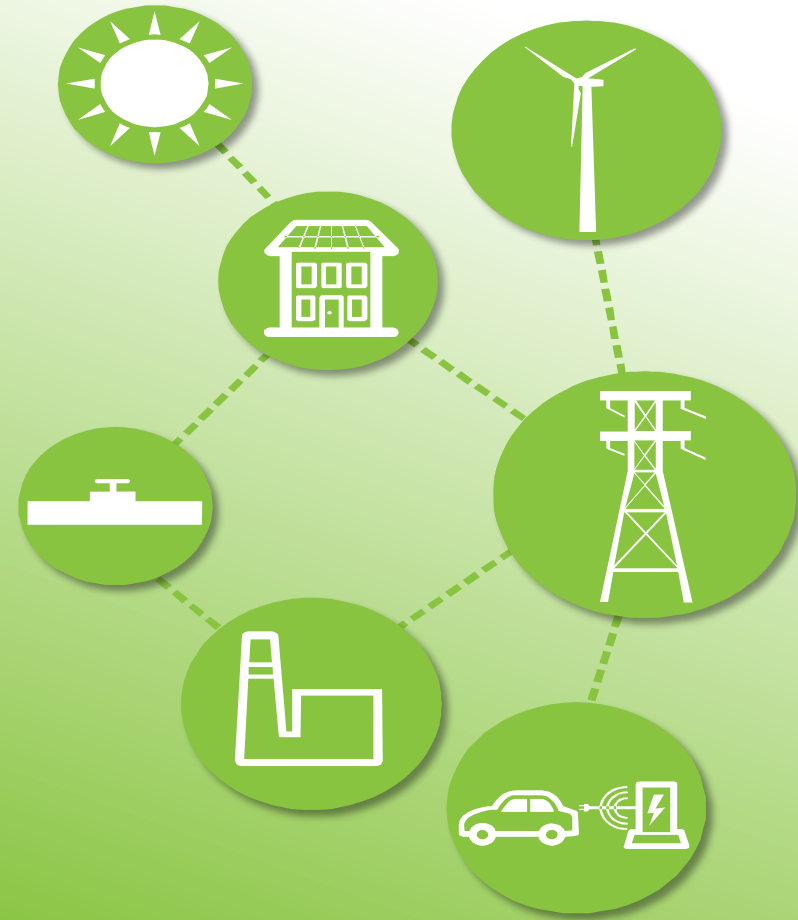




Spine



Spine: Open source Toolbox for modelling integrated energy systems

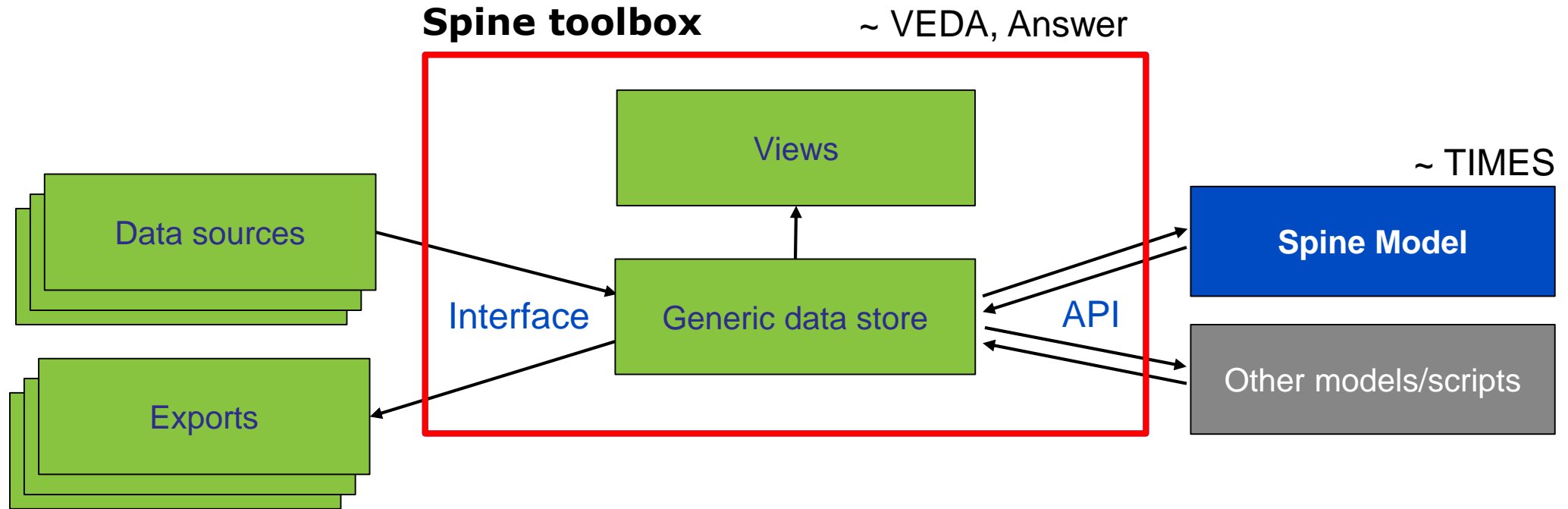
Spine Consortium

- | | | | |
|------------------------------|--------------------------|-----------------------|--------------------|
| ▪ Juha Kiviluoma | VTT | ▪ Erik Delarue | KUL |
| ▪ Hannele Holttinen | VTT | ▪ Kris Poncelet | KUL |
| ▪ Erkka Rinne | VTT | ▪ Maren Ihlemann | KUL |
| ▪ Tomi J. Lindroos | VTT | ▪ Steffen Kaminski | KUL |
| ▪ Pekka T. Savolainen | VTT | | |
| ▪ Janne Keränen | VTT | ▪ Lennart Söder | KTH |
| ▪ Antti Lehtilä | VTT | ▪ Mikael Amelin | KTH |
| ▪ Laura Sokka | VTT | ▪ Lars Nordström | KTH |
| ▪ Toni Lastusilta | VTT | ▪ Manuel Marin | KTH |
| ▪ Irina Granfors | VTT | ▪ Jon Olauson | KTH |
| ▪ Timo Kyntäjä | VTT | | |
| | | ▪ Jody Dillon | Energy Reform Ltd. |
| ▪ Terence O'Donnell | UCD | | |
| ▪ Lucy Cradden | UCD | | |
| ▪ Jonathan Ruddy | UCD | | |
| ▪ Mark O'Malley | UCD / Energy Reform Ltd. | | |

www.spine-model.org



Spine project - scope



- Open-source energy modeling toolbox
- Open-source generic energy-system optimization model

