SINTEF

1950 – 2025

75 år med teknologi for et bedre samfunn

Flow-Based Market-Coupling in EMPS

User meeting 2025

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Presentation overview

1. FBMC in EMPS
   - Introduction of Flow-Based Market-Coupling
   - Overview
   - Method
   - New input and results
2. FBMC in LtmApi

Introduction - FBMC

- New capacity calculation method (CCM) for the day-ahead market - live in october 24
  - Replaced the Net Transmission Capacity (NTC) method
- Why?
  - More sophisticated method that the NTC
  - Better utilization of the grid
  - Increases the systems social welfare
  - Provides transparency of grid info
- How?
  - Physical limits in the grid
  - Based on available margin on Critical Network Elements (CNE) and Power Transfer Distribution Factors (PTDF) for the CNEs in relevant Bidding Zones
  - Describes how the change in Net Position of a bidding zone influence the flow on the CNEs

History - FBMC in EMPS

- More grid information available to producer
- **Vannfly 2020-2023:**
  - Knowledge building research project at SINTEF Energy
  - Main delivery: **prototype FBMC functionality in EMPS**
- Operationalisation of FBMC 2024
  - Main delivery: official **FBMC functionality in EMPS**

Overview - FBMC in EMPS

- EMPS simulation
- Released in LTM version 10.9

- Usage requirements:
- *Licenced functionality*
- *EMPS input file*

Method: FBMC in EMPS

$$Objective: Minimise\ costs$$

Subject to:

$$\sum_{BZ}(Net\ position) = 0$$

$$NTC\ or\ FB\ constraints$$

- NTC constraints
  - Transmission corridors constrained by capacity limits
- *Economic power flow*

- FB constraints
  - CNEs constrained by RAM
  - Change in NP is described by PTDFs
- *Physical power flow*

Net position = sum of import/export in Bidding Zone

Consequence of new method

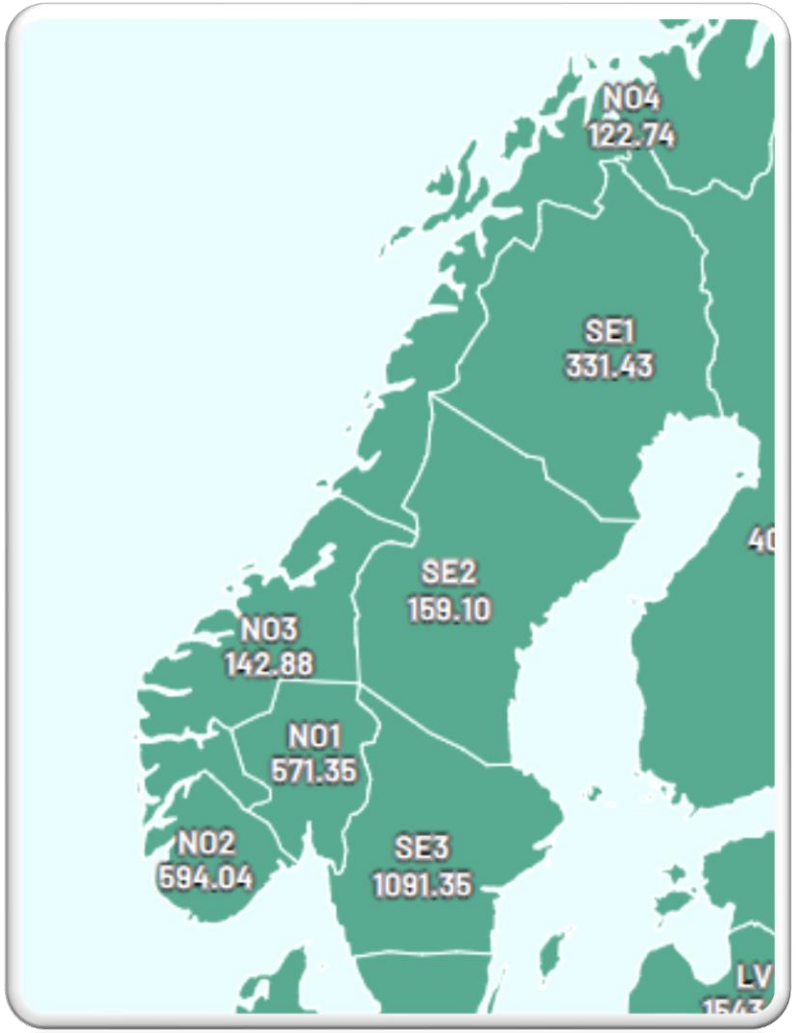
- FB constraints:
  - Change in structure requires building and solving a general ***LP-problem***
- Solving general LP-problems is computationally demanding
- Additional EMPS results

