TradeRES

New Markets Design & Models for
100% Renewable Power Systems

AMIRIS

Installation, Execution and Market Design Parametrisation

Market Designs in Germany and the EU – Research &Tools Workshop

12th of October 2023, online

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Motivation
Market Modelling with AMIRIS

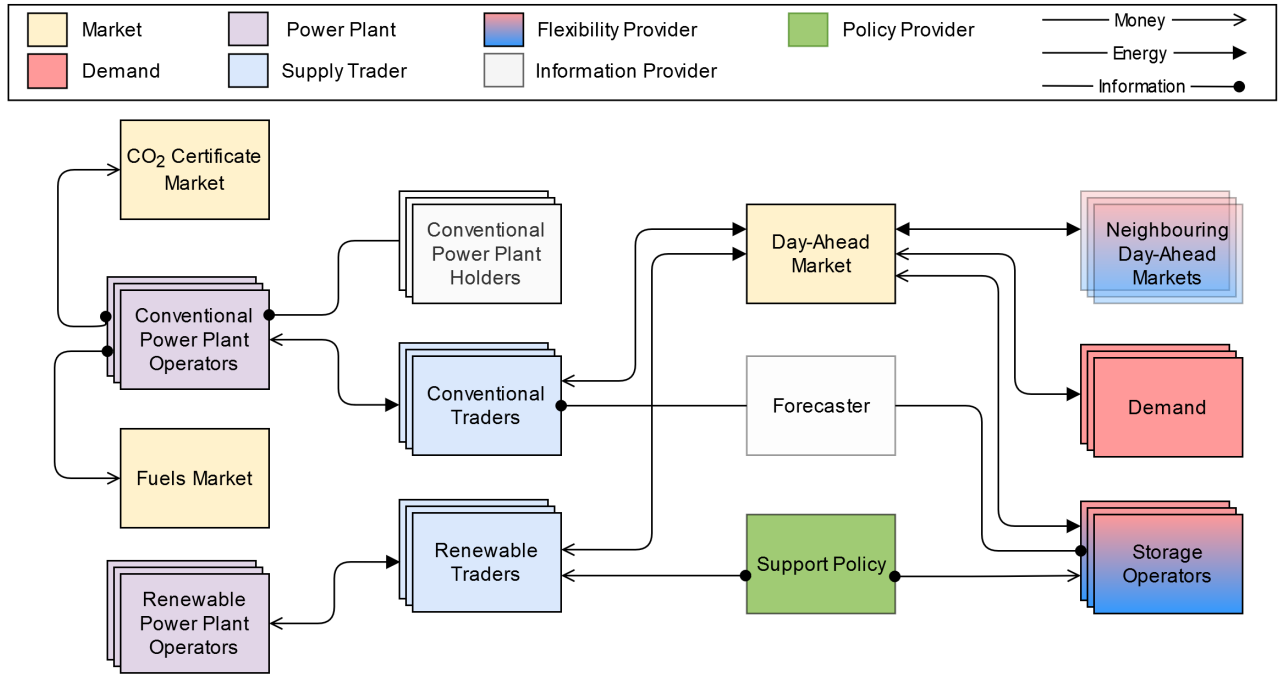
- Simulate trading and operation of power generation plants and flexibility options
- Model business-oriented behaviour under uncertainty
- Temporal resolution: ≤ hourly
- Spatial resolution: market zone(s)

Input

- Power plant park
- RES-E feed in potential
- Demand
- Efficiencies
- Availabilities
- Fuel prices
- CO_2 prices

Output

- Electricity prices
- Plant dispatch, FLH
- Market values
- System costs
- Costs for support instruments
- CO_2 emissions



