Modelling hydrogen in LTM (EMPS and FanSi)

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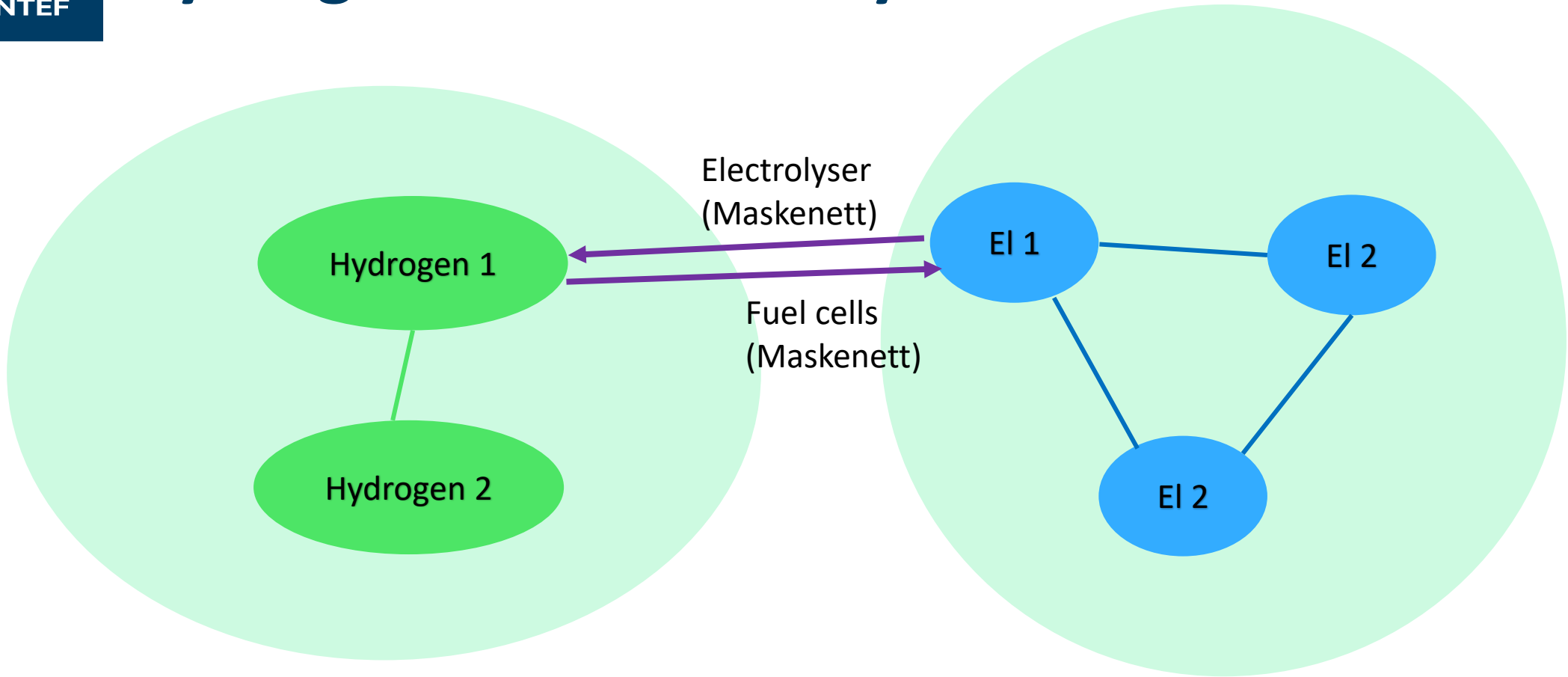
Own hydrogen modelling experience

- Part of larger project for Energy Department 2023. «Coherent value chains for hydrogen»