Spine Toolbox: goals

Open

- Github (online repository)
- Use open source software: Python

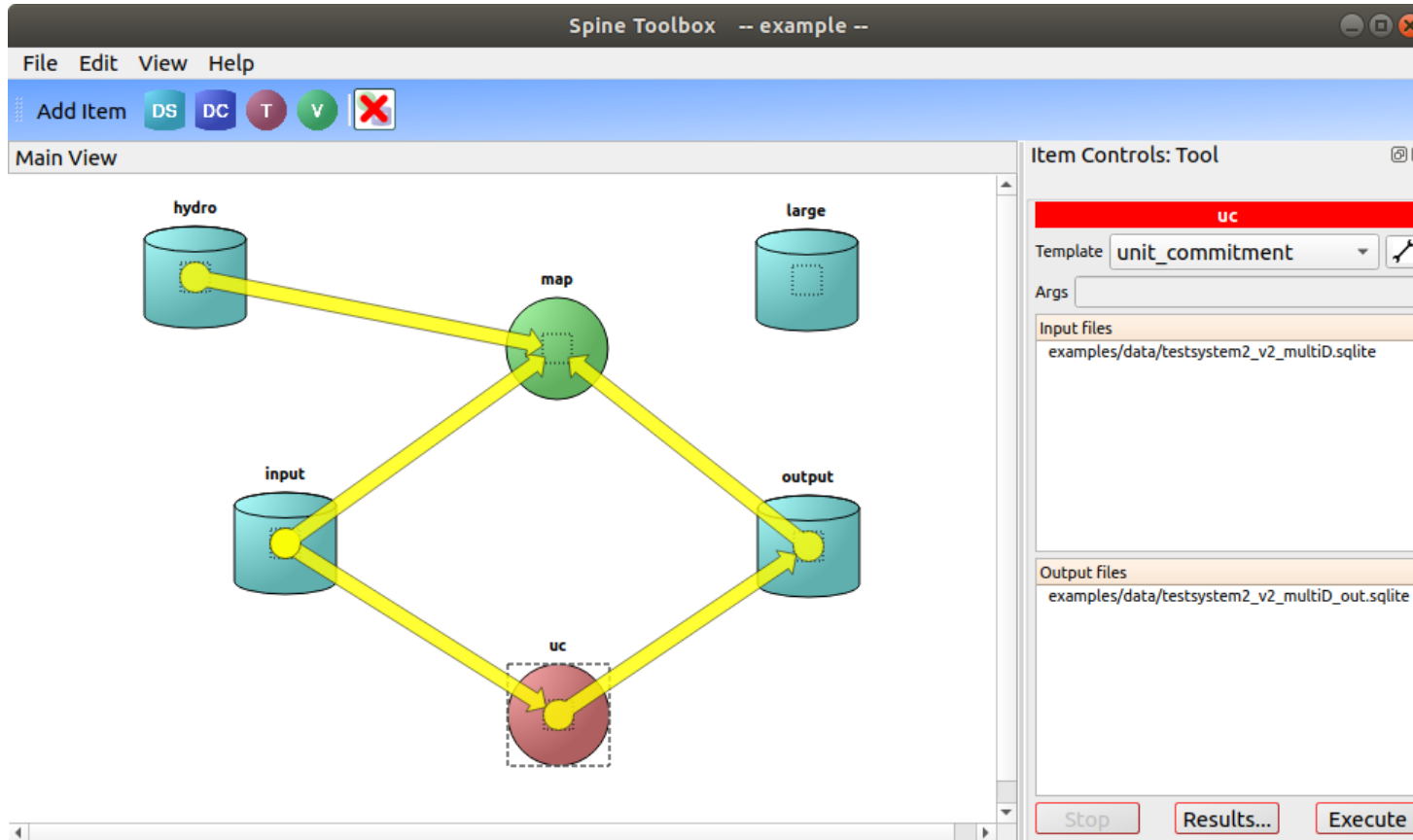
Flexible

- User friendly model development:
 - Direct link between data and model (easily add new parameters, entities, etc.)
- Ability to plug in different (types of) energy system models:
 - Optimization, agent-based, etc.
 - Julia, GAMS, Python
- Facilitate soft-linking between different models

Practical

- Graphical user interface (GUI)
- Convenient handling of input data:
 - Connection to different types of data sources (SQL, excel, manual entry, etc.)
 - Incorporate data processing scripts
- Facilitate scenario creation and management
- Viewing functionalities

Spine Toolbox: Main View



- GUI visualizing data stores, tools (models/scripts), views (viewing scripts)
- Drawing of connections to link data stores to tools or views
- API allows connecting to different types of databases (e.g., MySQL, SQLite, etc.)

Spine Toolbox: goals

Open

- Github/Gitlab
- Use open source software: Python