https://dlr-ve.gitlab.io/esy/amiris/home/

AMIRIS

Agents

AMIRIS
Agent Types

Markets
- Determine prices

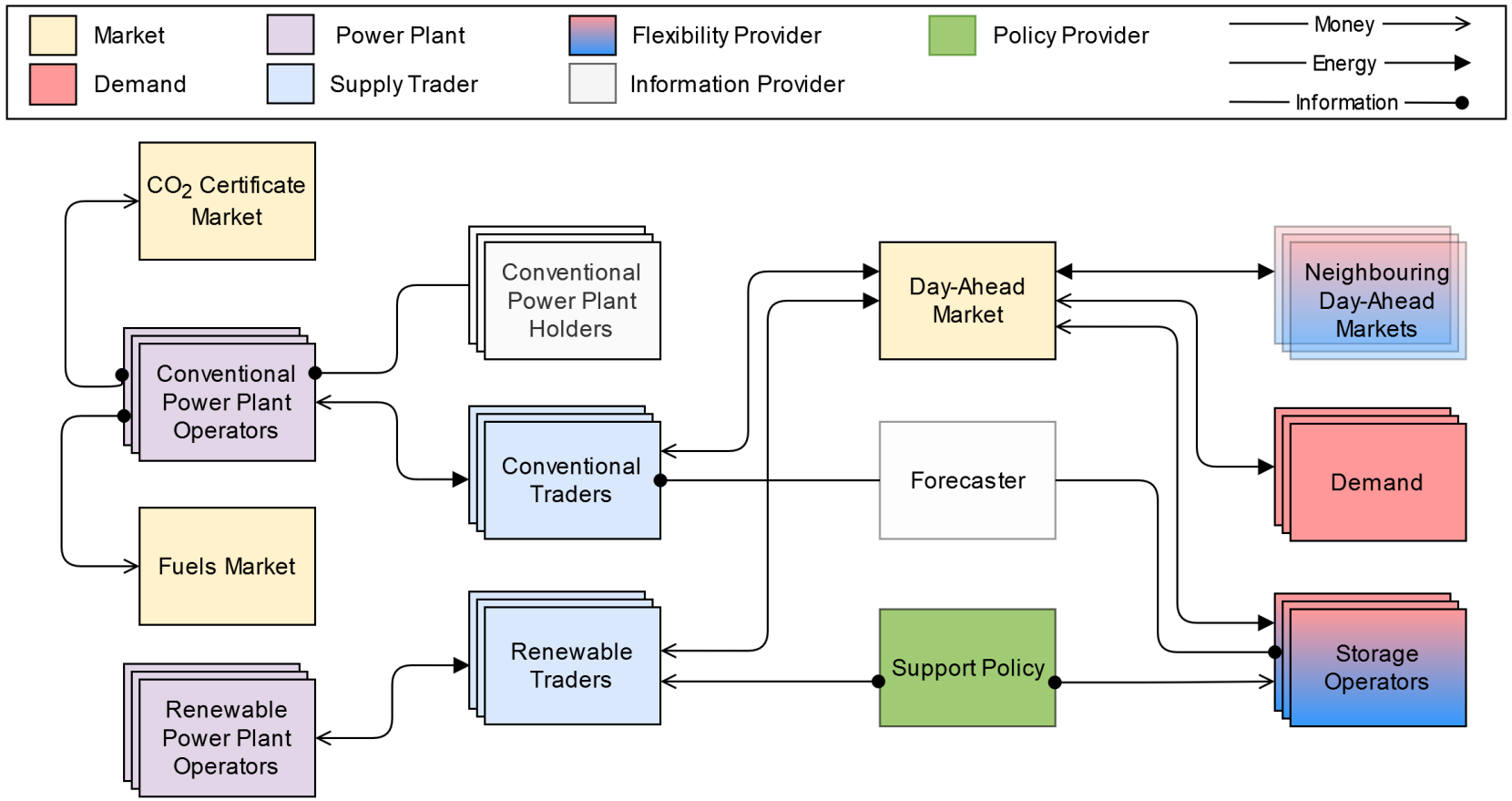
Plant operators
- Control power plants

Traders
- Fulfil marketing strategies

Flexibility providers
- Optimise dispatch

Information provider
- Create forecasts

Policy
- Provide support



AMIRIS

Interactions

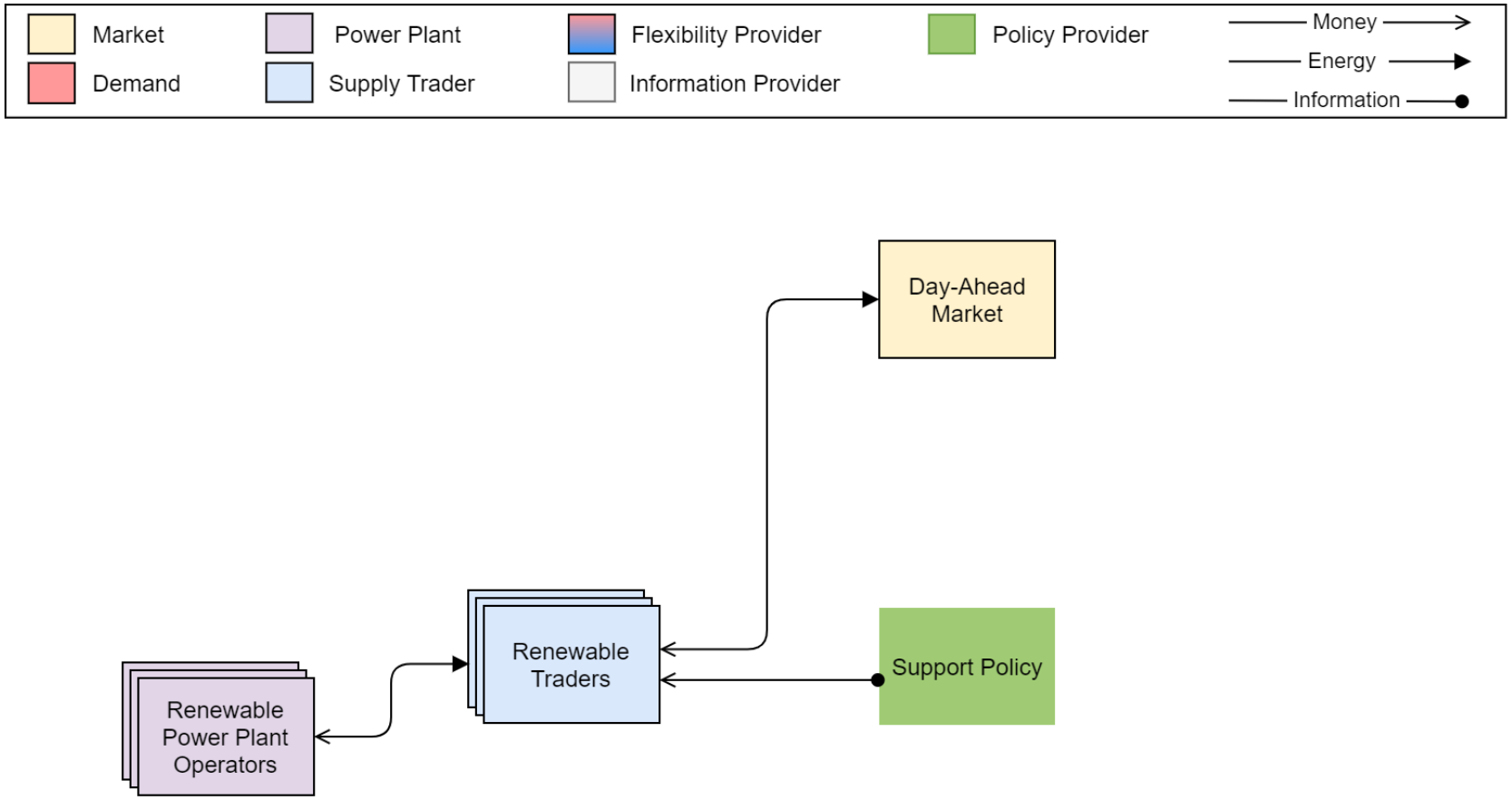
AMIRIS Interactions
Renewables

Power Plant Operator
- Calculate marginal cost
- Dispatch power plants

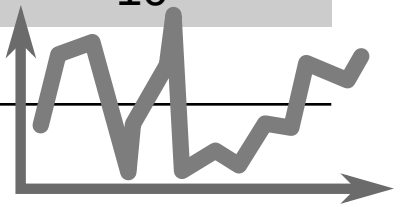
Renewable Trader
- Create bid
- Request support

Support Policy
- Calculate support tariffs
- Provide support funding

Day-Ahead Market
- Clears Market



Renewables
Power Plant Operator

Input parameter	Value
EnergyCarrier	WindOn
InstalledPowerInMW	1000
OpexVarInEURperMWH	10
YieldProfile	

Actions

1) *Calculate power potential*
2) *Calculate marginal costs*
3) *Send marginals to Trader*
4) *Receive assignment*
5) *Dispatch plants*