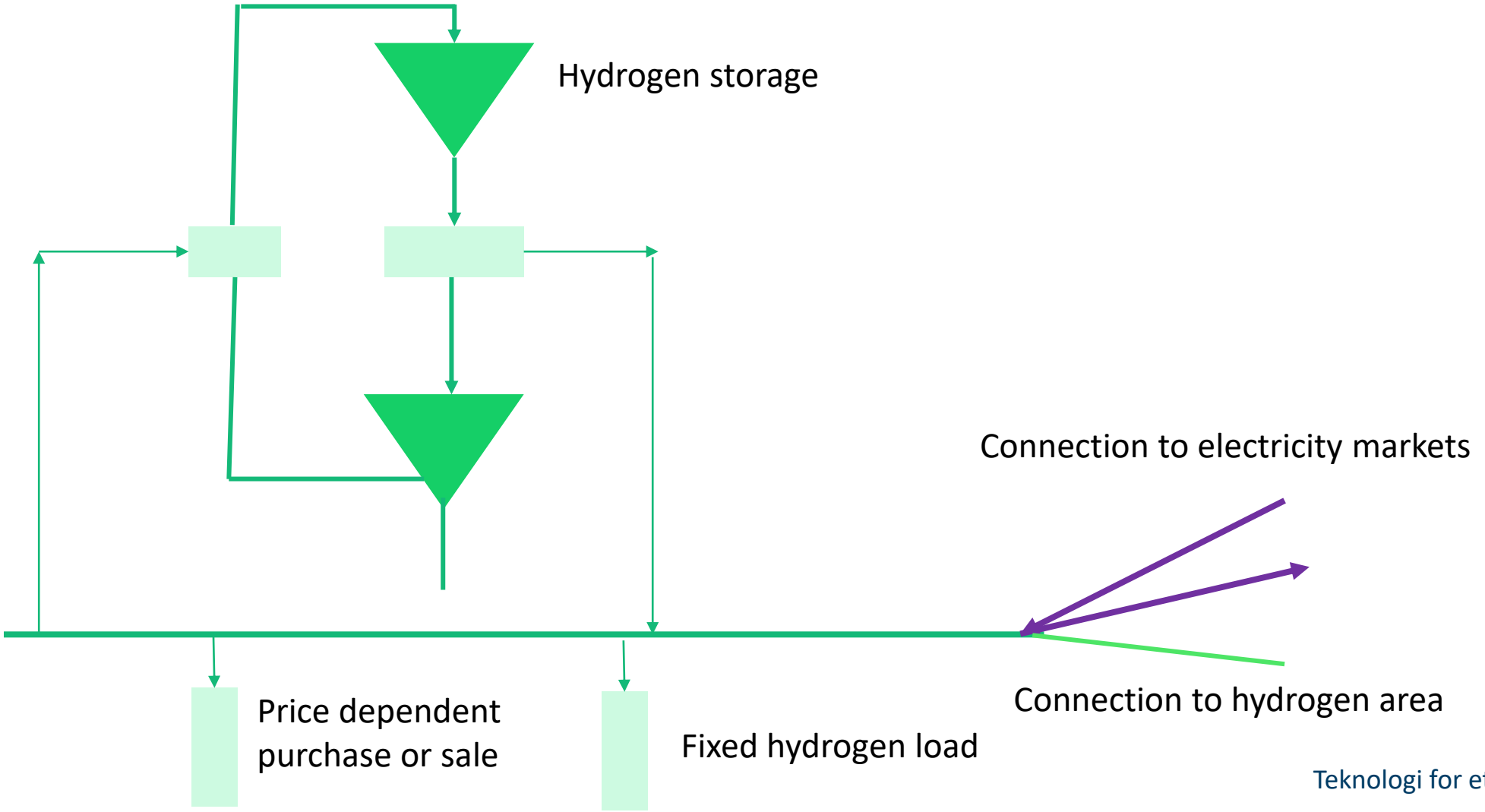
verdikjeder-for-hydrogen.pdf (regjeringen.no)

