



TradeRES

New Markets Design & Models for
100% Renewable Power Systems

MASCEM

Multi-Agent Simulator of Competitive Electricity Markets

July 19th, 2022



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 864276



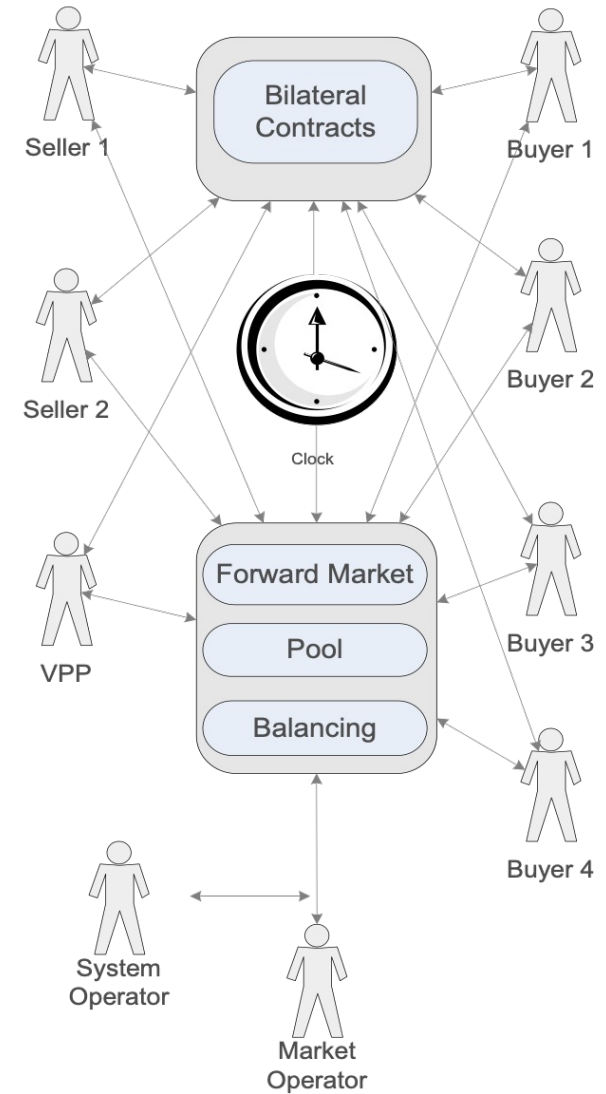
Agenda

- Overview
- ABM integration in Spine Toolbox
- Input
- Output
- How to run it
- Live demonstration



Overview

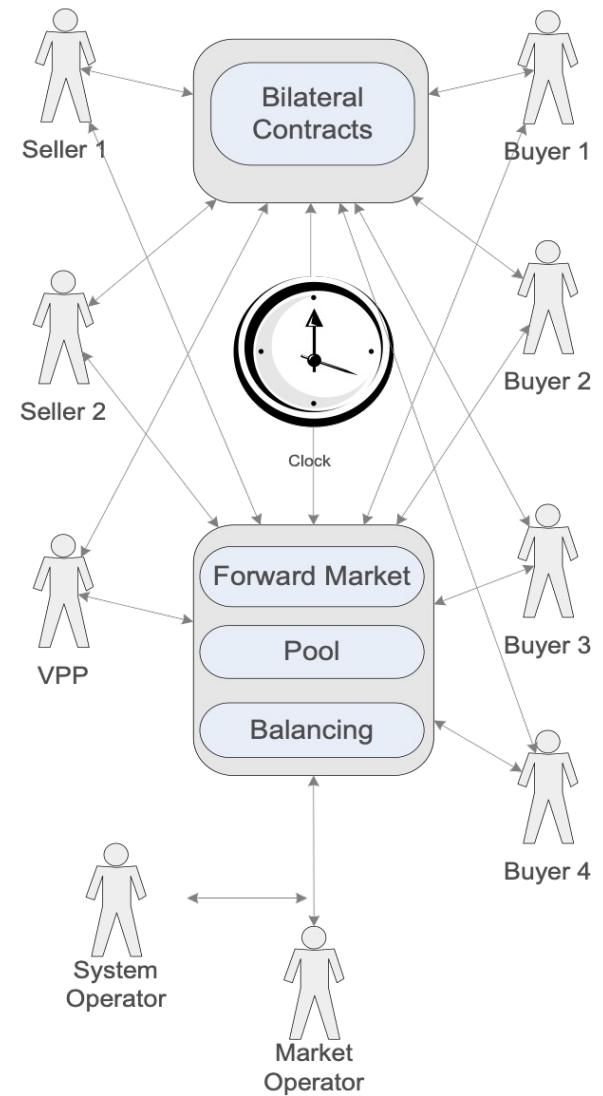
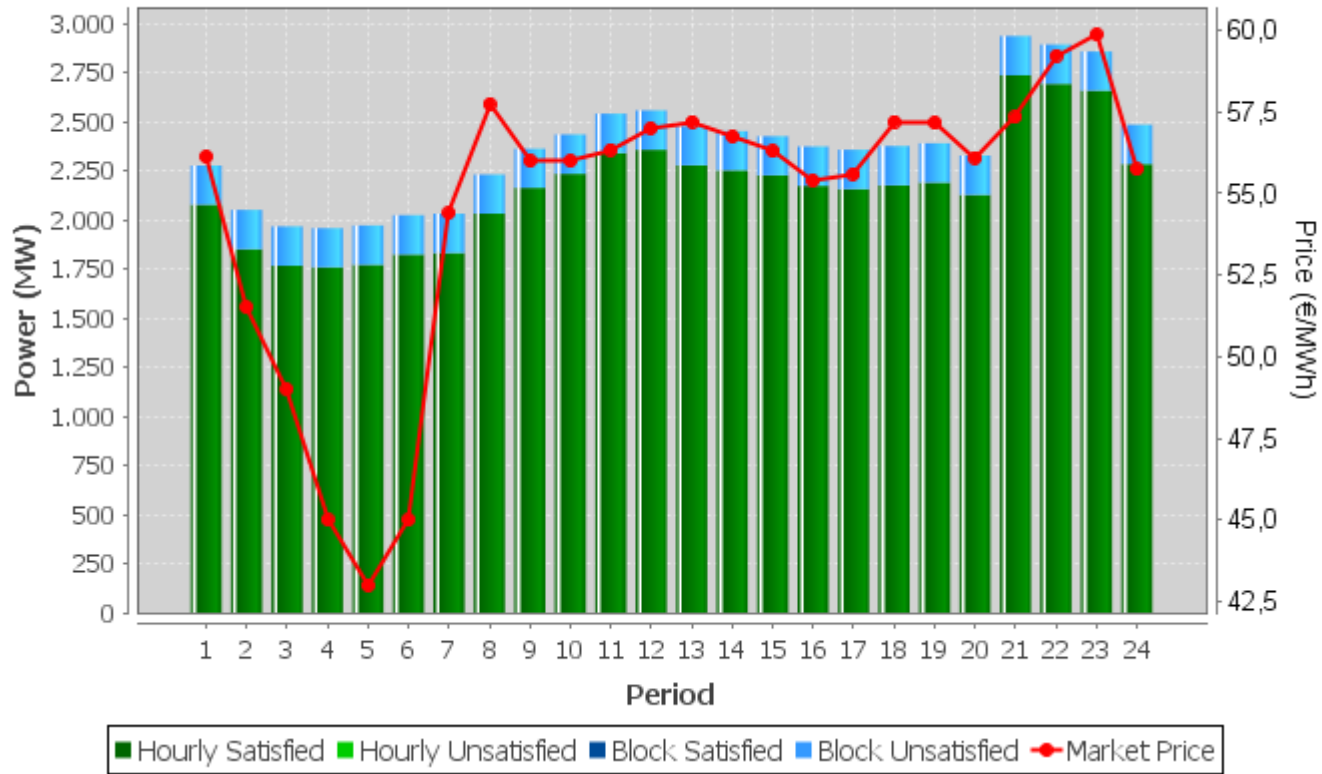
MASCEM: Multi-Agent Simulator of Competitive Electricity Markets