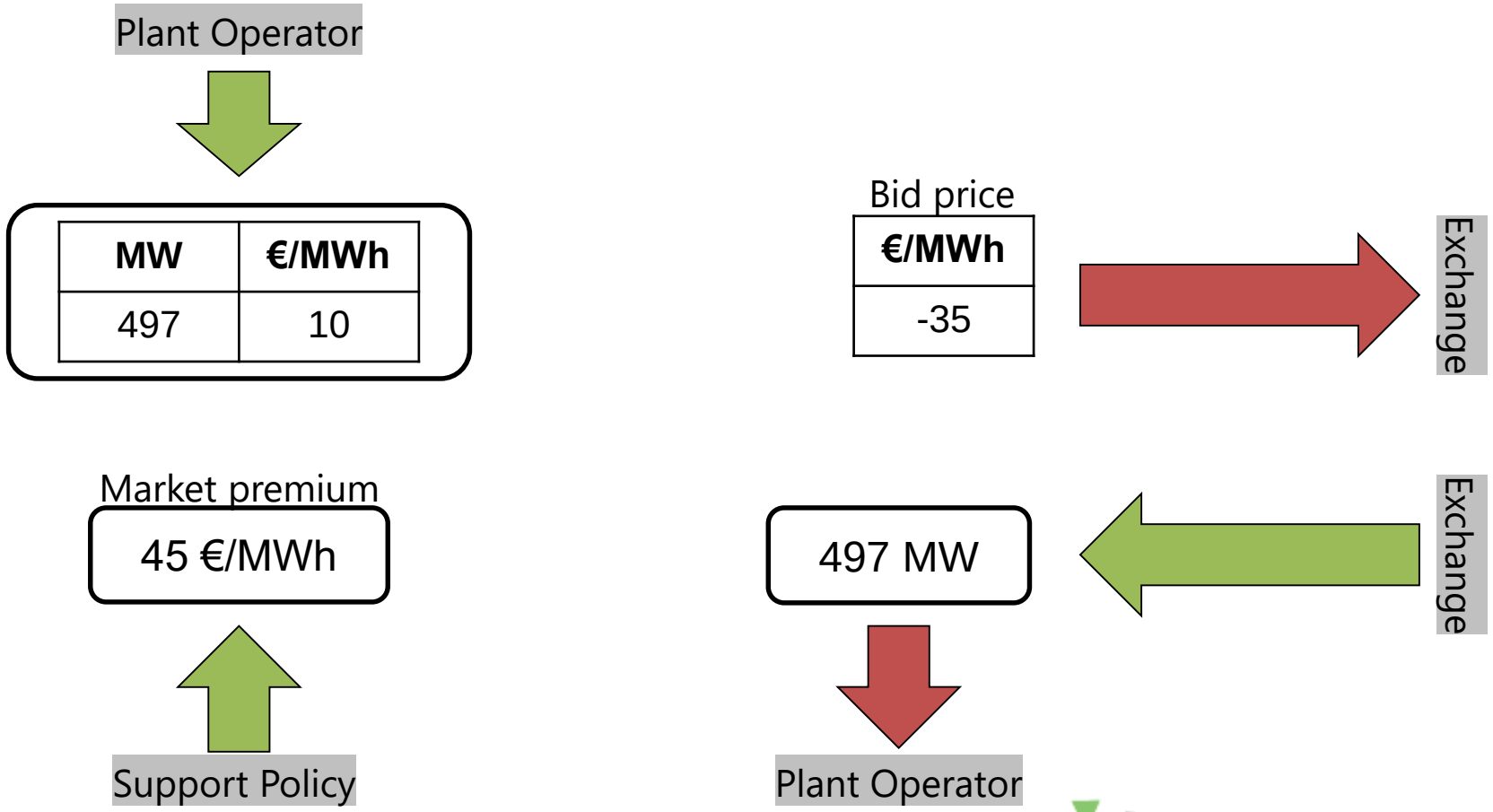
MW	€/MWh
497	10

497 MW

Renewables
Trader

Actions

1) *Receive marginal costs*
2) *Check support instrument*
3) *Derive bid*
4) *Send bids to Exchange*
5) *Receive awards*
6) *Forward power to operator*



Renewables
Support Policy

Actions

1) *Register clients*
2) *Track power prices*
3) *Track feed-in potentials*
4) *Calculate variable tariffs*
5) *Provide support*

Trader

Carrier	Instrument
PV	Feed-in tariff
WindOn	Market premium

Exchange

12 €/MWh

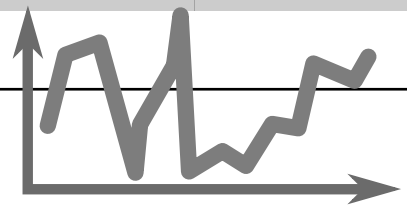
Plant Operator

Carrier	Feed-in
PV	0 MW
WindOn	497 MW

Carrier	Instrument	Support
PV	Feed-in tariff	90 €/MWh
WindOn	Market premium	45 €/MWh