- HydroConnect
  - KSP project at SINTEF (2021-2024)
  - The project will investigate if Norwegian hydropower can play a major role in climate change mitigation. HydroConnect – SINTEF
- **EU project openENTRANCE (2019-2023): Case study D6.2 (2023)** openENTRANCE – open ENergy TRanstion ANalyses for a low-Carbon Economy
- **Grønn platform project: Ocean Grid (2022-2024)** oceangridproject.no

Hydrogen and electricity in the same model



Hydrogen area with storage



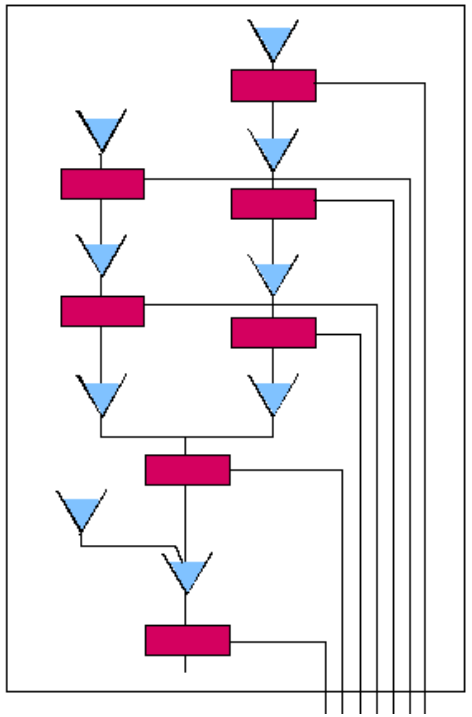
EMPS: Hydropower: Interaction between aggregate and detailed level

Detailed

(1) Input
(6) Fordeling av produksjon (regelbasert)

Aggregate

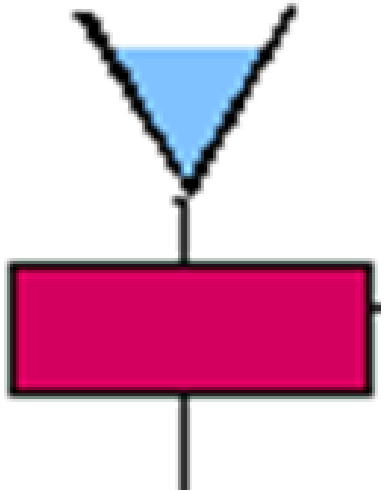
(3) Water value calculation (SDP)
(4) Area optimization (LP)
(8) Updated area optimization



(2) Aggregation

(5) Area production

(7) Efficiencies/costs
Violation of constraints



Relevant EMPS properties

- Aggregate level
  - Formal optimization for each weeks market problem
  - No reservoir balance constraints within the week

$$M(week) = M(week-1) + T(week) - \sum_{hour} \left(D(hour)\right)$$

$$Mmin \leq M(week) \leq Mmax$$
$$Dmin \leq D(hour) \leq Dmax$$

  - Aggregate hydro model does not include pumping

- Detailed hydro modelling
  - No reservoir balance constraints withing the week
  - Discharge heuristic not made for short-term pumping operation
    - Seasonal pumping

Consequences for hydrogen modelling

- Difficult to model hydrogen storage flexibility with existing EMPS functionality
  - Reservoir with constant inflow (I), increased load (I). Reservoir and plant size defines flexibility
  - Water value calculation (calibration) might be difficult

- Can model a hydrogen market without storage flexibility
  - Separate hydrogen area
    - Specified hydrogen load
    - Covered either by exogenous import with given price
    - or production from electricity in modelled areas

SINTEFs approach - FanSi model

- Using the FanSi model
  - Model combines optimization of long and short-term storages.
  - Hydrogen in separate areas as presented
  - Electric batteries also modelled using pumped storage plants (does not need to be in separate areas)

- FanSi methodology is reimplemented in ngLTM
  - Batteries etc will be separate technologies

Prototype EMPS with pumping possibility

- Developed in a EU project (about 15 years ago)
- Aggregate hydro model with pumping
- Reservoir balance constraints within the week

- Could be used to model batteries or hydrogen storages modelled in separate areas
- Does not solve the problem of real pumped storage plants in existing water courses.