Overview

Seller 22's Satisfied Supply





Overview

Market Operator

Day ahead Market

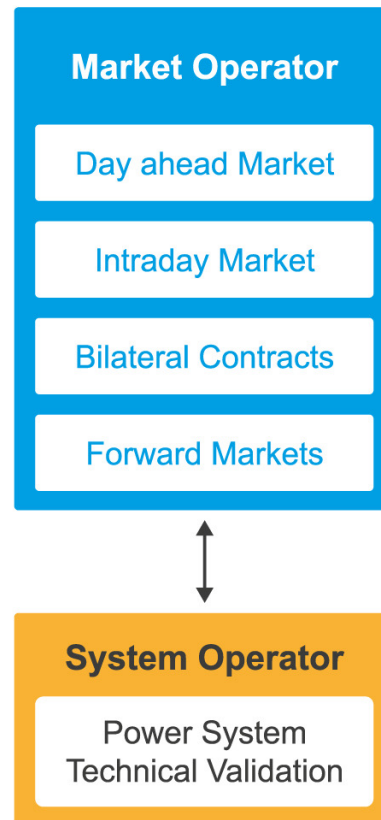
Intraday Market

Bilateral Contracts

Forward Markets

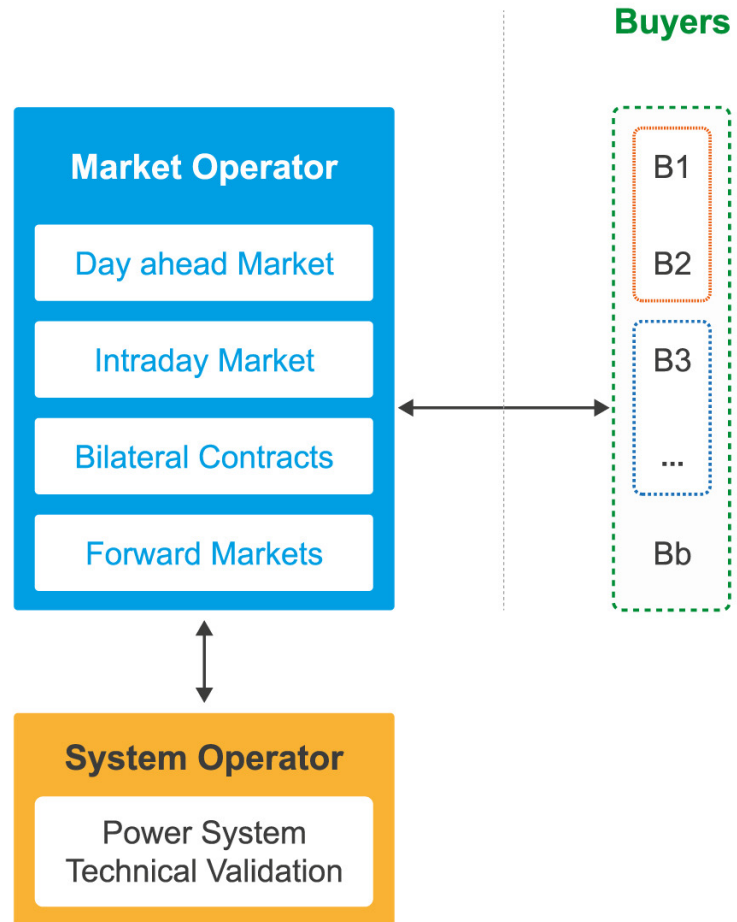


Overview



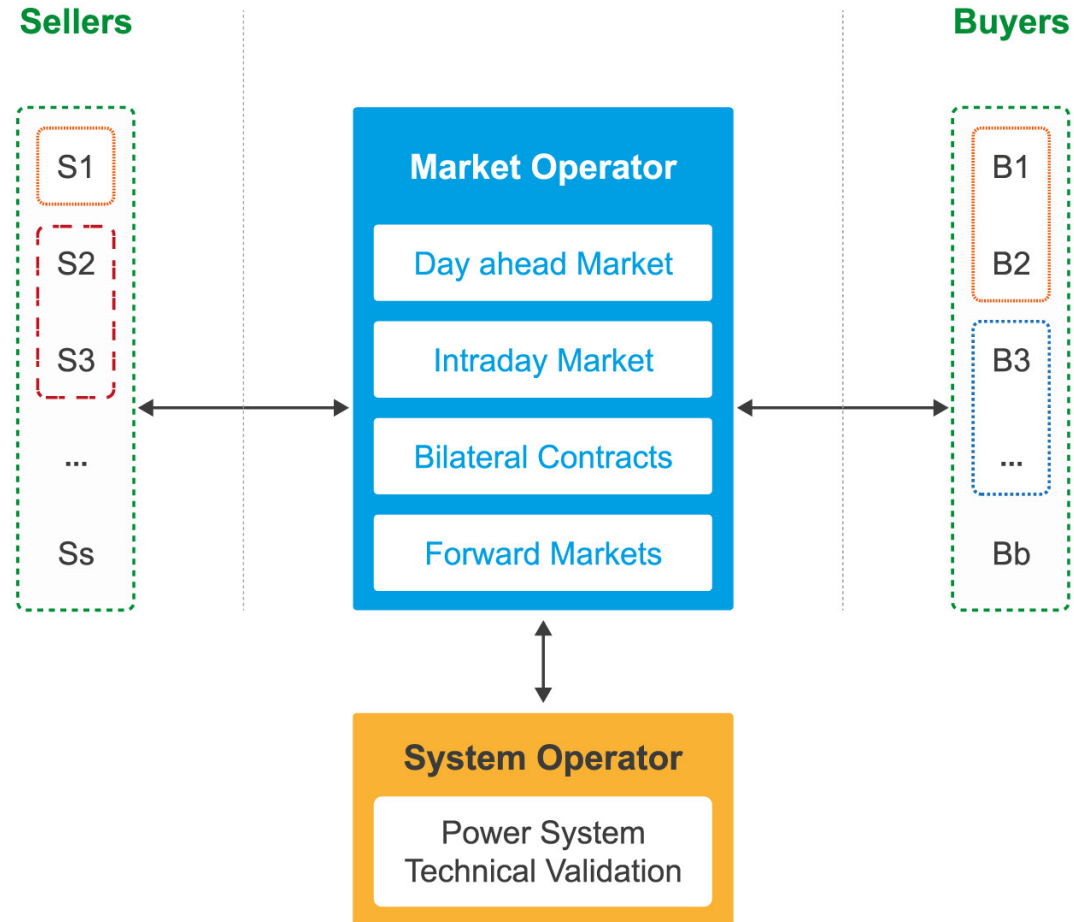


Overview



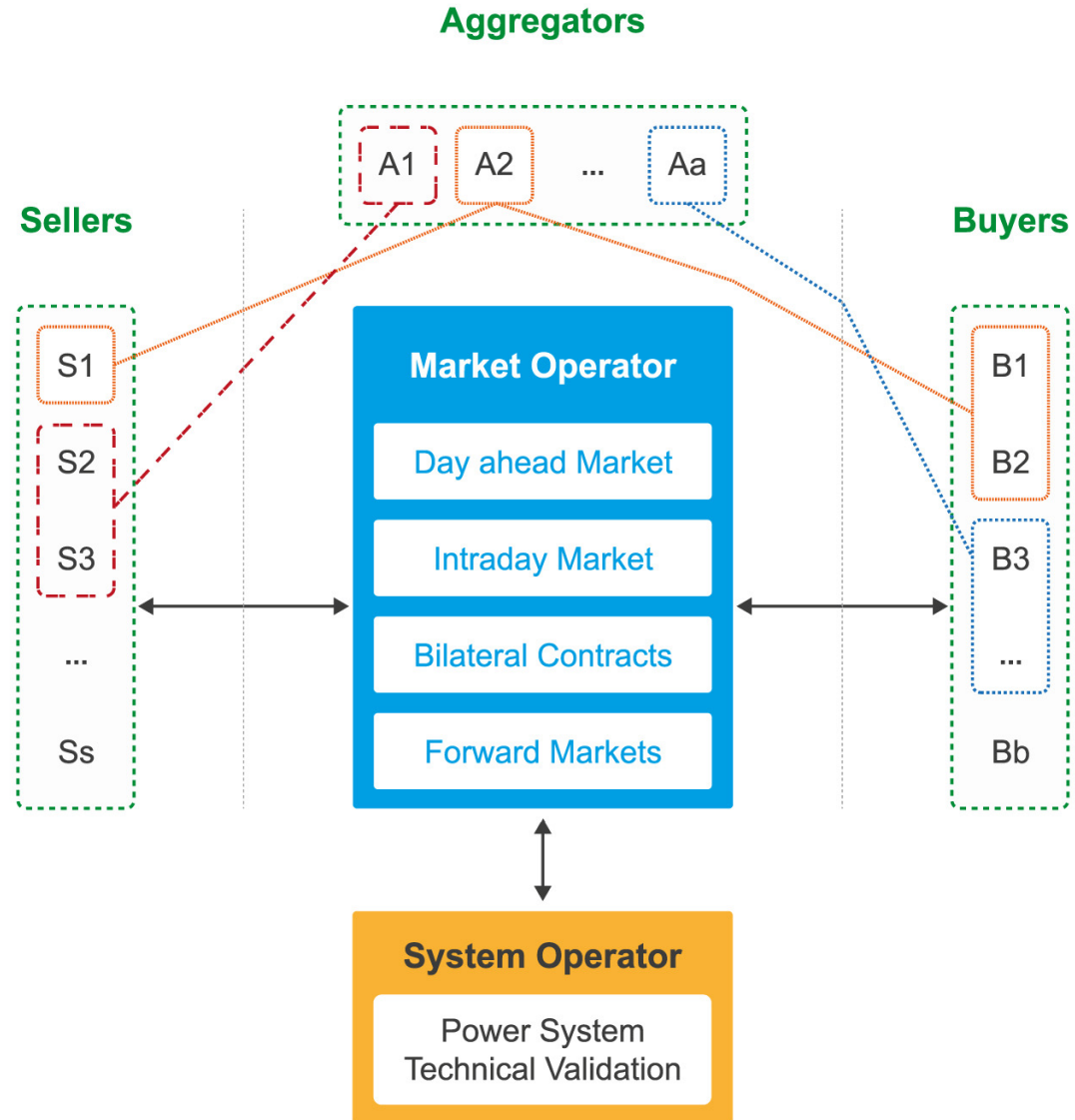


Overview



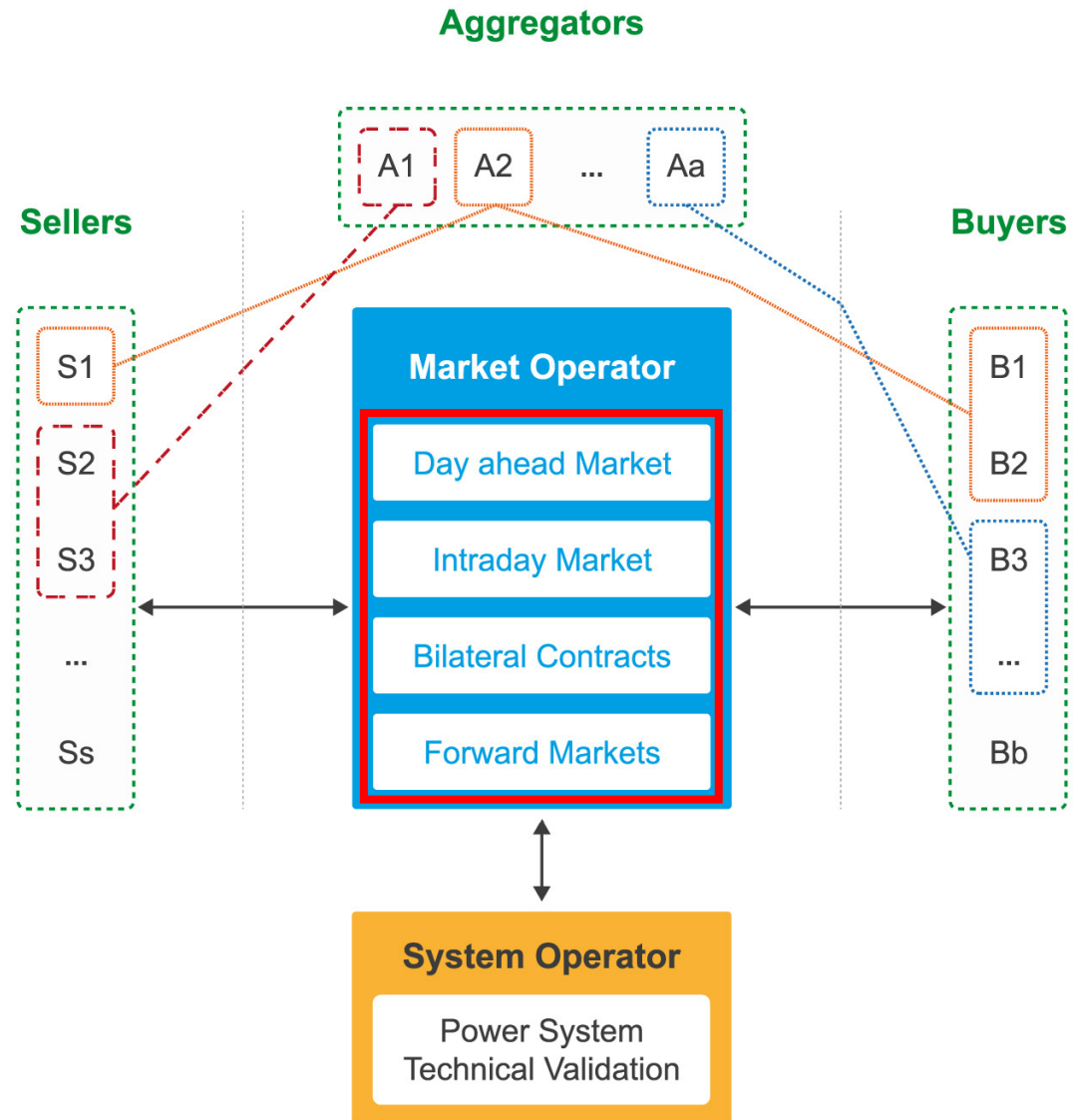


Overview





Overview





Overview





Overview

MIBEL

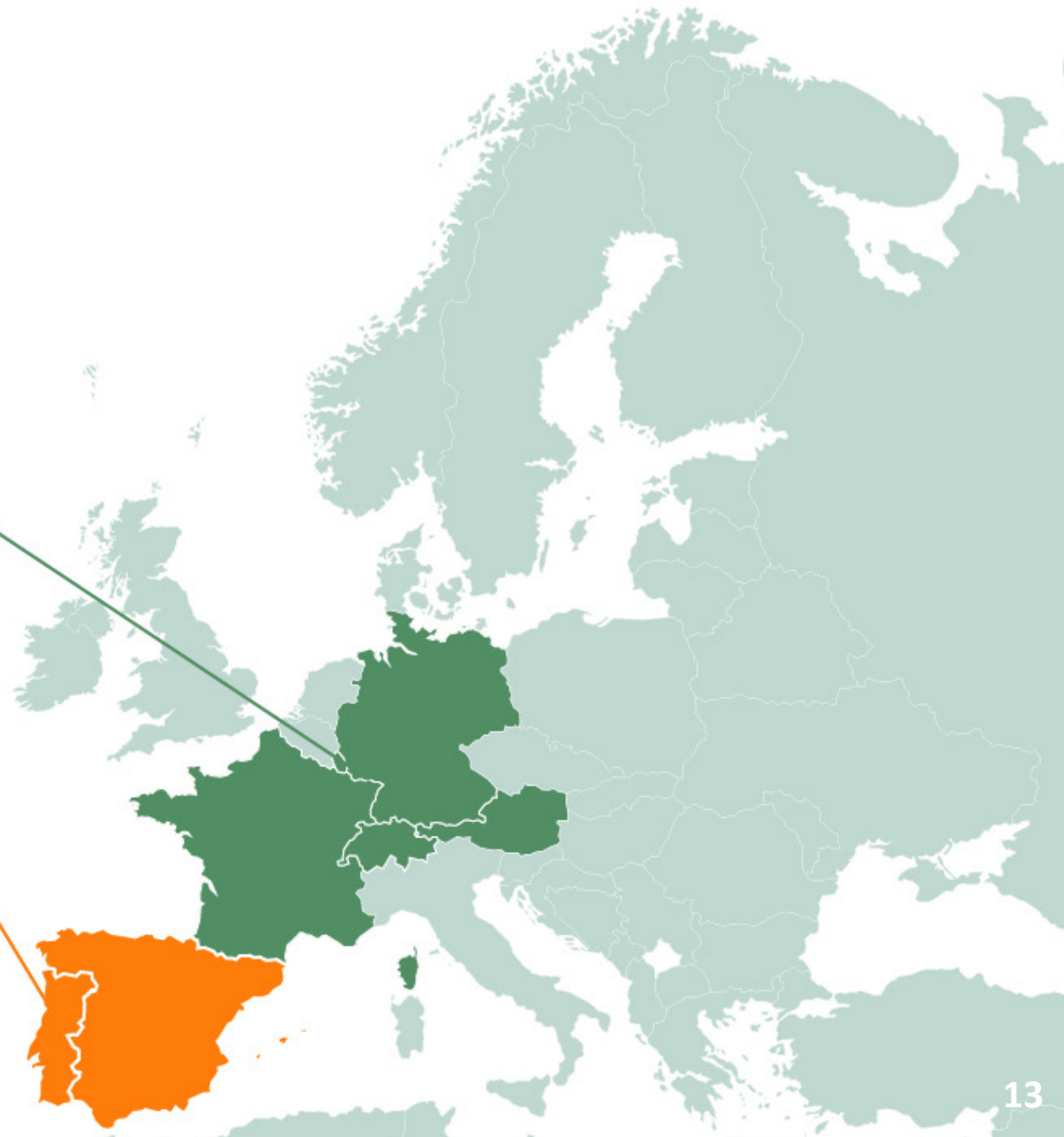




Overview

EPEX

MIBEL