Trader

Demand
Trader

Input parameter	Value
ValueOfLostLoad	3000
DemandSeries	

Actions

1) *Create bid*
2) *Send bid(s) to Exchange*

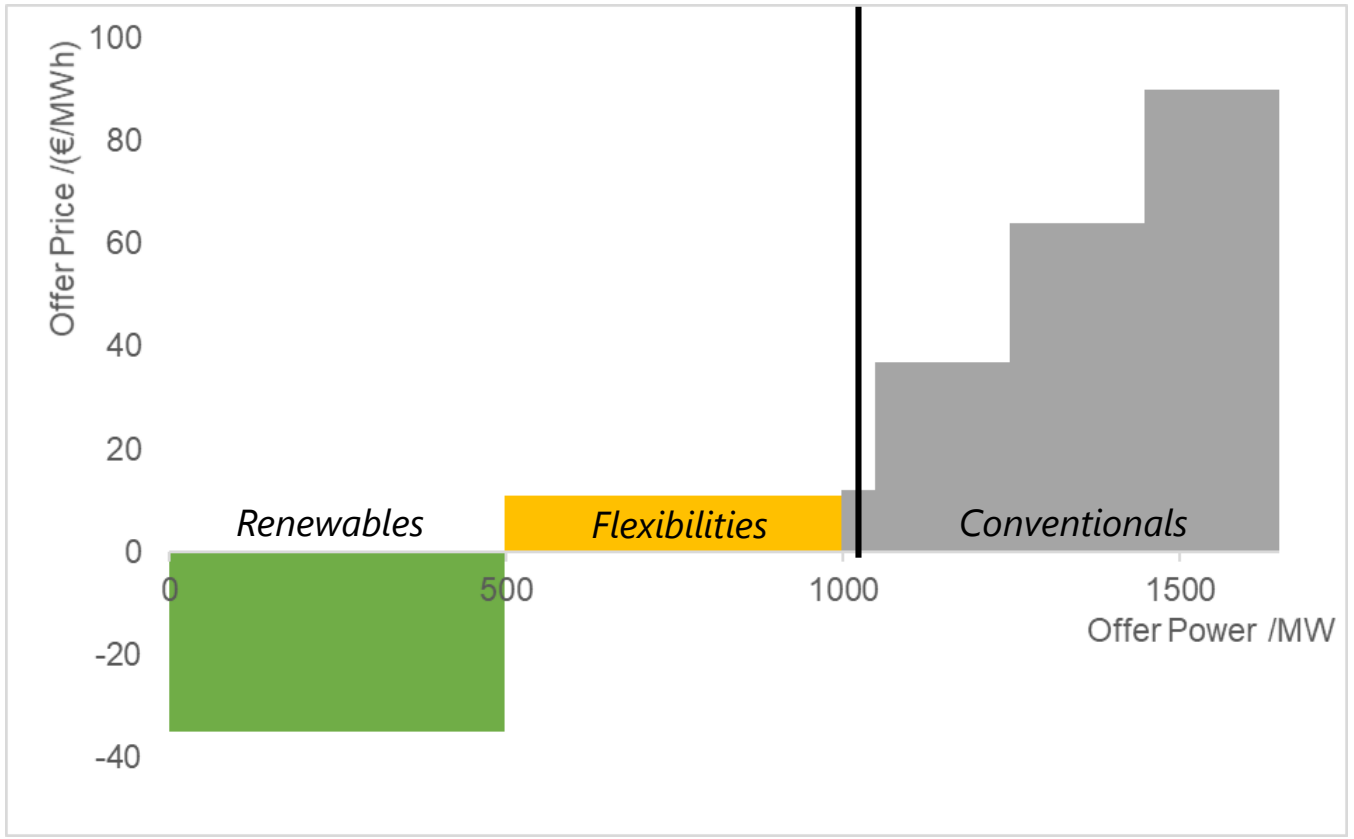
MW	€/MWh
1017	3000

Exchange

Energy Exchange
Market Clearing

Actions

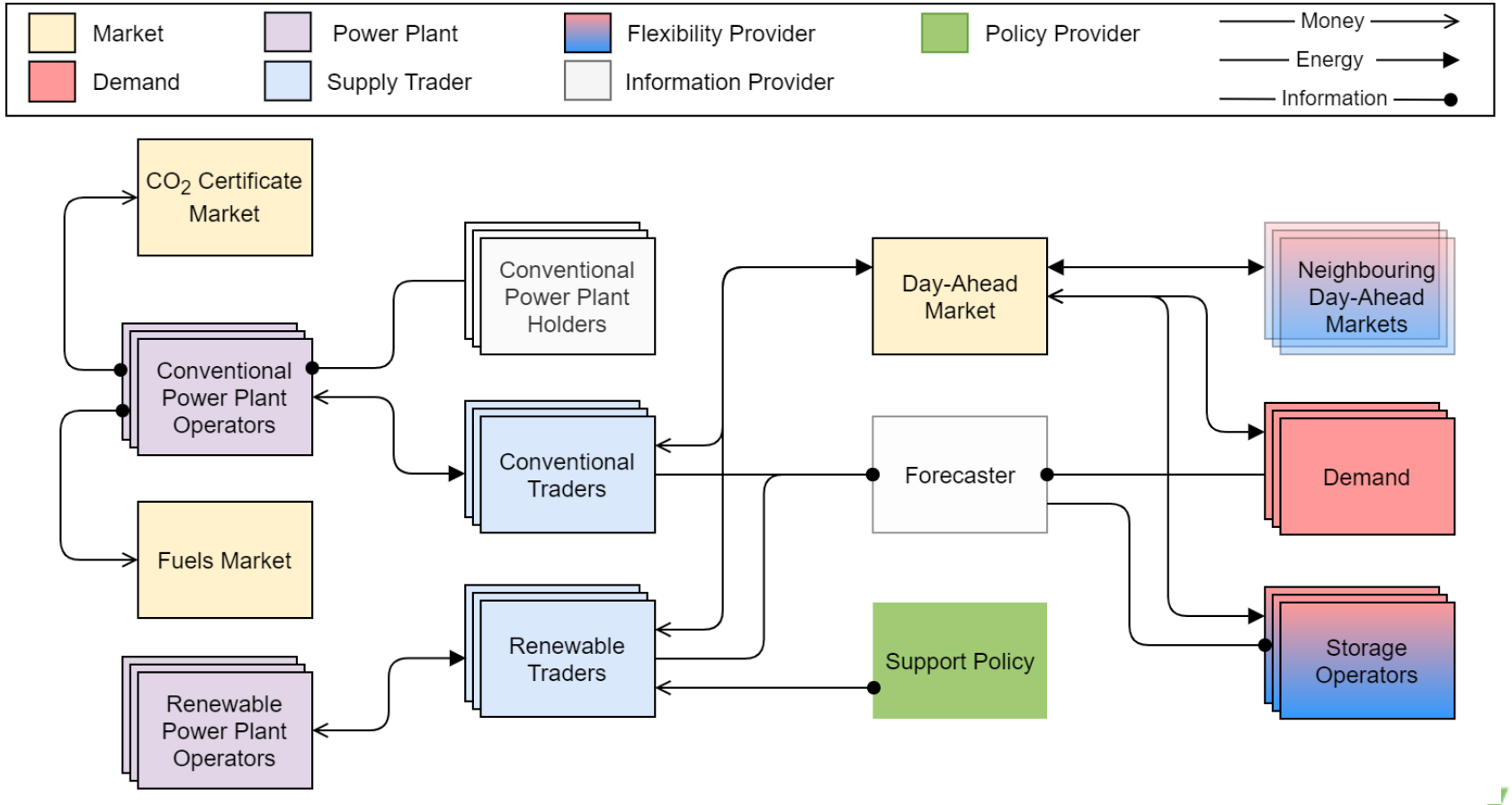
1) *Receive bids*
2) *Clear market*
3) *Send awards*



MW	€/MWh
497	12
500	12
20	12

Trader

AMIRIS Agents
Overview



AMIRIS

Setup

Setup
Requirements

- Java JDK 11

```
(base) PS C:\> java --version
openjdk 11.0.9.1 2020-11-04
OpenJDK Runtime Environment AdoptOpenJDK (build 11.0.9.1+1)
OpenJDK 64-Bit Server VM AdoptOpenJDK (build 11.0.9.1+1, mixed mode)
```

  - Obtain from, e.g., https://adoptium.net/

- Python 3.8 / 3.9

```
(base) PS C:\> python --version
Python 3.9.7
```

  - Obtain from, e.g., https://github.com/conda-forge/miniforge#mambaforge

Setup
AMIRIS

- Create environment

```
(base) PS C:\> mamba create -n AmirisEnv python=3.8
```

- Activate environment

```
(base) PS C:\> conda activate AmirisEnv
```

- Install *amirispy*

```
(AmirisEnv) PS C:\> pip install amirispy
```

- Create folder:

```
(AmirisEnv) PS C:\> mkdir amiris; cd amiris
```

- Install *AMIRIS*:

```
(AmirisEnv) PS C:\amiris> amiris install
```

Setup
Files

examples ← configuration files

amiris-core_2.0.0-alpha.8-jar-with-dependencies.jar ← AMIRIS executable

fameSetup.yaml ← ignore today!

examples/

- Austria2019
- Germany2019
- Simple

} three example scenarios

Examples/Simple/

- contracts
- timeseries
- LICENCE.md
- scenario.yaml ← Important file: Defines what is happening in simulation
- schema.yaml

Setup
Run AMIRIS

```
(AmirisEnv) PS C:\amiris> amiris run
usage: amiris run [-h] --jar JAR --scenario SCENARIO
                  [--output OUTPUT]
amiris run: error: the following arguments are required: --jar/-j, --scenario/-s
```

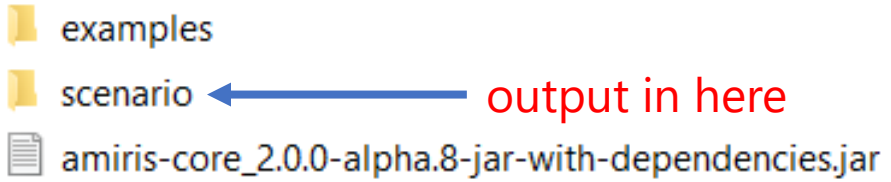
Required arguments

- -j AMIRIS executable
- -s Scenario file

```
(AmirisEnv) PS C:\amiris> amiris run -j .\amiris-core_2.0.0-alpha.8-jar-with-dependencies.jar
 -s .\examples\Simple\scenario.yaml
```

Console output

```
14:18:38 – PRINT – Start running AMIRIS
Starting up 1 processes.
Warm-up completed after 1 ticks.
04.10.2023 14:18:39:: Simulation completed! Ran 219 ticks in 258 ms
14:18:40 – PRINT – Successfully executed AMIRIS. See your results in '.'
```