New data input

- FB parameters
  - PTDFs for all Bidding Zones (Flow distribution)
  - RAM for all CNEs (Flow constraint)
- Input can be provided by JAO publication tool*:
  - Data available on .json or .csv format
  - Hourly resolution

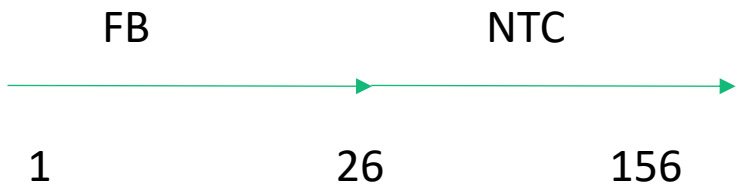
*https://publicationtool.jao.eu/nordic/

AC grid, Bidding Zones and EMPS price areas



FBMC functionality options

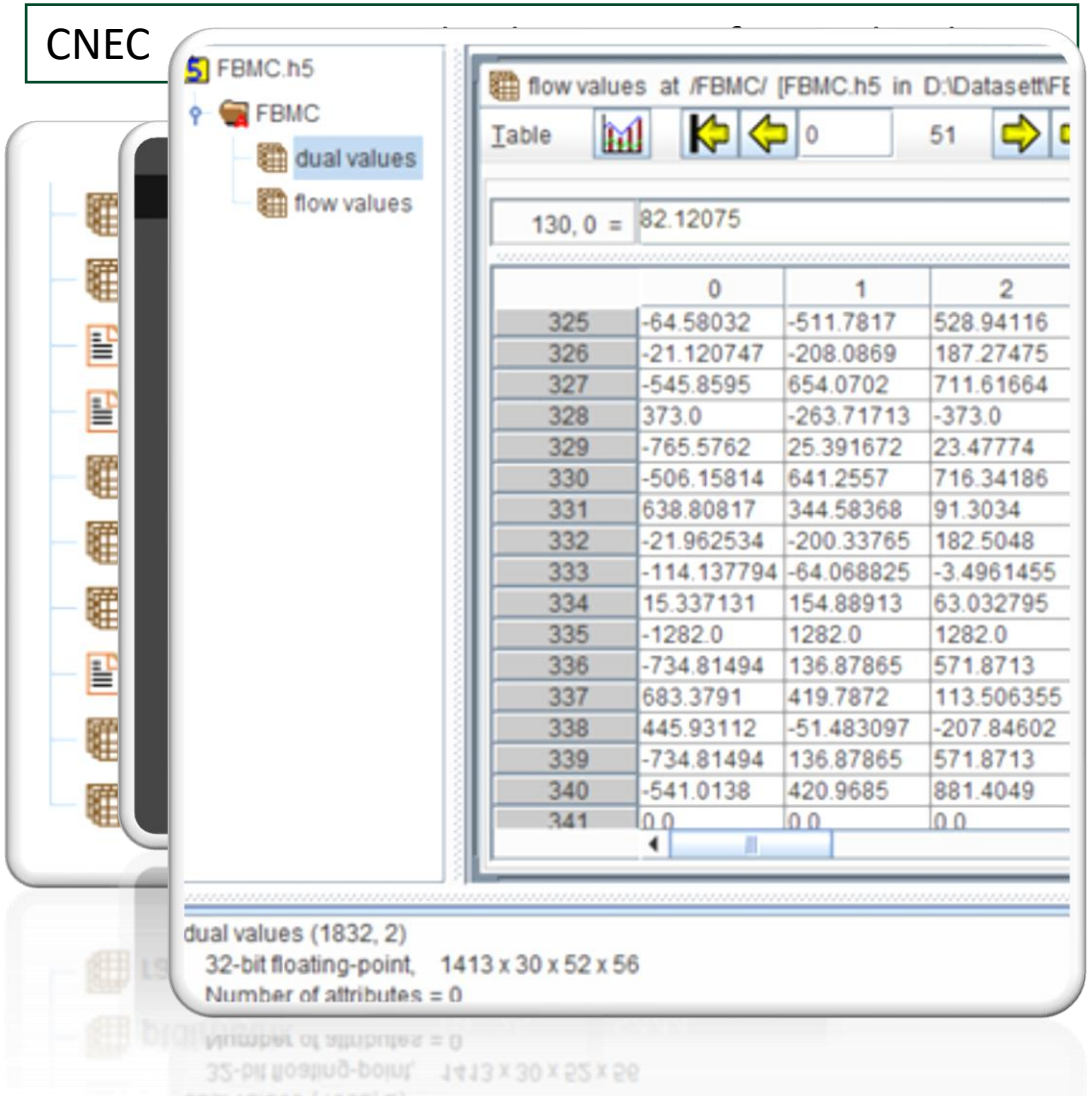
1. Simulation speed up:
   1. Parallell processing
   2. Flexible use of FB and NTC constraints
      - FB constraints activated/deactivated for a defined periods
   3. Solver options: CPLEX and Coin



