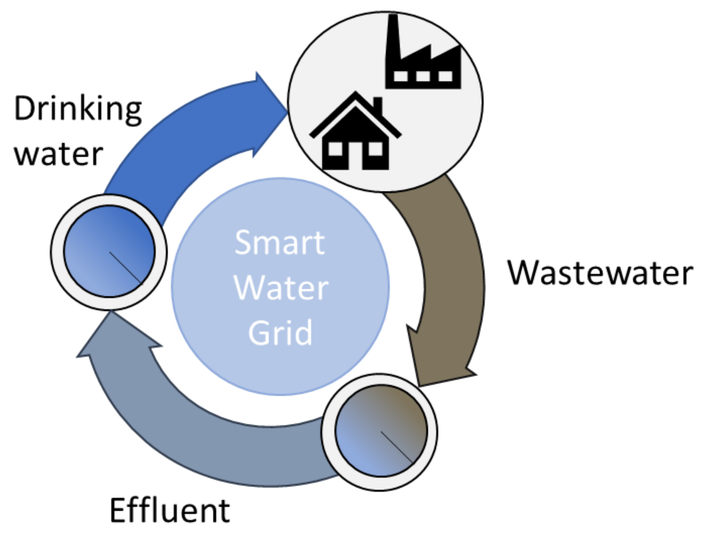
26 September 2022, By Victoria Séveno

A report published by 10 major Dutch water companies has warned that much of the Netherlands faces an imminent shortage of drinking water, largely due to population growth, pollution, and drought.

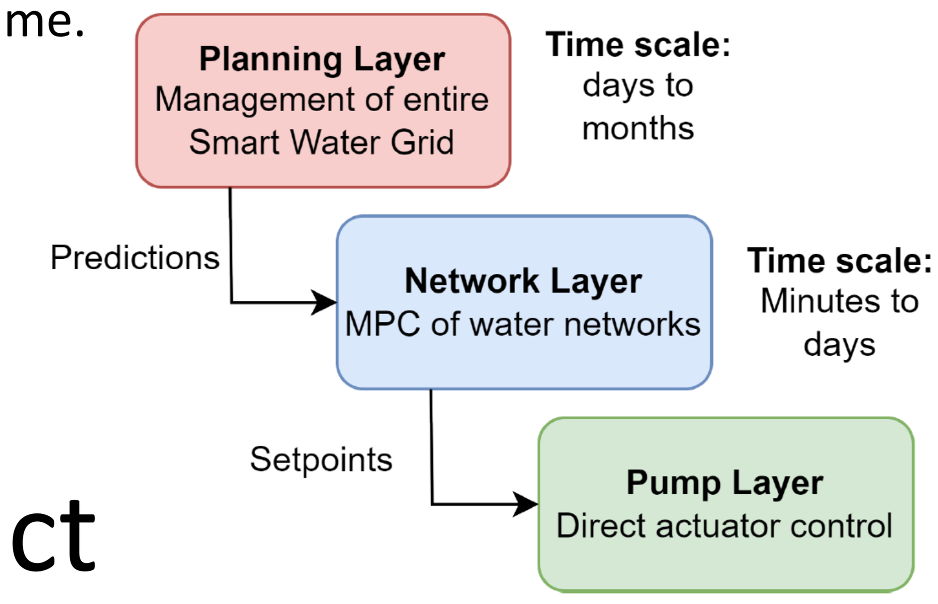
Dutch companies worry about water supplies after 2030

According to the report, "the water system is reaching its limit," and various measures are required in order to ensure

Approach



We first construct a model of a given water network to predict the response of any input (pump and valve settings) given some measured data (pressure, flow). Then we use that model to optimize pump scheduling over a finite time window and apply it to the network in real time.