Setup
Redirect output

```
(AmirisEnv) PS C:\amiris> amiris run -h
usage: amiris run [-h] --jar JAR --scenario SCENARIO [--output OUTPUT]

optional arguments:
  -h, --help            show this help message and exit
  --jar JAR, -j JAR     Path to 'amiris-core_<version>-jar-with-dependencies.jar'
  --scenario SCENARIO, -s SCENARIO
                        Path to a scenario yaml-file
  --output OUTPUT, -o OUTPUT
                        Directory to write output to
```

use this

```
(AmirisEnv) PS C:\amiris> amiris run -j .\amiris-core_2.0.0-alpha.8-jar-with-dependencies.jar
 -s .\examples\Simple\scenario.yaml -o simple
```

- examples
- simple ← output now in here

Setup
Results

- ConventionalPlantOperator.csv
- ConventionalPlantOperator_DispatchedP...
- ConventionalPlantOperator_VariableCost...
- ConventionalTrader.csv
- DemandTrader.csv
- EnergyExchange.csv
- NoSupportTrader.csv
- VariableRenewableOperator.csv

AgentId	TimeStep	TotalAwardedPowerInMW	ElectricityPriceInEURperMWH
1	01.01.2021 00:00	12431	267.4721054
1	01.01.2021 01:00	11416	262.9066734
1	01.01.2021 02:00	11163	260.8119727
1	01.01.2021 03:00	11036	257.4786831
1	01.01.2021 04:00	11192	256.4702082
1	01.01.2021 05:00	12177	256.2193284
1	01.01.2021 06:00	12685	256.2193284
1	01.01.2021 07:00	15222	259.7771467
1	01.01.2021 08:00	16491	260.2935264
1	01.01.2021 09:00	17125	257.9859146
1	01.01.2021 10:00	17378	255.7190453
1	01.01.2021 11:00	16997	255.4696391
1	01.01.2021 12:00	16237	257.2258181
1	01.01.2021 13:00	15476	256.4702082
1	01.01.2021 14:00	15222	259.5197279
1	01.01.2021 15:00	14968	262.3798356
1	01.01.2021 16:00	15095	265.3039864
1	01.01.2021 17:00	15729	265.8426993
1	01.01.2021 18:00	16491	264.7674623
1	01.01.2021 19:00	17505	263.1708901
1	01.01.2021 20:00	18012	260.035079
1	01.01.2021 21:00	17251	250.822094
1	01.01.2021 22:00	16744	0
1	01.01.2021 23:00	14968	0

AMIRIS

Parametrisation

Parametrisation

Scenario: Main config file to bundle all simulation properties

Open: examples/Germany2019/scenario.yaml

scenario.yaml

schema	*input validation*
general properties	*simulation start/end*
agents	*agents and their parameters*
contracts	*agent interactions*

File name is arbitrary

Split scenario.yaml into separate files, e.g. schema, contracts, etc., and join them using ***!include****, see https://gitlab.com/fame-framework/fame-io#split-and-join-multiple-yaml-files*

Parameterisation
General Properties

- Define
  - start and end of simulation
  - which random seed to use

```
GeneralProperties:
  RunId: 1          <-- ignore
  Simulation:
    StartTime: 2018-12-31_23:58:00
    StopTime: 2019-12-31_23:58:00
    RandomSeed: 1
  Output:           <-- ignore
```

*FAME's time definition **always** uses 365 days / 8760 hours per year, see also https://gitlab.com/fame-framework/wiki/-/wikis/architecture/decisions/TimeStamp*

YAML is indentation-based (2 spaces)

Parameterisation
Agents

- Define
  - agents
  - their type, ID, and attributes.

- Supported data types:
  - integer, floating point, enums, timeseries

In YAML, dash is used to denote lists

```yaml
Agents:
  - Type: EnergyExchange
    Id: 1
    Attributes:
      DistributionMethod: SAME_SHARES
      GateClosureInfoOffsetInSeconds: 11

  - Type: CarbonMarket
    Id: 3
    Attributes:
      OperationMode: FIXED
      Co2Prices: "./timeseries/co2_price.csv"

  - Type: FuelsMarket
    Id: 4
    Attributes:
      FuelPrices:
        - FuelType: LIGHNITE
          Price: 5.00
          ConversionFactor: 1.0
        - FuelType: NATURAL_GAS
          Price: "./timeseries/natural_gas_cost.csv"
          ConversionFactor: 1.0
```

All agents are explained in AMIRIS-Wiki: https://gitlab.com/dlr-ve/esy/amiris/amiris/-/wikis/Classes/Classes

*Every agent **must** have a unique ID within the simulation. This is how agents address each other.*

Execute
Germany2019

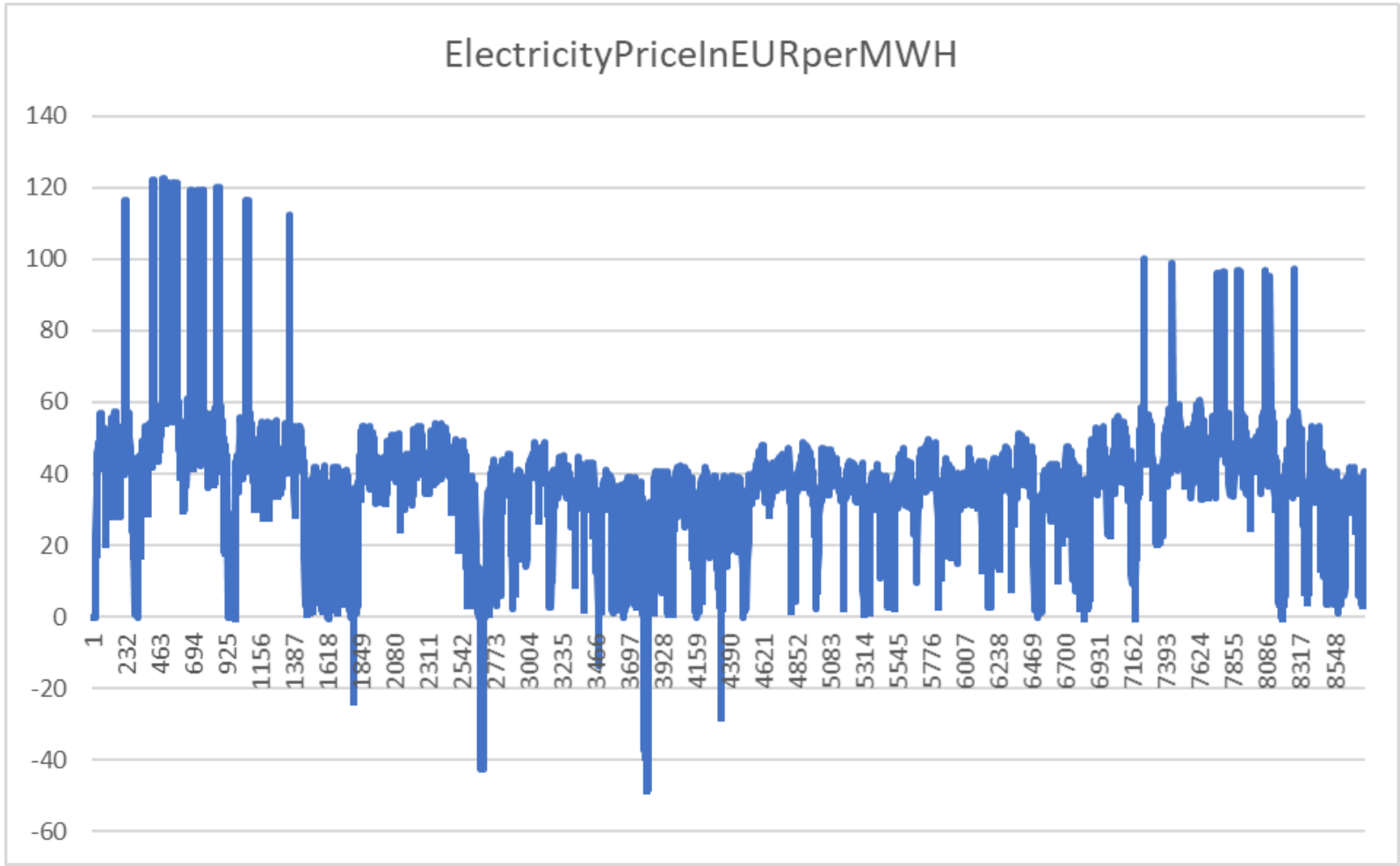
```
(base) PS C:\amiris> amiris run -j .\amiris-core_2.0.0-alpha.8-jar-with-dependencies.jar
 -s .\examples\Germany2019\scenario.yaml -o germany
```