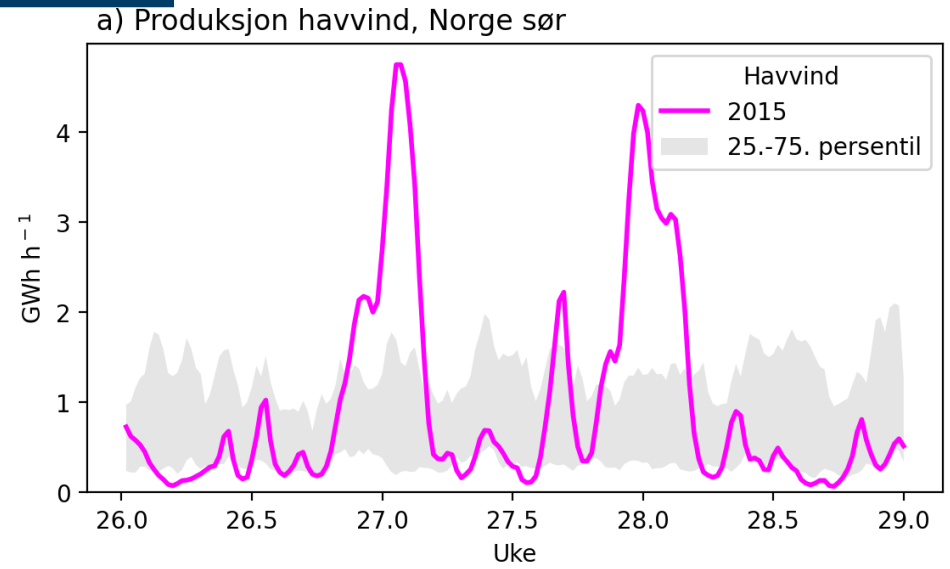
- Possible to implement in standard EMPS