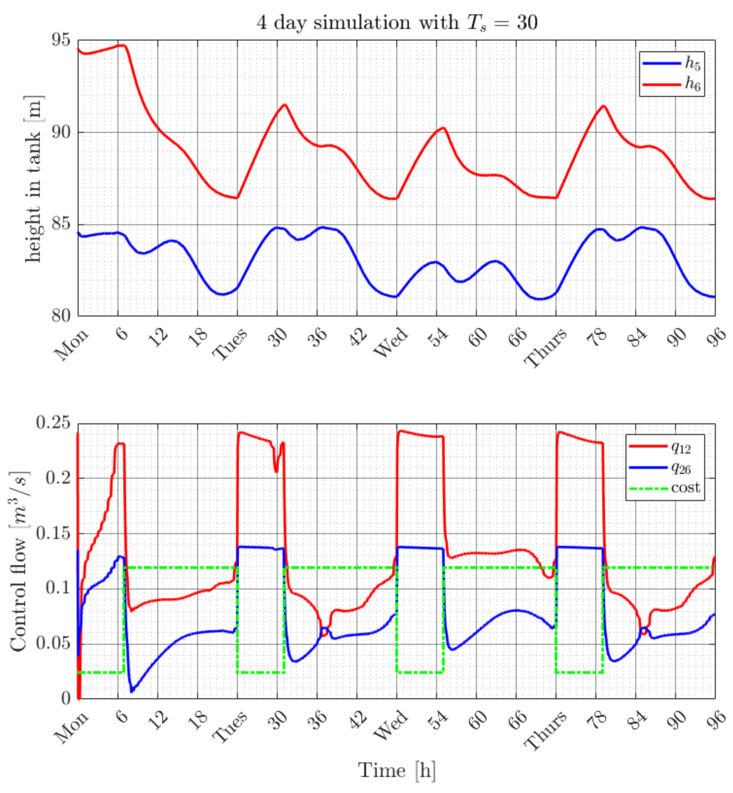


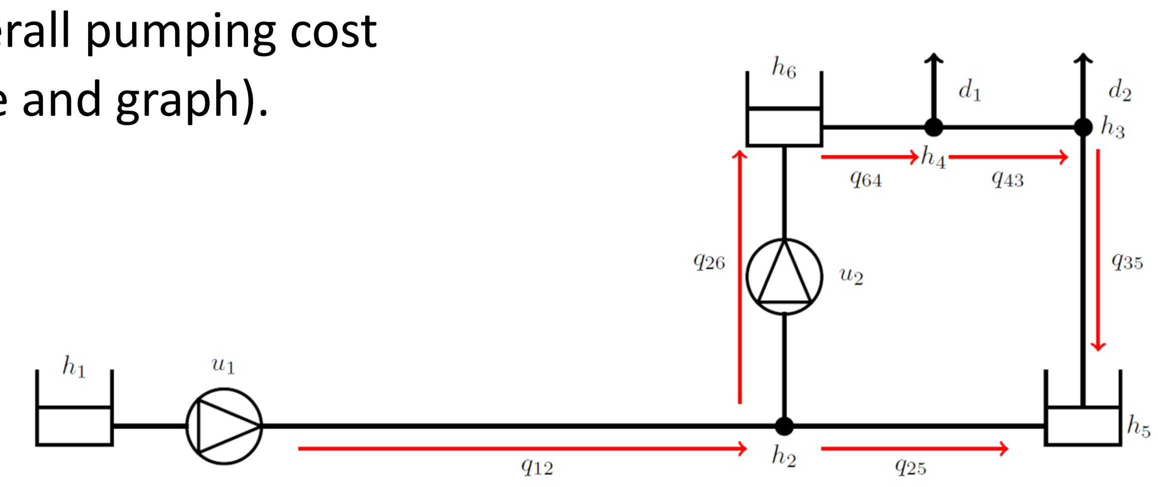
Pathway to impact

- We **evaluate the system more frequently**, thus reducing the real-time influence of unexpected events (like weather, demand, or network changes). This allows to also change the pumps faster, thus reducing the overall operating cost of the network, especially considering uncertain electricity tariffs.
- Inherit **AI-driven demand estimators** to accurately predict demand forecast for the next of couple hours. Therefore, the control algorithm can respond to critical events appropriately *before* they happen.
- Evaluating the system parameters at a higher speed requires *huge computational effort*, for which we **develop fast, parallelized algorithms**.

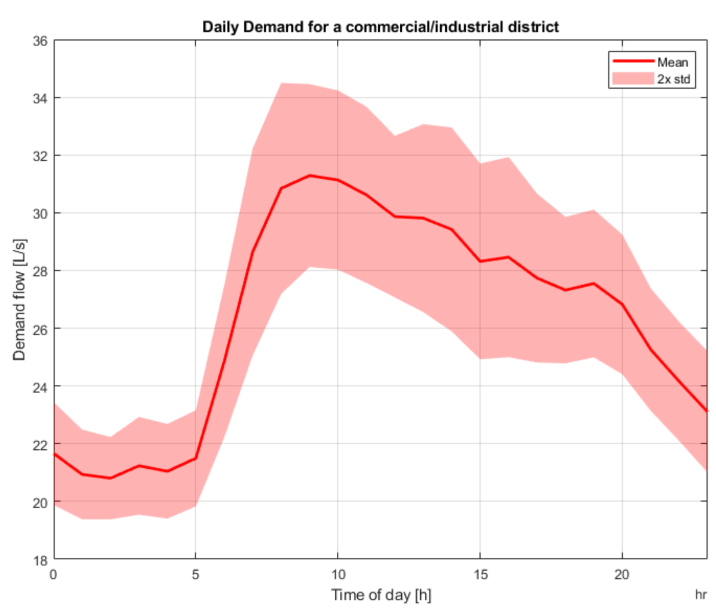
Predictive Water Network Control

Control of pressurized drinking water distribution networks is often employed at an hourly interval, meaning that only once an hour, the scheduling algorithm recomputes the optimal pump actuation and changes the pump settings accordingly. Updating the scheduling algorithm faster allows the network to respond quicker to unpredictable changes and in turn, saves overall pumping cost (see table and graph).





T_s	N	average cost/day
60m	24	305.06
30m	48	286.79
20m	72	281.16
15m	96	279.21
10m	144	278.09



Demand Forecasting

We developed a real-time demand forecasting algorithm. This will improve the prediction of a demand pattern (see graph on the left) for the next couple of hours, thus reducing the effect of unexpected peak usage.

Key stakeholders

As part of AquaConnect, it is important to overlap our research expertise with the future views on AquaConnects' stakeholders (and other interested parties). The current work is focused on pressurized drinking water networks, maintained in The Netherlands by drinking water companies (*Vitens, Brabant Water, Oasen, Evides, Dunea, etc*). But the methods can also be of interest to (water) research institutes/consultants (*KWR, Deltares, or RHDHV*).

Take-home message

Securing the availability of fresh water for the future is a multi-faceted challenge. This ranges from improved treatment methods to groundwater management to efficient water distribution. By smart predictive water distribution strategies, it is possible to significantly reduce future uncertainties, in turn mitigating the effects of climate change on our water networks.

Future Directions

- Develop the **GPU implementation** for computing the solution of the predictive control algorithm efficiently.
- Expand on our current reach in the smart water grid (controlling **waste-water treatment plants**, **drainage networks** or large-scale optimization of **ground water control**).
- Explore **data-driven implementations** that use measured data to keep the prediction accurate and thus reduce uncertain parameters.

NWO — TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY — ICT GROUP ICT Netherlands Smarter Solutions — AquaConnect