examples

germany ← output in here

simple

→ Plot electricity price time series in “EnergyExchange.csv”



Parameterisation
Contracts

Define **when** agents send **what** data to **which** other agents

You **can** define agents without contracts:
they simply do nothing. There is no check!

Parameterisation
Contracts: Nice to know

Open: examples/Germany2019/contracts/conventionals.yaml

- Simulations often require *many* contracts!
- Contracts are often *similar*!
- Short notations available:
  - 1:N → one sender to multiple receivers
  - N:1 → one receiver from multiple senders
  - M[1:1] → m times one sender to **one** receiver

- Sender / receiver lists *repeat* often!
- Use YAML anchors to replace similar lists
  - Define: &anchorName <something>
  - Reference: *anchorName

```yaml
AgentGroups:
  - &builders  [2000, 2001, 2002, 2003, 2004, 2005]
  - &traders   [1000, 1001, 1002, 1003, 1004, 1005]
  - &operators [500, 501, 502, 503, 504, 505]
  - &exchange 1
  - &carbonMarket 3
  - &fuelsMarket 4
  - &forecaster 6

Contracts:
################################
# -- PlantBuildingManagement -- #
################################
  - SenderId: *builders
    ReceiverId: *operators
    ProductName: PowerPlantPortfolio
    FirstDeliveryTime: -60
    DeliveryIntervalInSteps: 31536000

##############################
# -- Forecast Preparation -- #
##############################
  - SenderId: *forecaster
    ReceiverId: *traders
    ProductName: ForecastRequest
    FirstDeliveryTime: -26
    DeliveryIntervalInSteps: 3600
```