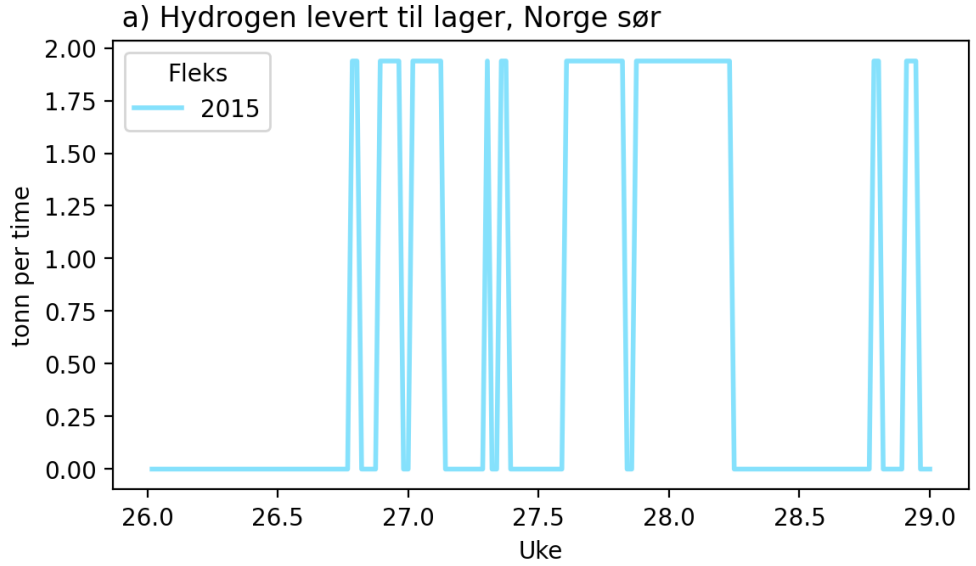
Flexibility in i hydrogen production

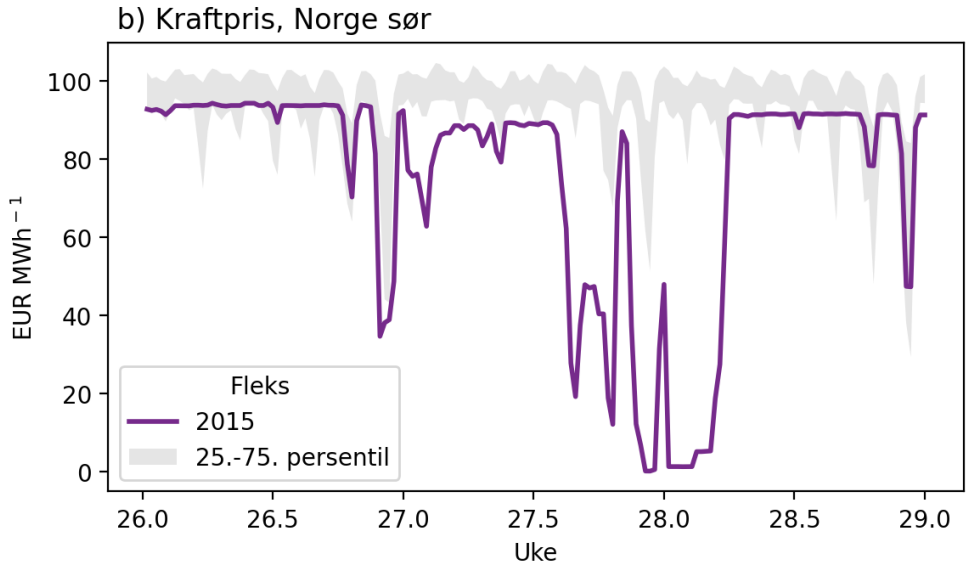
- 24 TWh flexible green hydrogen production
- 24 TWh new offshore wind production
- One case without flexibility "Uflex" and two cases with flexibility

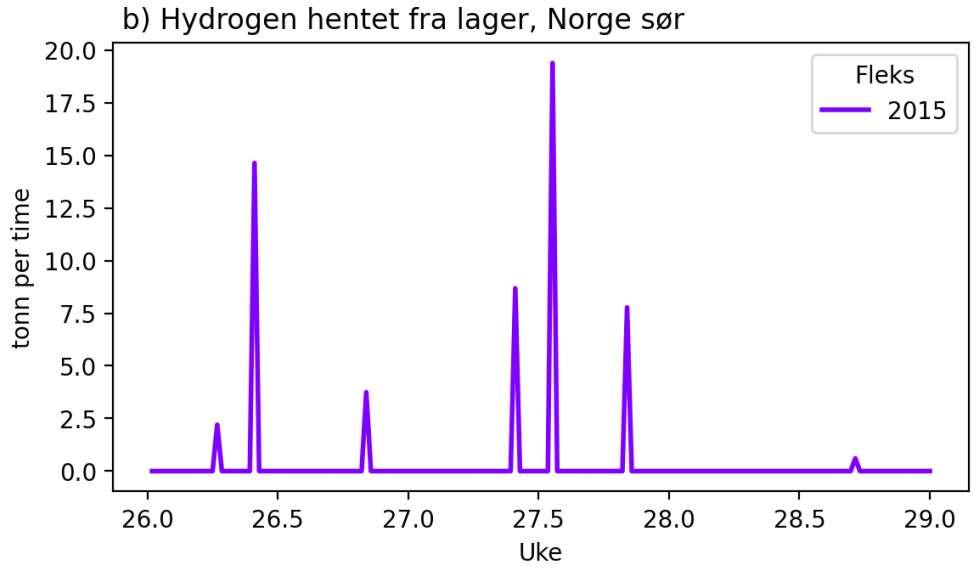
	Storage size	Production capacity
Uflex	**0**	**0**
Flex	**10 hours**	**10%**
High Flex	**160 hours**	**30%**