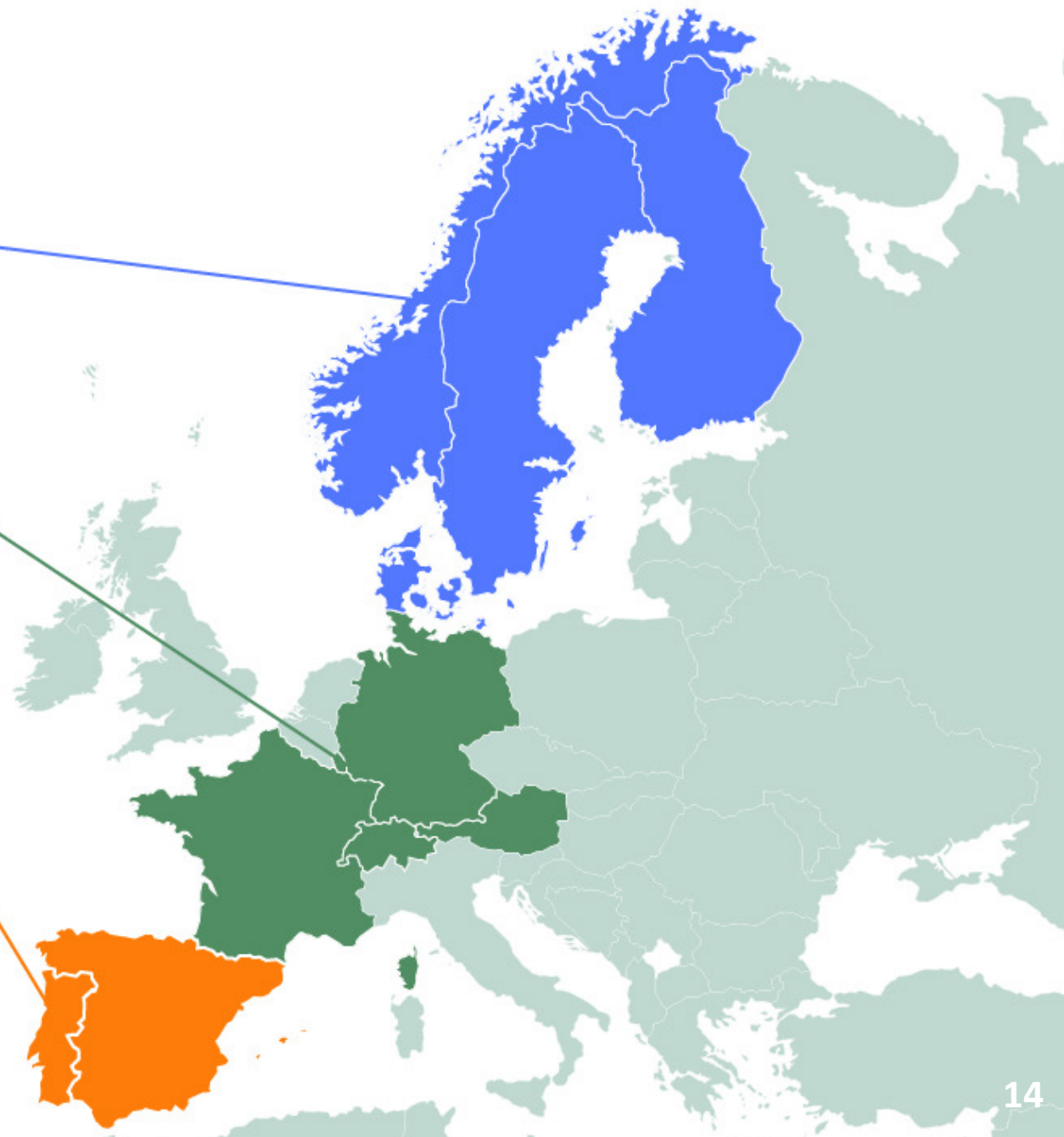


Overview

NORDPOOL

EPEX

MIBEL





Overview

- Double-sided auction-based
- 24 hourly periods
- Day-ahead
 - 1 to 25 energy-price pairs per Bid
 - Complex conditions
- Intraday
 - Buyers can sell
 - Sellers can buy
 - Complex conditions

MIBEL



<https://www.omie.es/en/mercado-de-electricidad>





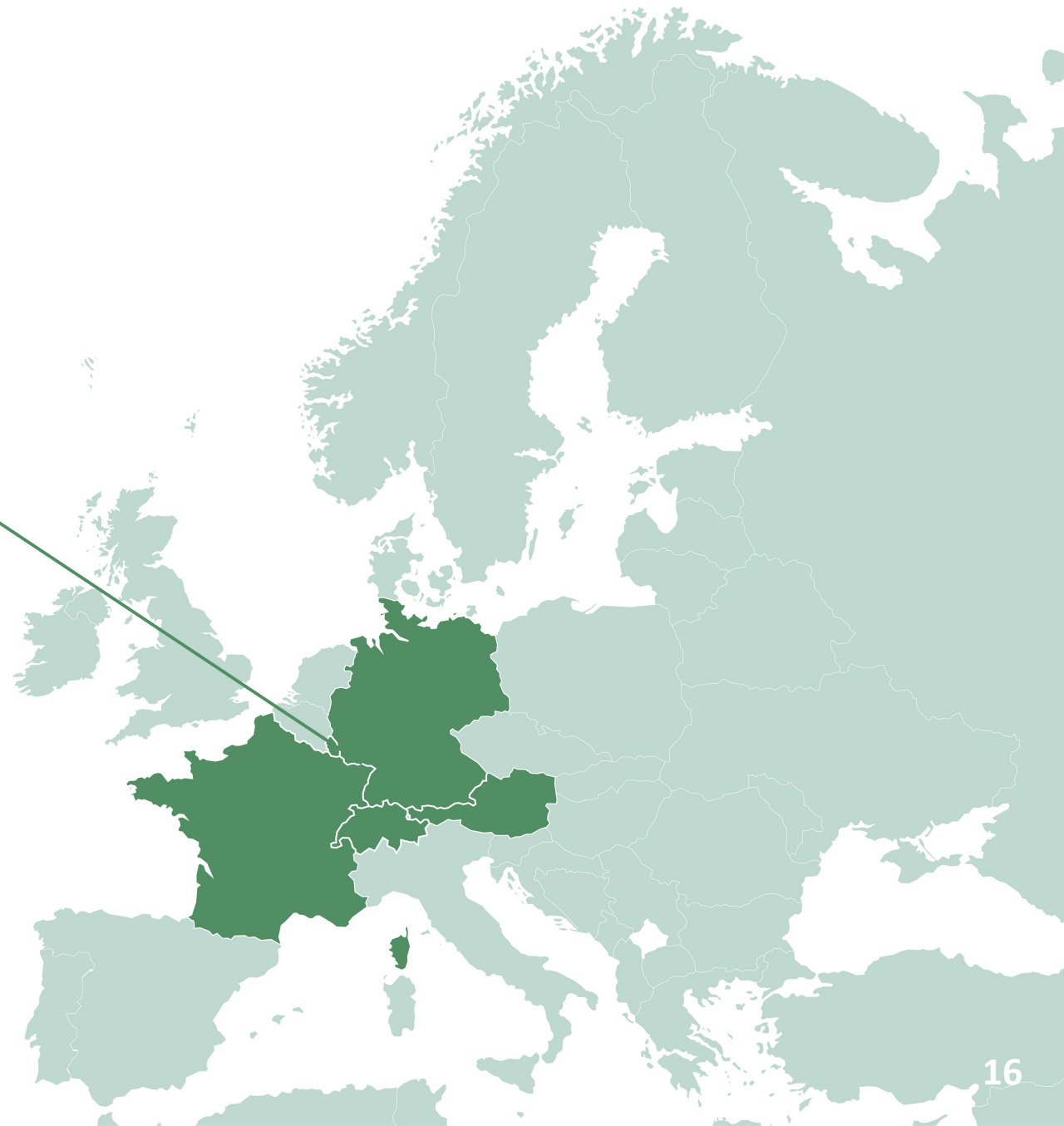
Overview

EPEX

- Double-sided auction-based
- 24 hourly periods
- Day-ahead
 - 1 to 256 energy-price pairs per Bid
 - Block offers