anchors

comment

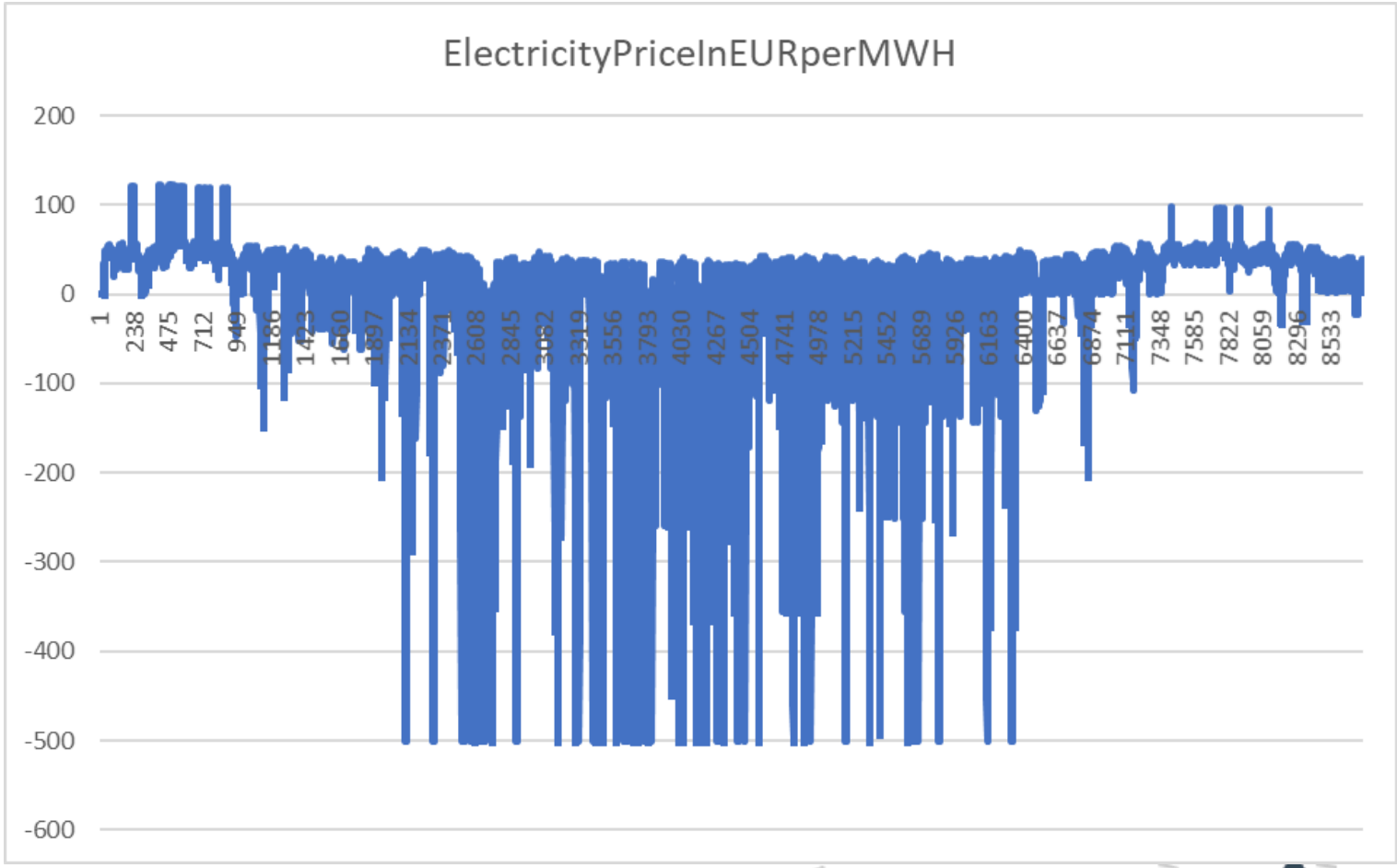
reference

AMIRIS

Parameter Experiments

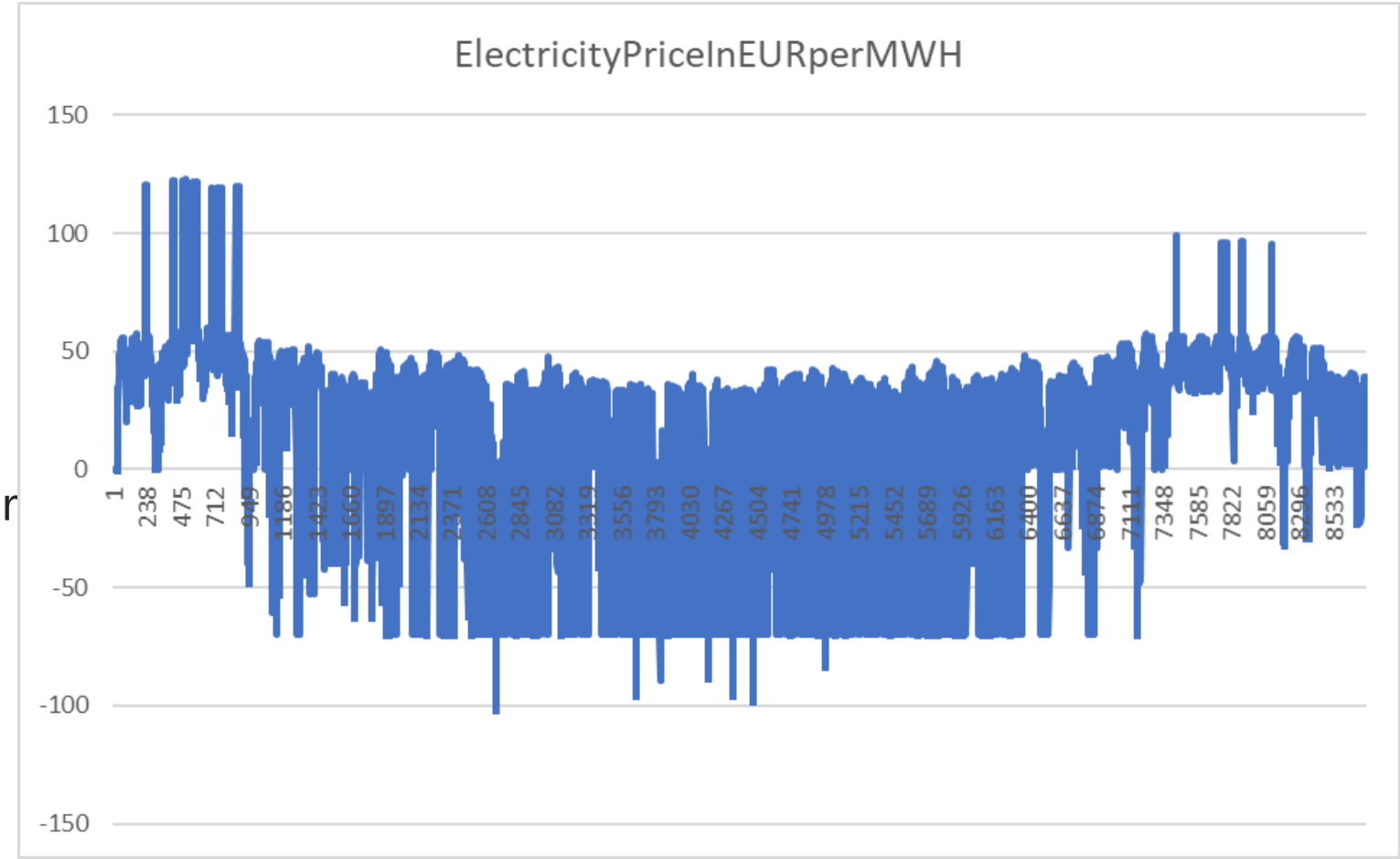
Application
Add PV Agent

1. Copy & rename *scenario* file
2. Add PV *Agent*
3. Choose Unique *ID*
4. Copy & rename *Contracts* folder
5. Redirect Contracts in scenario
6. Add *PV* Contracts
7. Rerun
8. Evaluate Electricity Prices



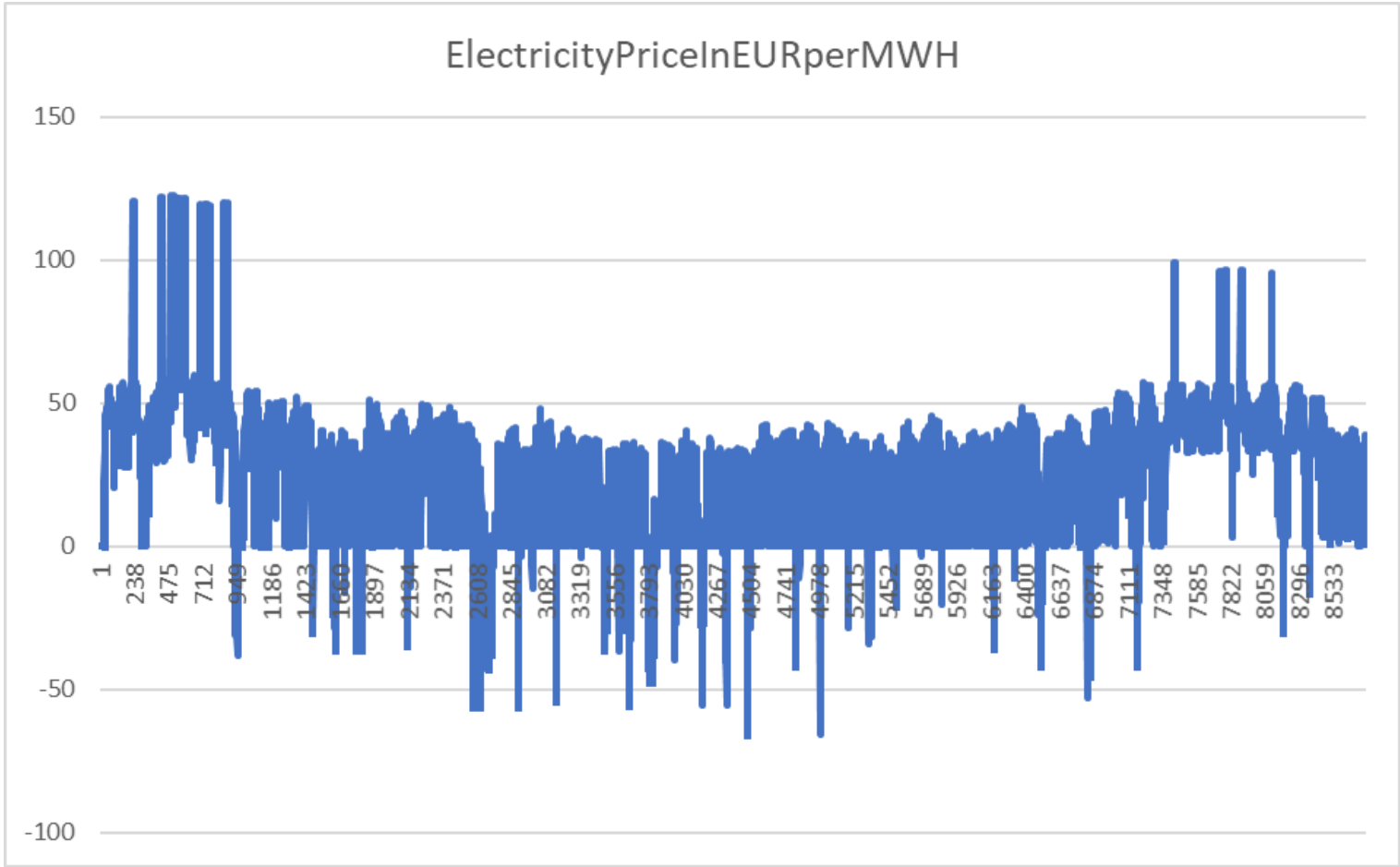
Application
Change Support Instrument: Fixed Premium