Example results for a three week period weather year 2015 (scenario Flex)









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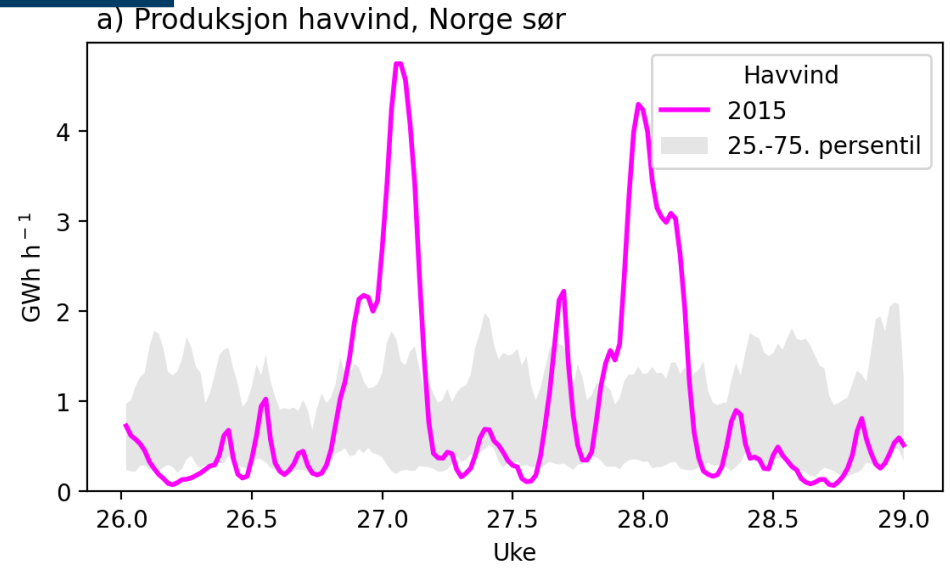
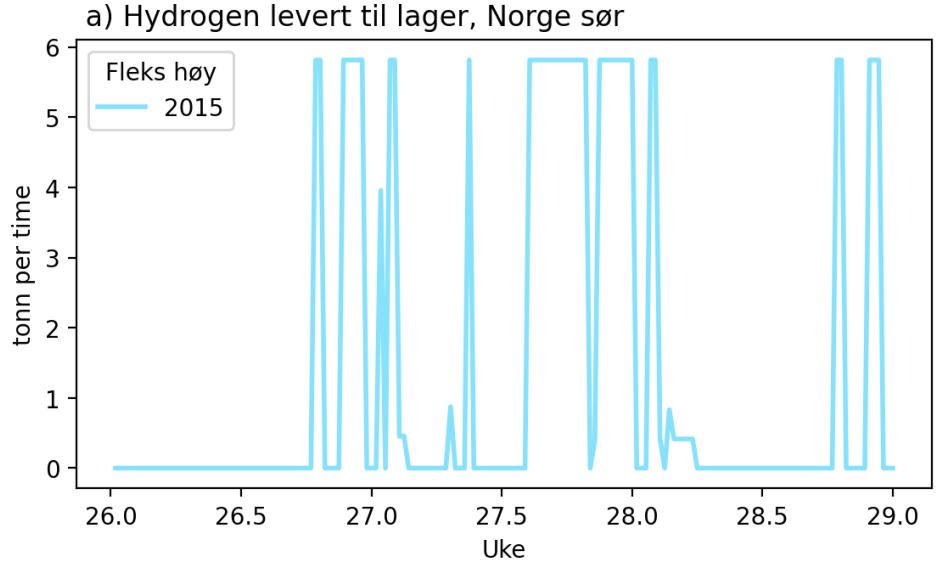