<https://www.epexspot.com/en/basicpowermarket>





Overview

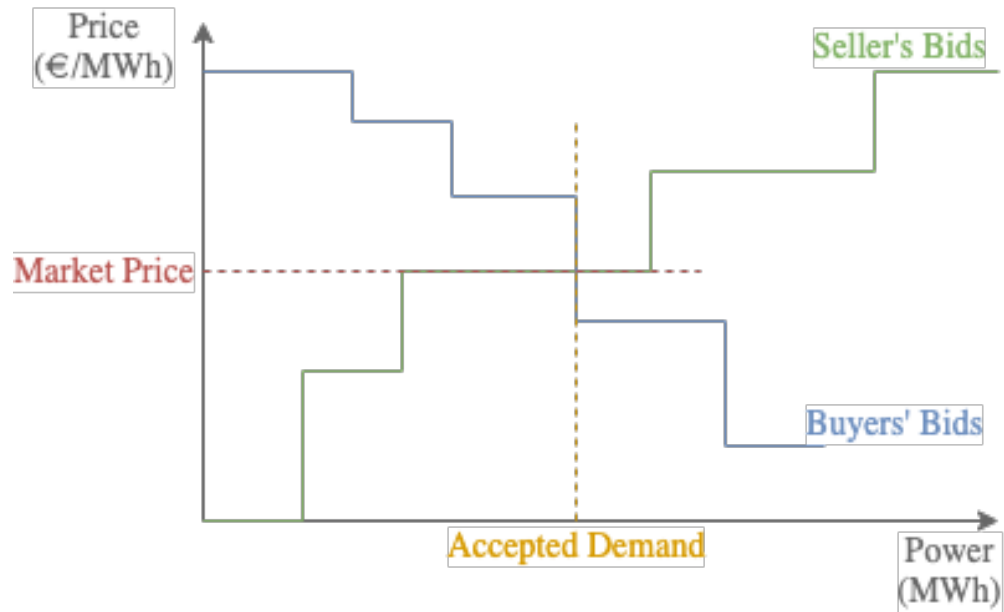
NORDPOOL

- Double-sided auction-based
- 24 hourly periods
- Day-ahead
 - 1 to 64 energy-price pairs per Bid
 - Block orders
 - Flexible orders

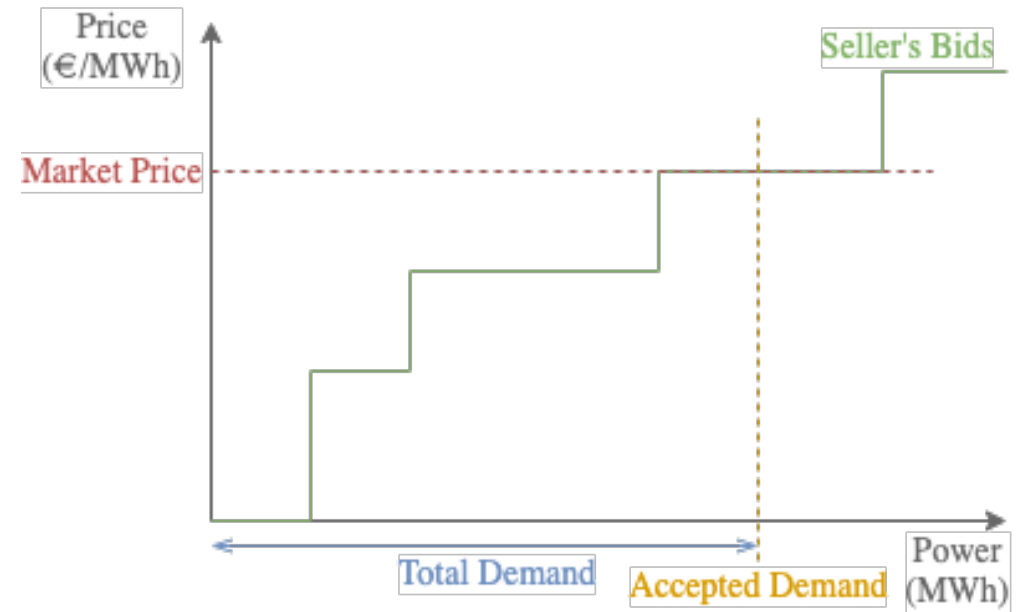




Overview



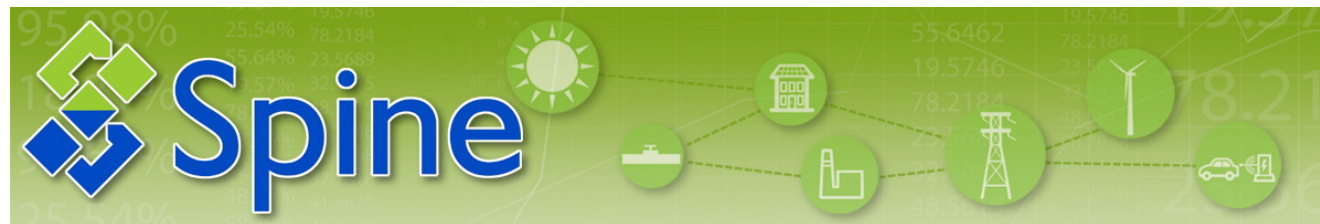
Symmetric pool



Asymmetric pool



ABM integration in Spine Toolbox



http://www.spine-model.org/spine_toolbox.htm
<https://github.com/Spine-project/Spine-Toolbox>