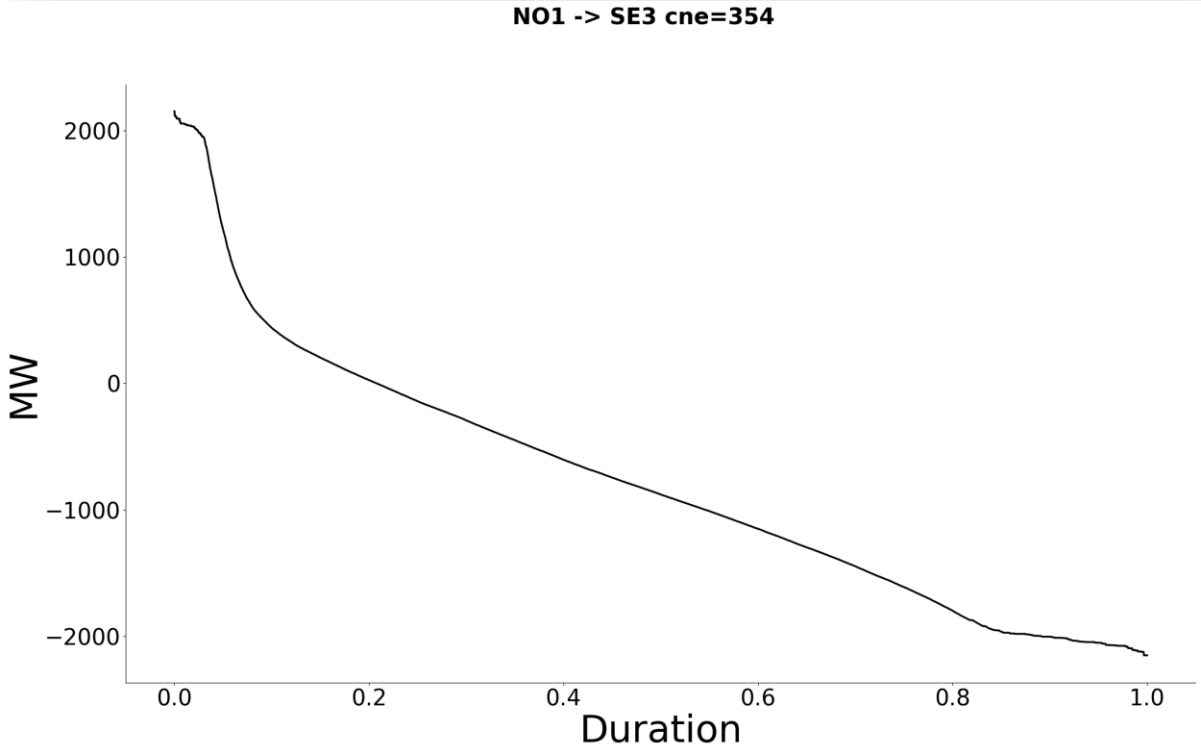
2. Scenario dependent FB-parameters

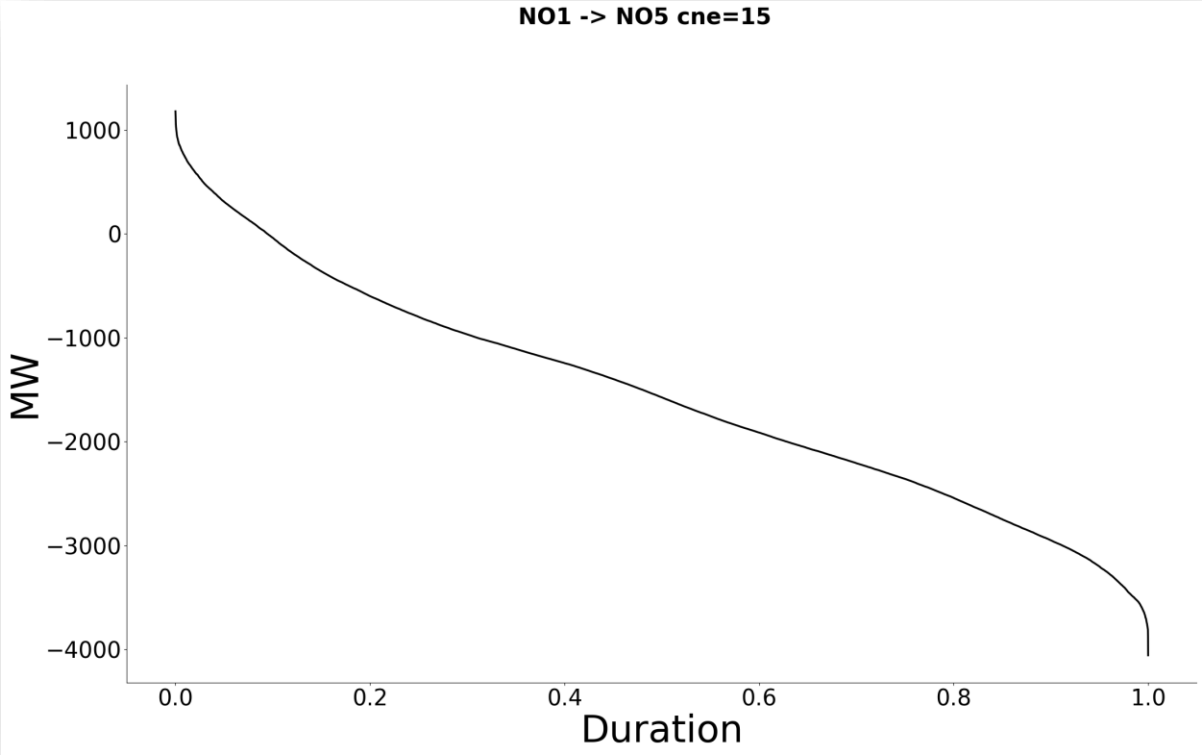
Input and output

- Input:
  - ptdf_constraints.h5
- Output:
  - fbmc_stats.txt
  - fbmc.h5



Example new results – physical flow on CNE(C)





Related projects - FBMC

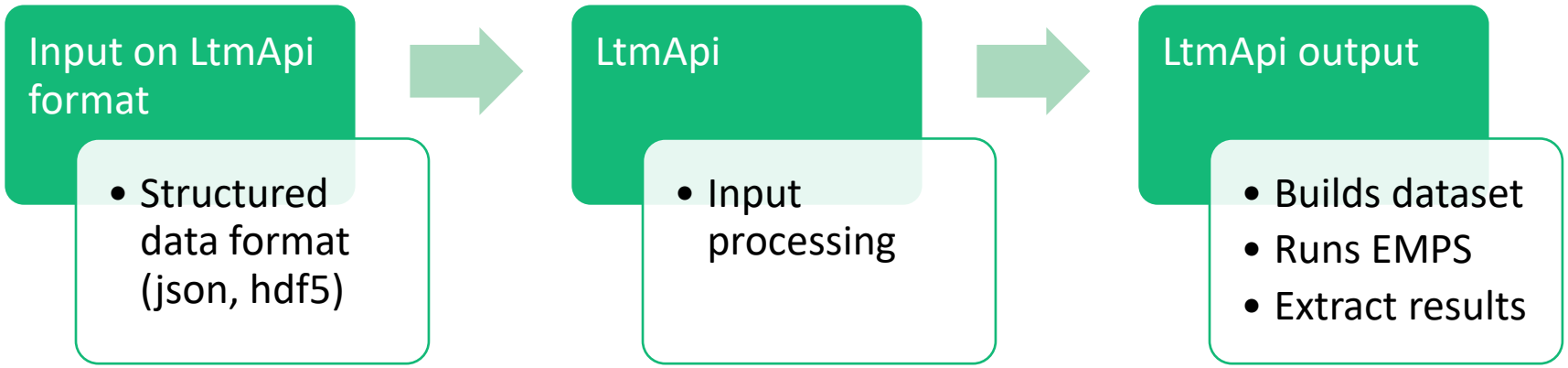
- Småstein – FB-parameters calculator based on EMPS results and open grid information
  - Input to EMPS
- NordenStein – project proposal

Summary

- FBMC functionality is available in EMPS
- Requires new input data
- Produces new results
- Increased simulation time (dependent on LP-solver, parallell processing, FB activation period, degree of details in dataset, etc…)

FBMC in the LtmApi

- LtmApi allows for building, running and extracting results using python



EMPS input

Price Areas

Hydro power

Market description

....