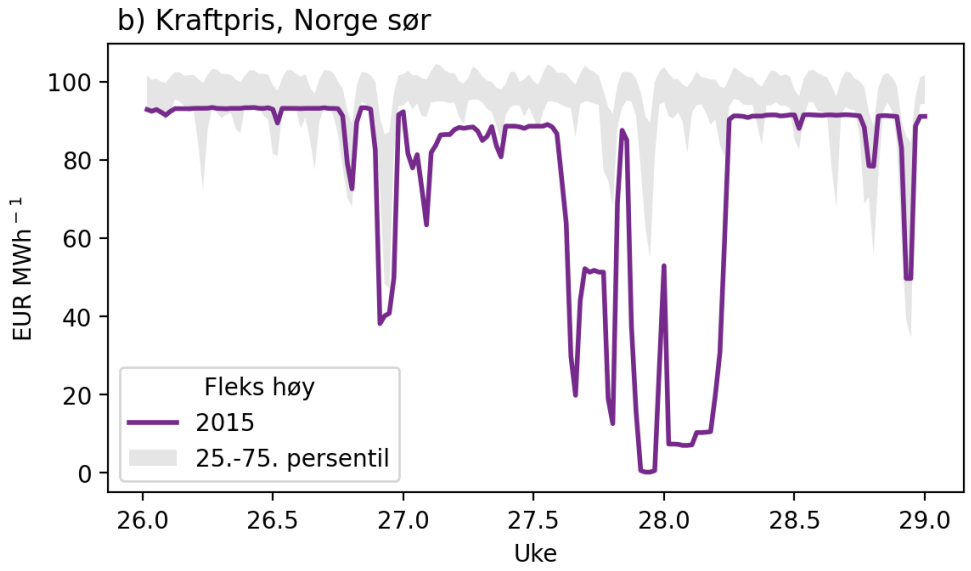
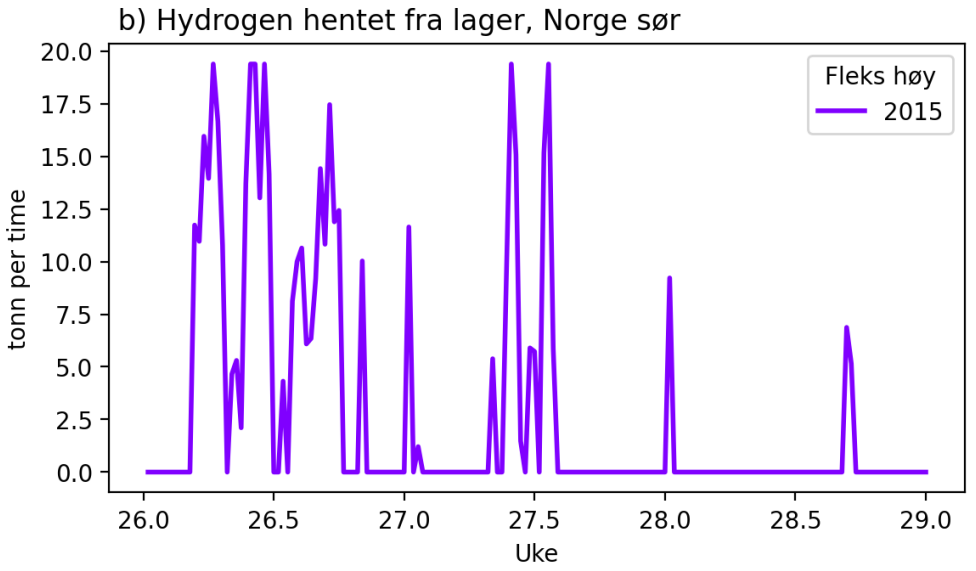
Example results for a three week periode weather year 2015 (scenario high Flex)









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