ABM integration in Spine Toolbox



<https://em.gecad.isep.ipp.pt/>

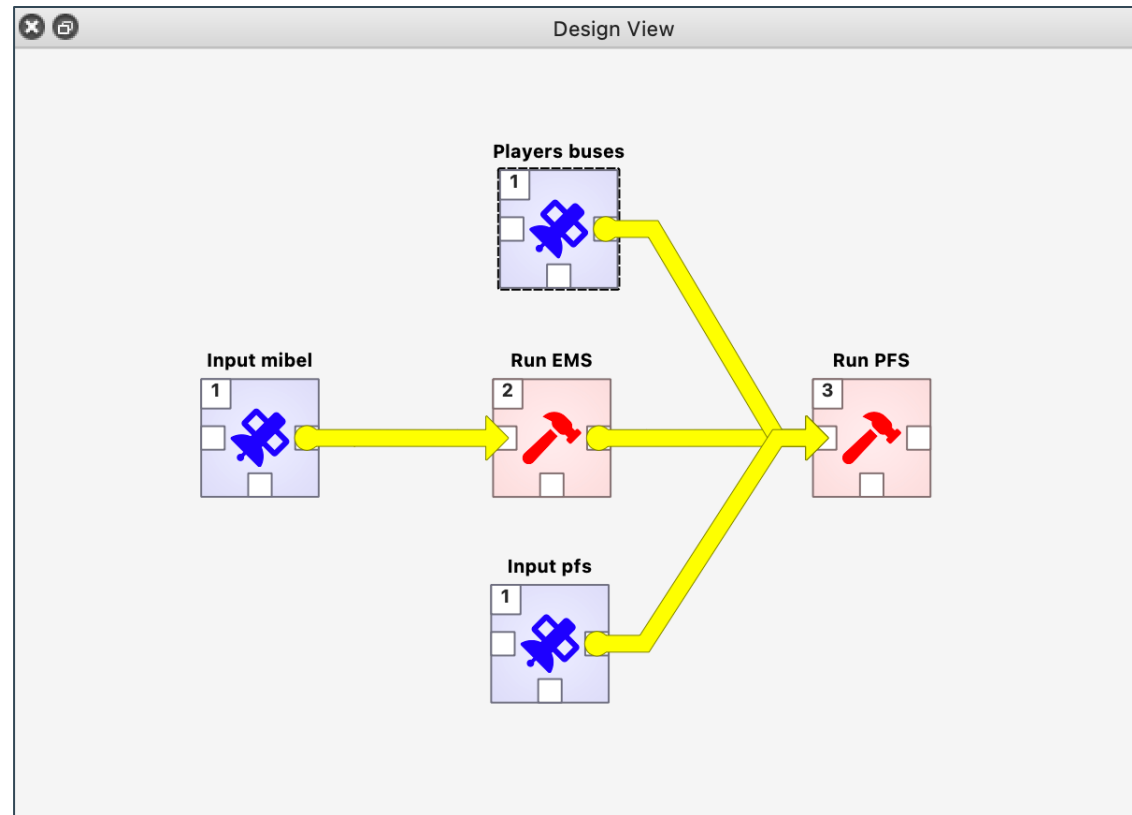


<https://pf.gecad.isep.ipp.pt/>



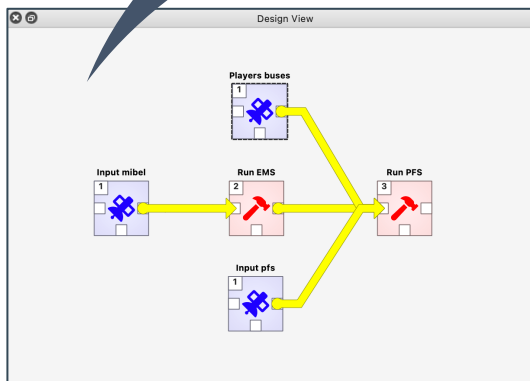


Input





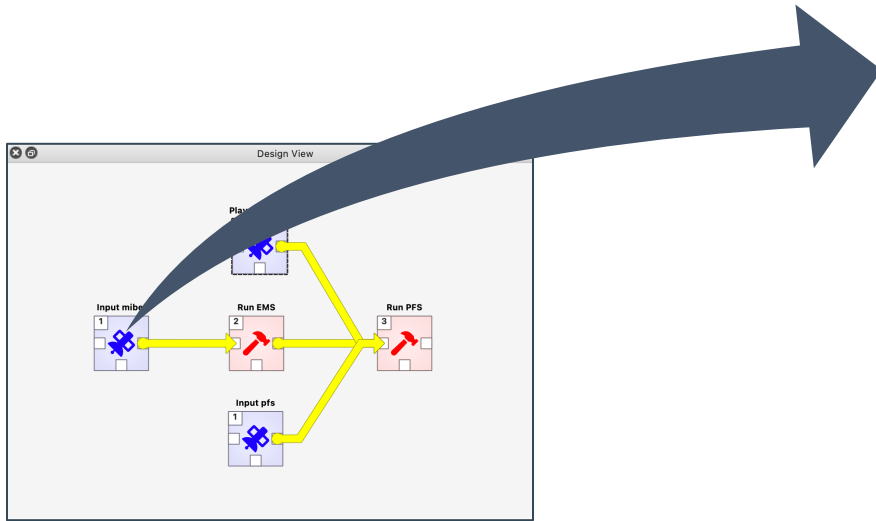
Input



MIBEL	EPEX	Nord Pool
<pre>{ "electricityMarket": { "marketType": "DAY_AHEAD", "sessionID": "1", "numberOfPeriods": 24, "numberOfOffersPerBid": 1, "playersBids": [{ "playerID": "Player 1", "bids": [{ "period": 1, "transactionType": "SELL", "offers": [{ "price": 25.0, "power": 100.0 }], ... }], ... }], ... 1. "complexConditions": { "indivisibility": true, "chargeGradient": 10.0, "minimumIncome": { "totalIncome": 100.0, "valuePerPowerUnit": 5.0, "scheduledStop": true } } }, ...] } }</pre>	<pre>{ "electricityMarket": { "sessionID": "1", "numberOfPeriods": 24, "numberOfOffersPerBid": 1, "playersBids": [{ "playerID": "Player 1", "bids": [{ "period": 1, "transactionType": "BUY", "offers": [{ "price": 25.0, "power": 100.0 }], ... }], ... }], ... 1. "blockOffers": [{ "power": 100.0, "price": 25.0, "startPeriod": 1, "endPeriod": 3, "transactionType": "SELL" }], ... } }</pre>	<pre>{ "electricityMarket": { "sessionID": "1", "numberOfPeriods": 24, "numberOfOffersPerBid": 2, "playersBids": [{ "playerID": "Player 1", "bids": [{ "period": 1, "transactionType": "BUY", "offers": [{ "price": 20.0, "power": 100.0 }], ... }], ... }], ... 1. "blockOrders": [{ "power": 100.0, "price": 25.0, "startPeriod": 1, "endPeriod": 3, "transactionType": "BUY" }], ...], "flexibleOrders": [{ "price": 25.0, "power": 25.0, "transactionType": "SELL" }], ... } }</pre>



Input



Asymmetrical Pool

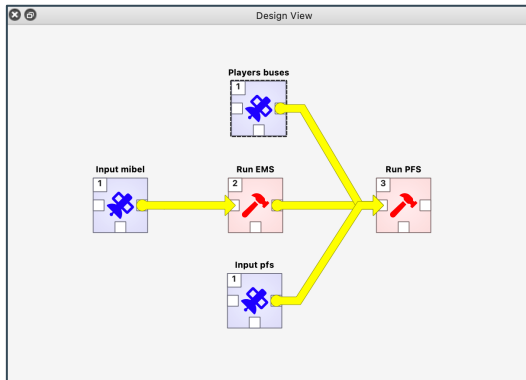
```
{ "demandBids": [  
  {  
    "offerUUID": "Player1Period1",  
    "energy": 0.0621,  
    "instant": 1493641594783  
  }, ...  
],  
  "supplyBids": [  
    {  
      "offerUUID": "Player9Period1",  
      "energy": 1.987,  
      "price": 0.0998,  
      "instant": 1493642533688  
    }, ...  
  ]  
}
```

Symmetrical Pool

```
{ "demandBids": [  
  {  
    "offerUUID": "Player1Period1",  
    "energy": 0.0621,  
    "price": 0.1827,  
    "instant": 1493641594783  
  }, ...  
],  
  "supplyBids": [  
    {  
      "offerUUID": "Player9Period1",  
      "energy": 1.987,  
      "price": 0.0998,  
      "instant": 1493642533688  
    }, ...  
  ]  
}
```



Input

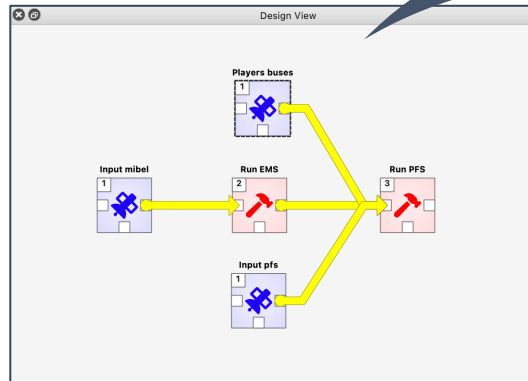


Power Flow

```
{
  "network": {
    "name": "Spine 1",
    "elements": {
      "buses": [
        {
          "id": 0,
          "busName": "bus 1",
          "voltage": 12
        },
        ...
      ],
      "lines": [
        {
          "id": 6,
          "name": "line 1",
          "initialBus": 0,
          "finalBus": 1,
          "length": 21,
          "lineCapacitance": 1.5,
          "lineReactance": 1.4,
          "lineResistance": 1.4,
          "zeroSequenceLineCapacitance": 1.1,
          "zeroSequenceLineReactance": 1.2,
          "zeroSequenceLineResistance": 1.3,
          "maximumThermal": 11
        },
        ...
      ],
      "externalGrids": [
        {
          "id": 10,
          "name": "external grid 1",
          "bus": 1,
          "controllable": true,
          "degree": 20,
          "inService": true,
          "maxActivePower": 100,
          "maxReactivePower": 100,
          "maxRXRatio": 100,
          "maxShortCircuitApparentPower": 100,
          "minActivePower": 100,
          "minReactivePower": 100,
          "minRXRatio": 100,
          "minShortCircuitApparentPower": 100,
          "voltage": 100,
          "zeroSequenceMaxRXRatio": 100,
          "zeroSequenceMaxX0XRatio": 100
        }
      ]
    }
  },
  "powerflow": {
    "balancedAC": {},
    "resultType": "json"
  }
}
```




Input

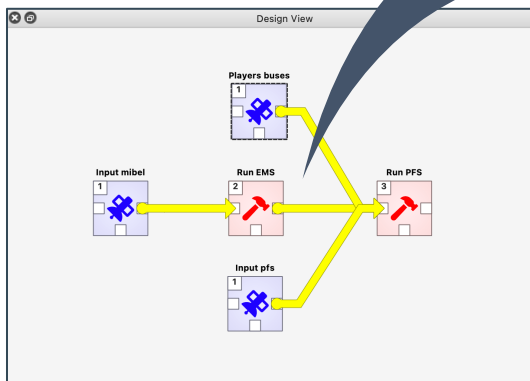


```
Players Busses Mappings
{
  "playersBuses": [
    {
      "player": "Player 1",
      "bus": 0
    }, ...
  ]
}
```





Output



Electricity Market Session Output

```

{"status": "ok",
 "message": {
  "market": "MIBEL",
  "session": {
    "totalDemandByPeriodOffers": 4700.0,
    "totalSupplySatisfied": 4600.0,
    "session": 1,
    "socialWelfare": 2500.0,
    "totalSupplyByPeriodOffers": 4600.0,
    "totalSupply": 4600.0,
    "playersResult": [{
      "playerPeriodsResult": [{
        "transactionType": "buying",
        "costs": 2500.0,
        "period": 1,
        "marketPrice": 25.0,
        "satisfied": 100.0,
        "demand": 100.0
      }, {
        "removalJustification": "Player 1 removed from exchange because of indivisibility condition!",
        "period": 2
      }, ... ]
    }],
    "totalDemandSupply": 2400.0,
    "totalCostsProfits": 60000.0,
    "totalSatisfied": 2400.0,
    "totalCostsProfitsByPeriodOffers": 60000.0,
    "demandSupplyByPeriodOffers": 2400.0,
    "playerId": "Player 1"
  }, ... ],
  "consumptionSurplus": 2500.0,
  "demandSatisfiedByPeriodOffers": 4600.0,
  "averageMarketPrice": 25.0,
  "totalDemand": 4700.0,
  "totalDemandSatisfied": 4600.0,
  "generationSurplus": 0,
  "supplySatisfiedByPeriodOffers": 4600.0,
  "periods": [{
    "period": 1,
    "totalDemandByPeriodOffers": 150.0,
    "totalDemand": 150.0,
    "totalSupplySatisfied": 100.0,
    "socialWelfare": 0,
    "totalSupplyByPeriodOffers": 100.0,
    "totalSupply": 100.0,
    "totalDemandSatisfied": 100.0,
    "generationSurplus": 0,
    "supplySatisfiedByPeriodOffers": 100.0,
    "consumptionSurplus": 0,
    "demandSatisfiedByPeriodOffers": 100.0
  }, ... ]
}, ... ]
},
 "marketType": "SPOT"
}}

```

Period Pool Output

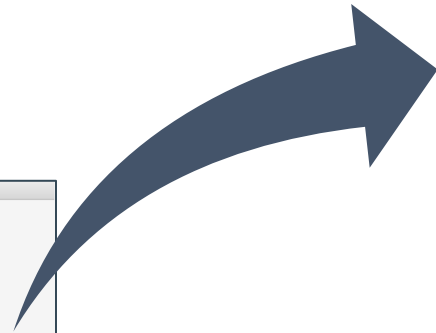
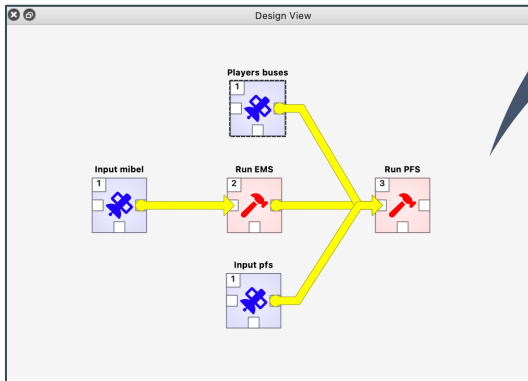
```

{"status": "ok",
 "message": {
  "marketPrice": 0.1745,
  "hasTrading": true,
  "tradingResults": [
    {
      "offerUUID": "Player1Period1",
      "wasTraded": true,
      "transactionType": "buy",
      "energy": 0.0621,
      "tradedEnergy": 0.0621
    }, ...
  ],
  "totalDemand": 20.4421,
  "totalSupply": 2.7837,
  "poolResult": "TRADING",
  "totalTradedEnergy": 2.7837,
  "lastTradedSupplyOffer": "Player5Period1",
  "lastTradedDemandOffer": "Player7Period1"
}
}