Busbars

Reservoirs

Hydro plants

Aggregated hydro power

...

Market steps

Loads

....

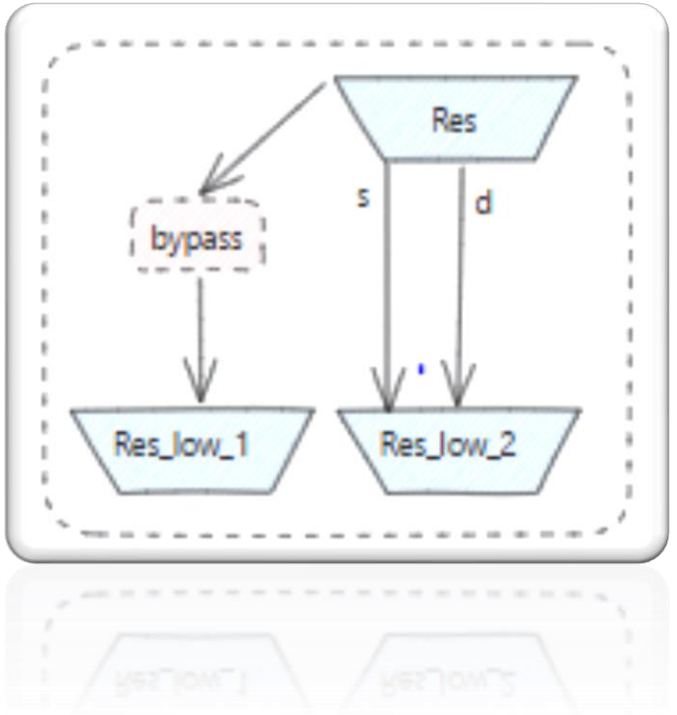
....

Api objects

LtmApi - input

- LtmApiModel description on structure data format (json)
  - Objects (Plants, Reservoirs, Batteries, DC-lines, Market_steps, Loads, Bidding Zones etc.)

```
{
    "reservoirs": [
        {"name": "UpperReservoir", ...},
        {"name": "LowerReservoir1", ...},
        {"name": "LowerReservoir2", ...}
    ],
    "plants": [
        {"name": "HydroPlant1", ...}
    ],
    "bypasses": [
        {"name": "Bypass1", ...}
    ],
    "spills": [
        {"name": "Spill1", ...}
    ]
}
```



FBMC in LtmApi – additional input

Api objects

Bidding Zones


```
{
    "#comment": "tev and battery",
    "name": "N2",
    "is_fbmc": true
},
{
    "#comment": "otra",
    "name": "N3",
    "is_fbmc": true
},
{
    "#comment": "HVDC numedal",
    "name": "N1_hvdc",
    "is_fbmc": true
},
{
    "#comment": "HVDC tev",
    "name": "N2_hvdc",
    "is_fbmc": true
},
{
```


CNEs


```
{
    "name": "N1-N2",
    "cnecName": "Test1",
    "biddingZoneFrom": "N1",
    "biddingZoneTo": "N2",
    "active": {
        "name": "",
        "timestamps": [
            "2025-02-13T00:00:00Z"
        ],
        "scenarios": [
            [
                1
            ]
        ]
    },
    "ram": {
        "name": "",
        "timestamps": [
            "2025-02-13T00:00:00Z"
        ],
```


- *API can build CNE objects from JAO input!*

Summary 2

- LtmApi for FBMC functionality is available
  - JAO API format support (json)
  - LtmApi FBMC input objects (Bidding Zones and CNEs)

- LtmApi extraction of FBMC output – ***still in progress***
  - Physical flow on CNEs
  - Results summary

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Sintef dataset - 2030

FBMC input fra uke 1 2023	57 areas • 11 NO, 4 SE, 2 DK, FI 1, + UK and northern Europe	~1200 hydro modules
3 hour time resolution	52 weeks	30 scenarios

AC-grid: NO,SE,DK2,FI	MASKENETT 2030