1. Copy & rename *scenario* file
2. Update *SupportPolicy*:
    1. Add *Set* "OtherPV"
    2. *MPFIX: Premium*
3. Update *PV Agent*
    1. Change *Set*: OtherPV
    2. Change *Support Instrument*: MPFIX
4. Copy & rename *Contracts* folder
5. Redirect Contracts in scenario
6. Switch PV Agent Contracts
7. Rerun
8. Evaluate Electricity Prices

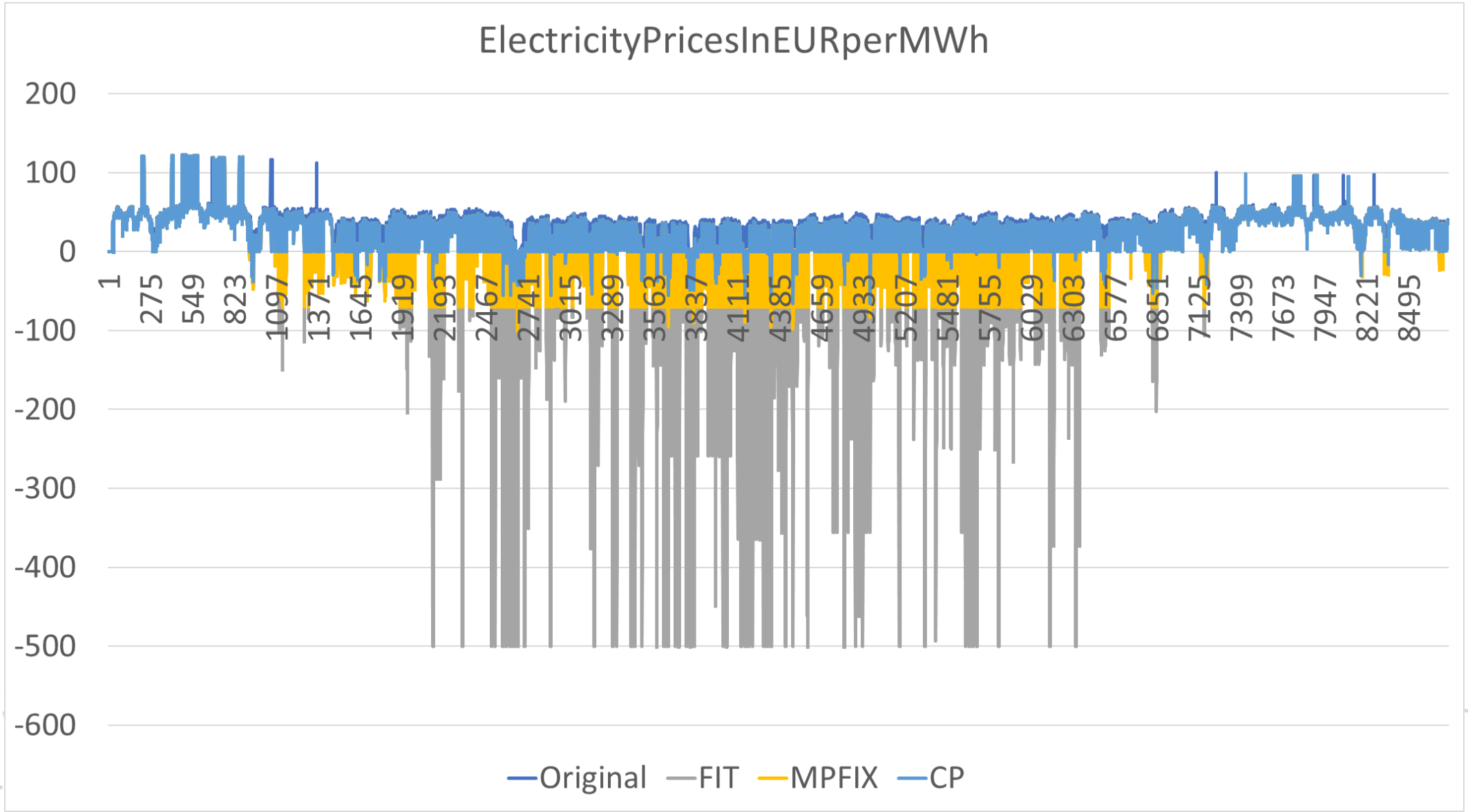


Application
Change Support Instrument: Capacity Premium

1. Copy & rename *scenario* file
2. Update *SupportPolicy*:
    1. In *Set* "OtherPV"
    2. Change to *CP*
3. Update *PV Agent*
    1. Change *Support Instrument*: CP
4. Rerun
5. Evaluate Electricity Prices



Overall experiment comparison



Application
Experiment Summary

- Support Policy had high impact on electricity prices (with limited flexibility)
- Renewables became price setting (bidding at opportunity costs)
- Opportunity cost depended on the employed support instrument

Disclaimer

- This was merely an experiment, not consistent scenario work
- Support paid out at negative prices due to historic regulations

AMIRIS

What do you think?

AMIRIS

Final Remarks

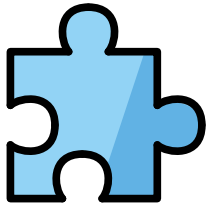
AMIRIS
Following FAIR4RS Principles

Findable

- DOI
- Wikipedia
- COMSES
- HECI
- OEP
- openmod
- Website

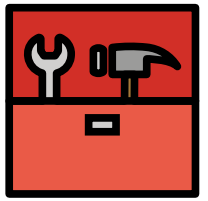
Accessible

- GitLab
- PyPI
- Zenodo



Interoperable

- API
- Workflow tools
- CSV
- YAML



(Re-)usable

- Apache 2.0
- REUSE
- Wiki
- Javadoc
- Win/Mac/Linux
- Scalable (H)PC

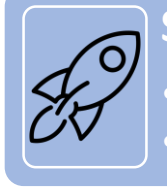
will upload presentation here

Key Indicators

Users
- 12 confirmed external user
- 4 bugs reported

PhD candidates
- 4 internal
- 3 external

Visibility
- 14k views on Wikipedia
- 9k views on openmod



Software
- 39 releases
- 60k downloads

Barker et al. (2022). 10.1038/s41597-022-01710-x

AMIRIS
See also

Website	https://dlr-ve.gitlab.io/esy/amiris/home/
Gitlab project	https://gitlab.com/dlr-ve/esy/amiris/amiris
Open mod forum	https://forum.openmod.org/tag/amiris
Wiki	https://gitlab.com/dlr-ve/esy/amiris/amiris/-/wikis/home
Javadoc	https://dlr-ve.gitlab.io/esy/amiris/amiris/
Zenodo	https://zenodo.org/communities/amiris
E-Mail	amiris@dlr.de

FAME Framework https://gitlab.com/fame-framework

Visit our website

Imprint

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