```



Output



Power Flow Output

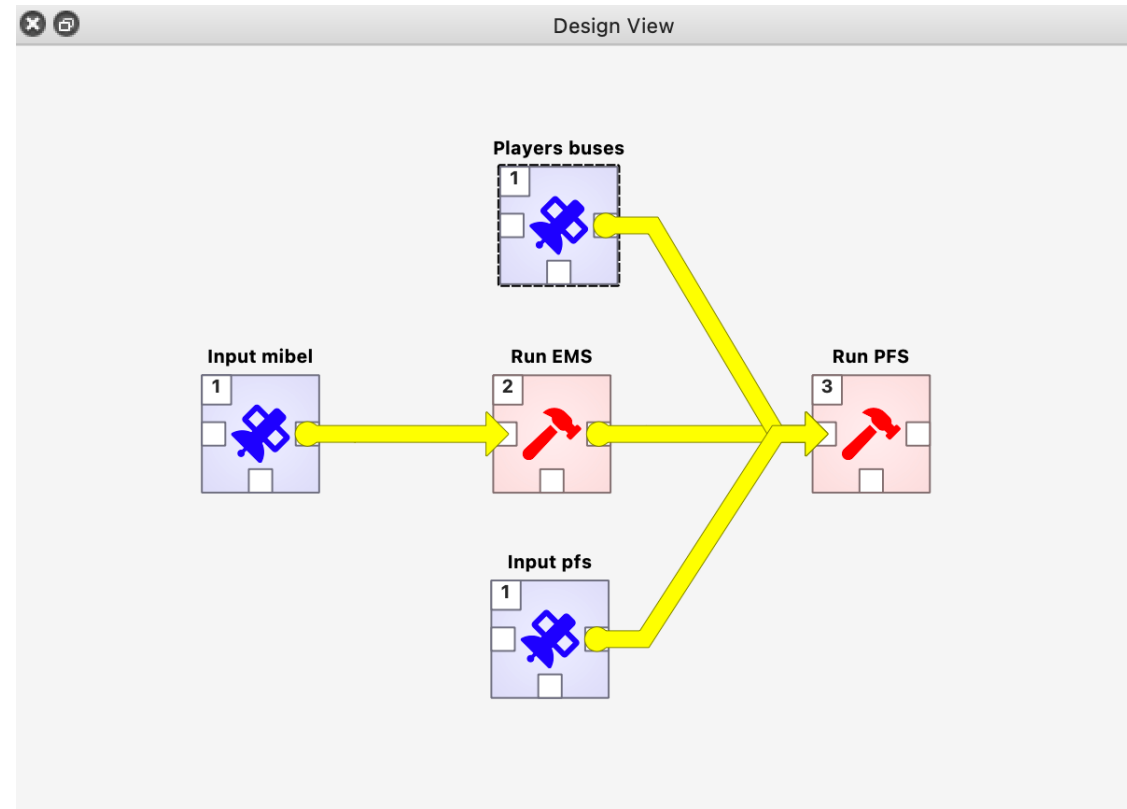
```
{ "results": [ {  
  "period": 1,  
  "result": {  
    "results": {  
      "buses": {  
        "vm_pu": { "0": 1.0, ... },  
        "va_degree": { "0": 0.0, ... },  
        "p_mw": { "0": 242.4489795918, ... },  
        "q_mvar": { "0": 242.4496921051, ... }  
      },  
      "lines": {  
        "p_from_mw": { "6": -242.4489795918, ... },  
        "q_from_mvar": { "6": -242.4496921051, ... },  
        "p_to_mw": { "6": 24244.8979591837, ... },  
        "q_to_mvar": { "6": 24237.7728270453, ... },  
        "pl_mw": { "6": 24002.4489795918, ... },  
        "ql_mvar": { "6": 23995.3231349403, ... },  
        "i_from_ka": { "6": 16.4965878141, ... },  
        "i_to_ka": { "6": 15.2253597533, ... },  
        "i_ka": { "6": 16.4965878141, ... },  
        "vm_from_pu": { "6": 1.0, ... },  
        "va_from_degree": { "6": 0.0, ... },  
        "vm_to_pu": { "6": 100.0, ... },  
        "va_to_degree": { "6": 0.0, ... },  
        "loading_percent": { "6": 149.9689801278, ... }  
      },  
      "loads": {  
        "p_mw": { "11": 100.0, ... },  
        "q_mvar": { "11": 0.0, ... }  
      },  
      "externalGrids": {  
        "p_mw": { "0": -142.4489795918, ... },  
        "q_mvar": { "0": -242.4496921051, ... }  
      }, ...  
    }  
  }, ...  
}
```



How to run it



<https://github.com/TradeRES/mascem-demo>










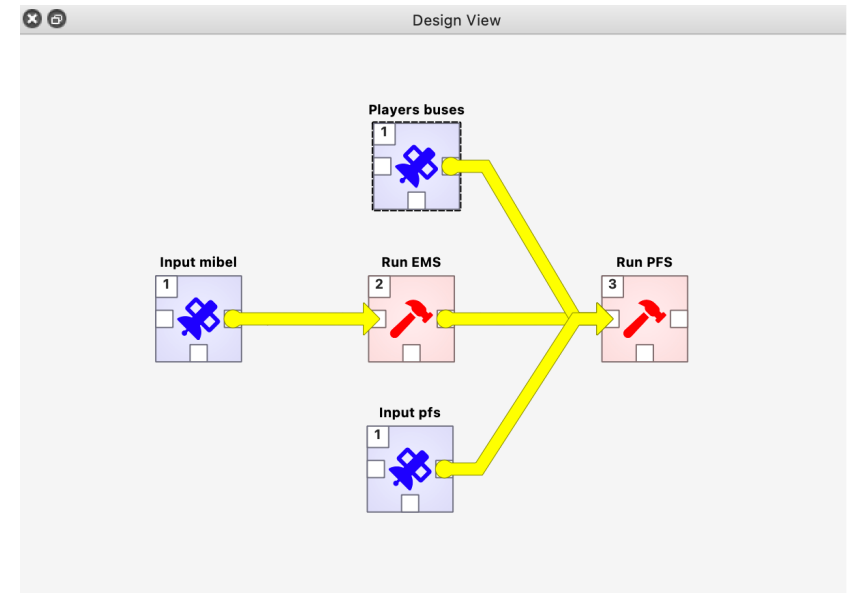


How to run it



<https://github.com/TradeRES/mascem-demo>

 gabrieljsantos Update README.md	4fbce19 on 5 Nov 2021	🕒 3 commits
 .spinetoolbox	MASCEM Demo added	7 months ago
 run-ems	MASCEM Demo added	7 months ago
 run-pfs	MASCEM Demo added	7 months ago
 .gitignore	Initial commit	7 months ago
 README.md	Update README.md	7 months ago
 UNLICENSE	Initial commit	7 months ago



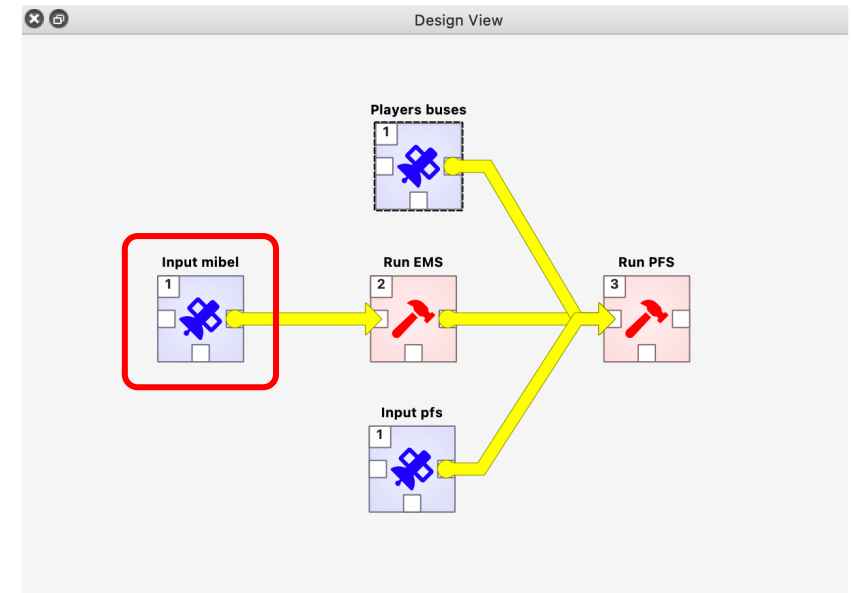









How to run it

<https://github.com/TradeRES/mascem-demo>

Input mibel

- Schema:
<https://raw.githubusercontent.com/TradeRES/mascem-demo/main/run-ems/resources/generalSchema.json>
- Example:
https://github.com/TradeRES/mascem-demo/tree/main/.spinetoolbox/items/input_mibel



 gabrieljsantos Update README.md
 .spinetoolbox
 run-ems
 run-pfs
 .gitignore
 README.md
 UNLICENSE

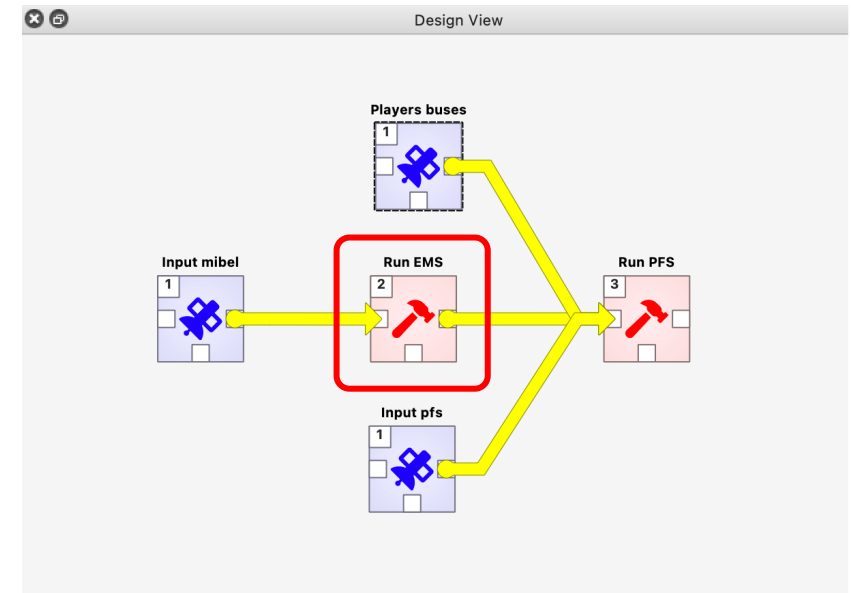


How to run it

<https://github.com/TradeRES/mascem-demo>

Run EMS

- Schema:
<https://em.gecad.isep.ipp.pt/api/v1/mibel/schema>
- Output example:
https://github.com/TradeRES/mascem-demo/tree/main/.spinetoolbox/items/run_ems/output





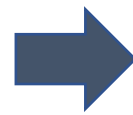
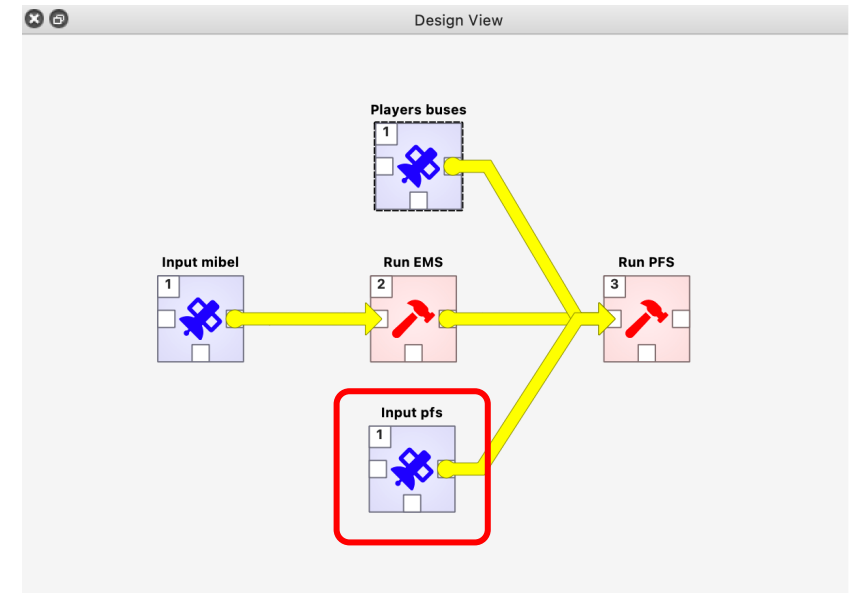
How to run it










<https://github.com/TradeRES/mascem-demo>

Input pfs

- Schema:
https://github.com/TradeRES/mascem-demo/blob/main/run-pfs/resources/pfs_schema.json
- Example:
https://github.com/TradeRES/mascem-demo/tree/main/.spinetoolbox/items/input_pfs



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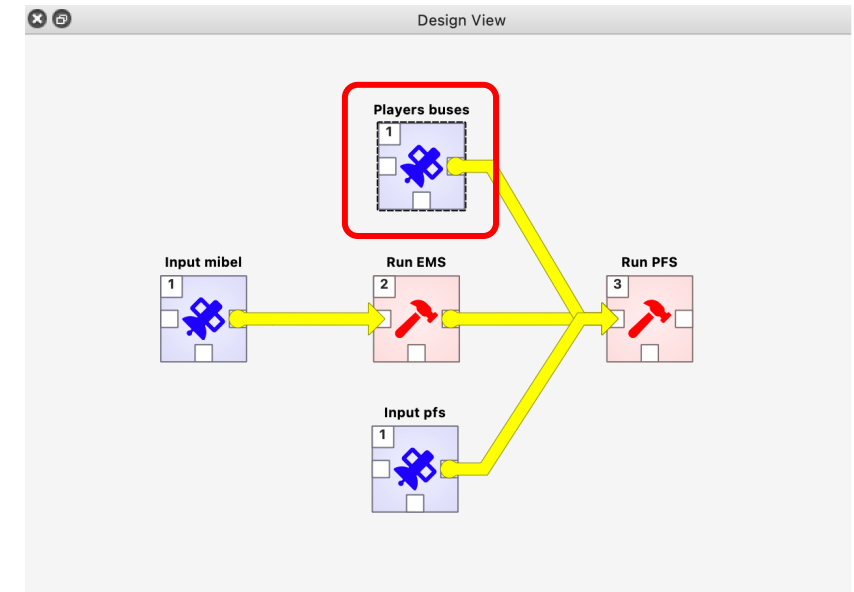
How to run it










<https://github.com/TradeRES/mascem-demo>

Player buses

- Schema:
https://raw.githubusercontent.com/TradeRES/mascem-demo/main/run-pfs/resources/pbus_schema.json
- Example:
https://github.com/TradeRES/mascem-demo/blob/main/.spinetoolbox/items/players_buses



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 run-ems
 run-pfs
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 README.md
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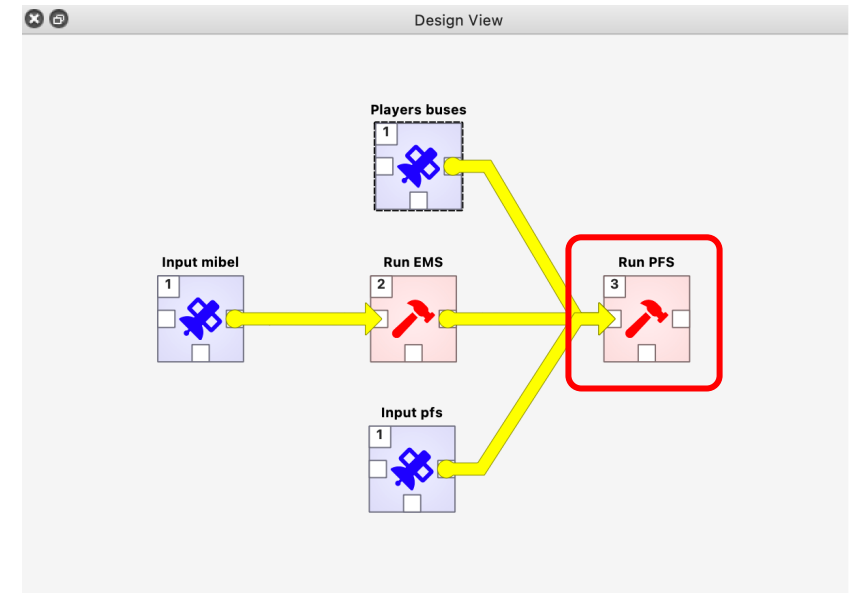
How to run it



<https://github.com/TradeRES/mascem-demo>

Run PFS

- Schema:
<https://pf.gecad.isep.ipp.pt/api/v1/networks/schemas/generalSchema>
- Output example:
https://github.com/TradeRES/mascem-demo/tree/main/.spinetoolbox/items/run_pfs/output



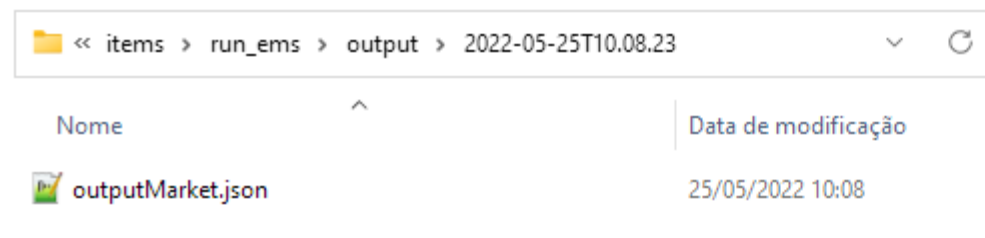


How to run it

<https://github.com/TradeRES/mascem-demo>

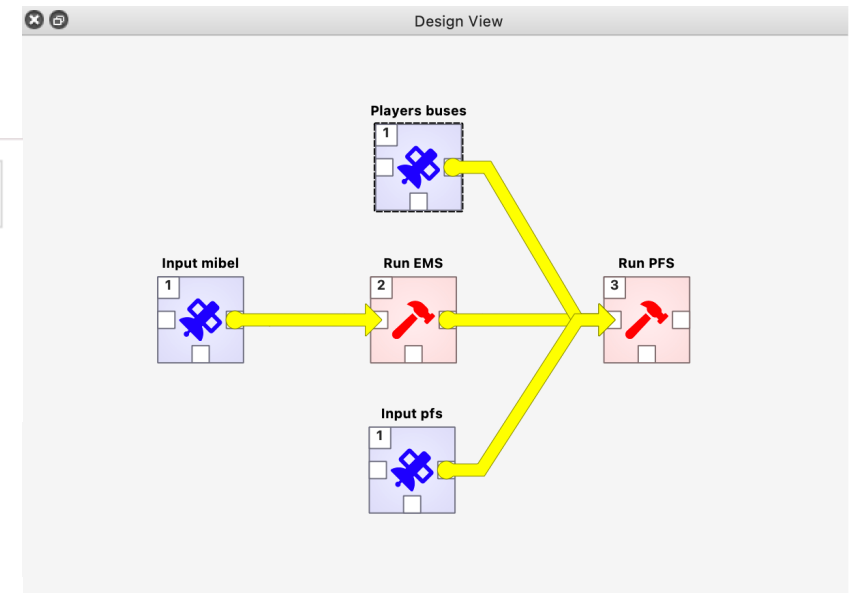
Run EMS

- `./run-ems/output/YYYY-MM-DDTHH.mm.ss/`



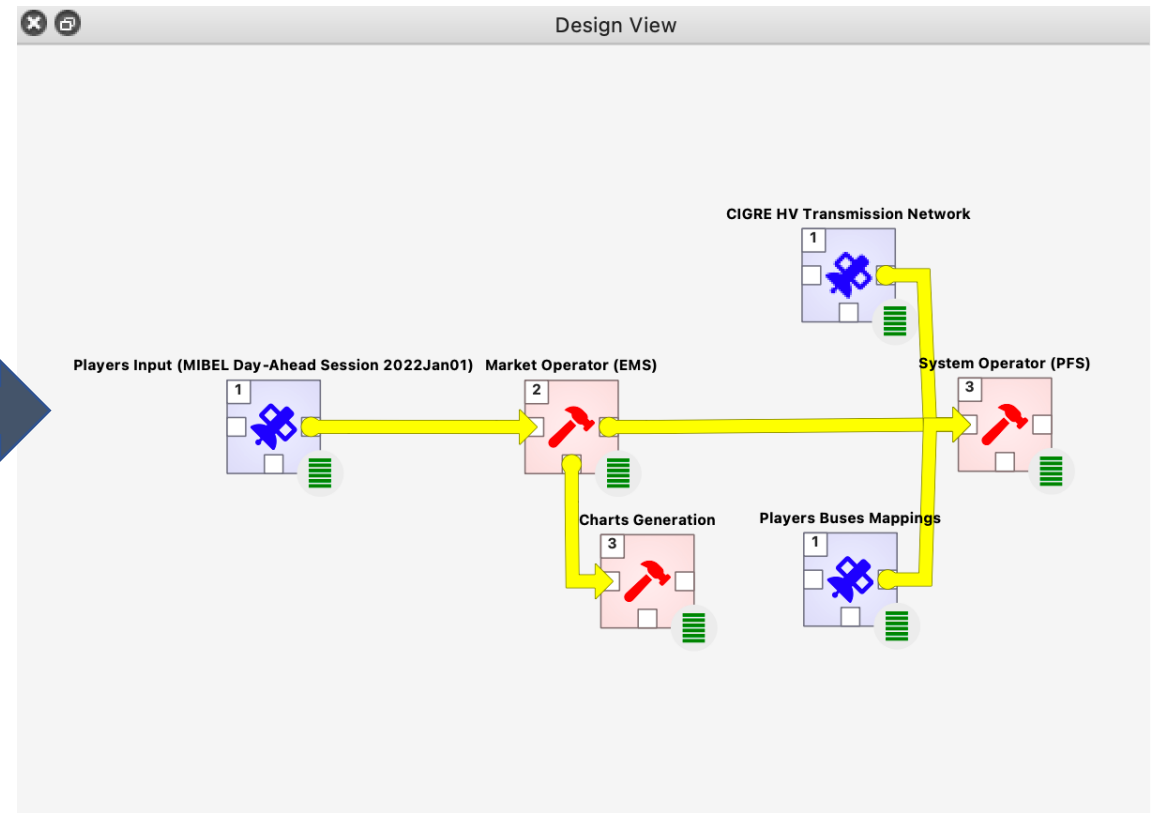
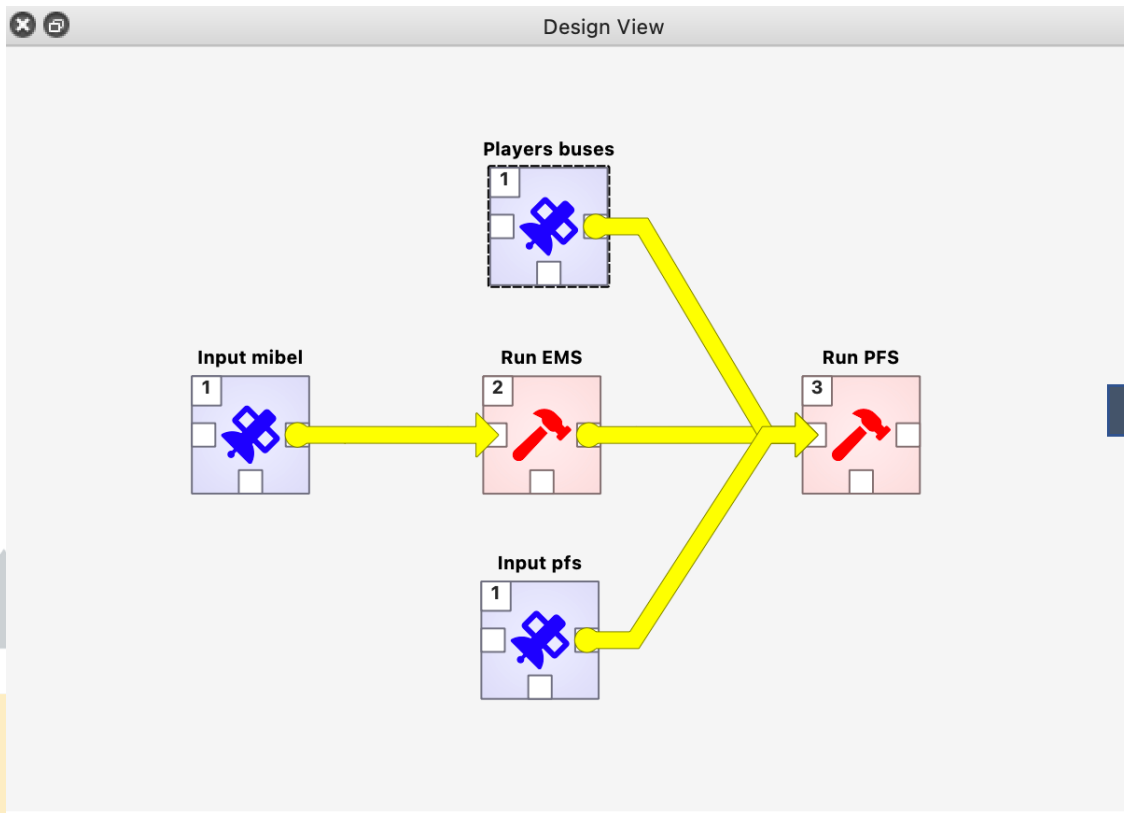
Run PFS

- `./run-pfs/output/YYYY-MM-DDTHH.mm.ss/`





Live demonstration

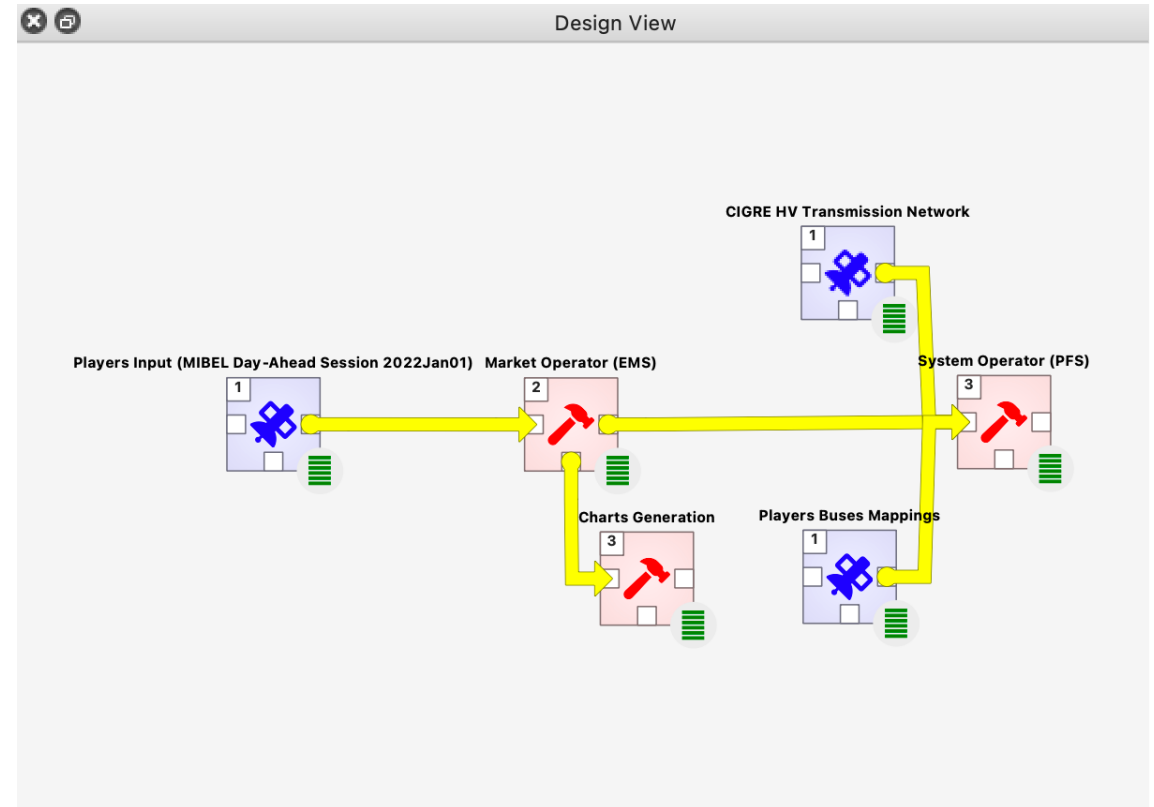




Live demonstration

Scenario

- MIBEL day-ahead market
- 5 buyers
- 3 sellers
- Based on real data from
 - <https://www.omie.es/es/file-access-list>



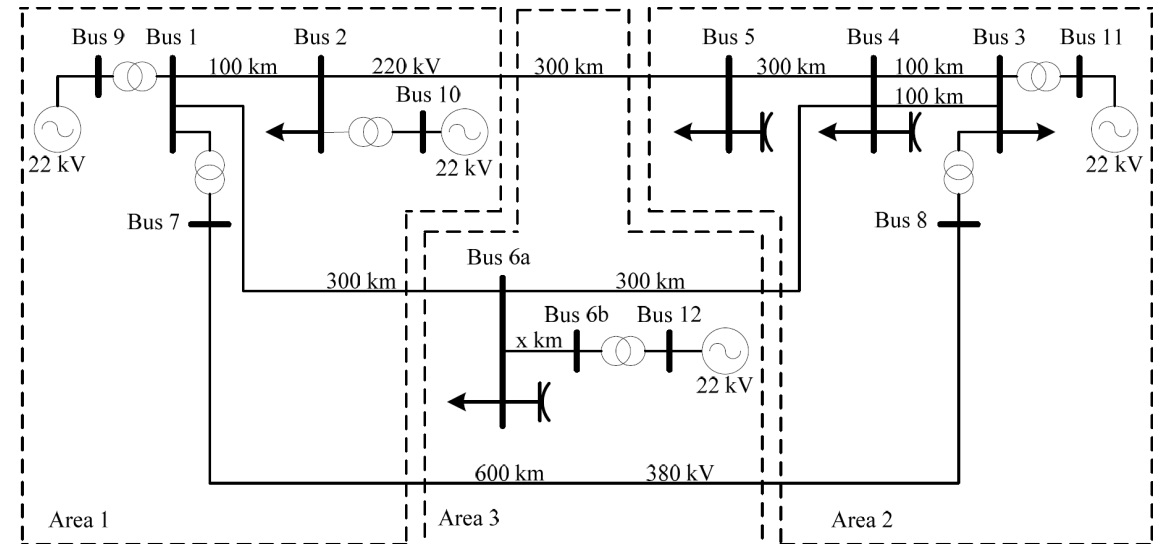


Live demonstration

Scenario

- CIGRE HV Transmission Network

- 13 buses
- 9 lines
- 5 loads (\Leftrightarrow buyers)
- 3 generators (\Leftrightarrow sellers)
- 3 shunts
- 6 transformers
- 1 external grid
- <https://doi.org/10.1109/PES.2006.1709447>





Live demonstration

The screenshot displays the Spine Toolbox application window titled "mibel-cigre_hv [Users/g santos/Desktop/mas cem-webinar-demo/mibel-cigre_hv] - Spine Toolbox". The interface includes a menu bar (File, Edit, View, Plugins, Consoles, Help) and a toolbar with various icons and an "Execute" button. The main workspace is divided into several panels:

- Project Panel:** Lists "Data Stores", "Data Connections" (CIGRE HV T..., Players Bus..., Players Inpu...), "Tools" (Charts Gen..., Market Ope..., System Ope...), "Views", "Importers", "Exporters", and "Manipulators".
- Design View:** Shows a workflow diagram for "CIGRE HV Transmission Network". It features nodes for "Players Input (MIBEL Day-Ahead Session 2022Jan01)", "Market Operator (EMS)", "System Operator (PFS)", "Charts Generation", and "Players Buses Mappings". Yellow arrows indicate the flow between these nodes. The "Charts Generation" node is highlighted with a red box.
- Properties Panel:** Contains the text "Select a project item to view its properties".
- Event Log:** Displays a log of events from 09:42:05 on 15-07-2022, including "Project name changed to mibel-cigre_hv", "Loading specifications...", "Loading project items...", "Restoring connections...", "Restoring jumps...", and "Project mibel-cigre_hv is now open".
- Console:** Contains the text "Select and execute a Tool to see its console".



Find out more

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MASCEM

Multi-Agent Simulator of Competitive Electricity Markets

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