Flexible

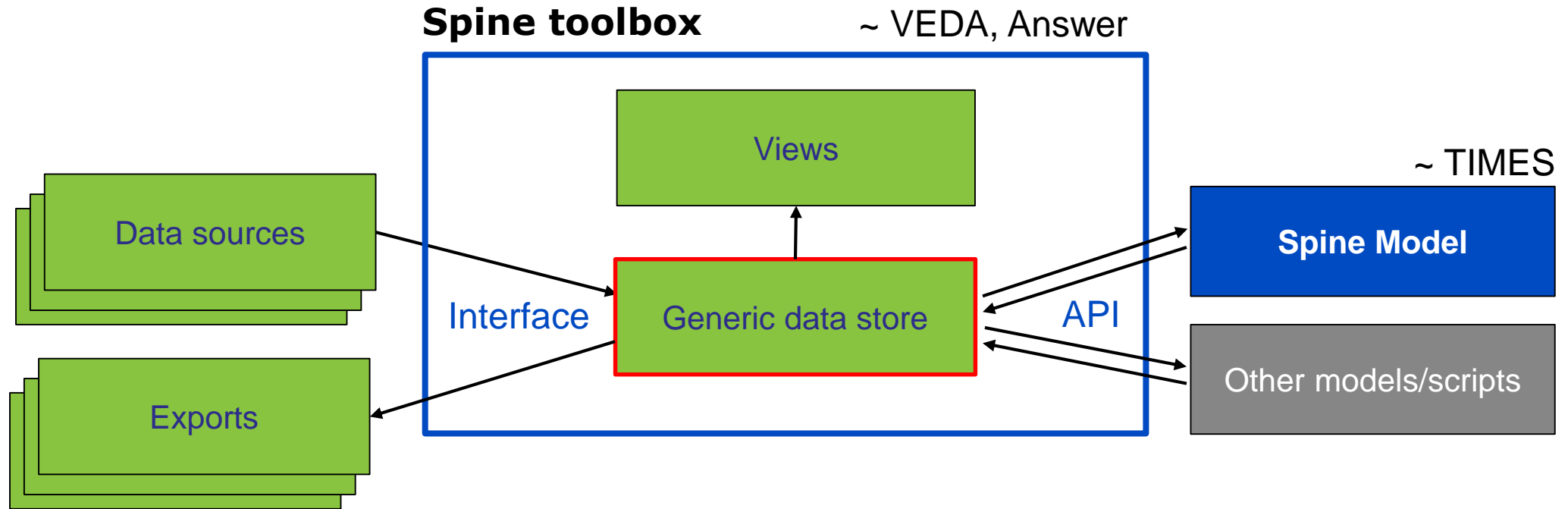
- User friendly model development:
 - Direct link between data and model (easily add new parameters, entities, etc.)
- Ability to plug in different (types of) energy system models:
 - Optimization, agent-based, etc.
 - Julia, GAMS, Python
- Facilitate soft-linking between different models

- Generic data structure
- API for data access

Practical

- GUI
- Convenient handling of input data:
 - Connection to different types of data sources (SQL, excel, manual entry, etc.)
 - Incorporate data processing scripts
- Facilitate scenario creation and management
- Viewing functionalities

Spine project - scope



- **Open-source energy modeling toolbox**
- Open-source generic energy-system optimization model

Spine's generic data store: toolbox tree view

Parameter ParameterClass

The screenshot displays the Spine toolbox tree view for a database named 'testsystem2_v2_multiD.sqlite'. The tree is organized into four main categories:

- ObjectClass:** Includes 'direction', 'commoditygroup', 'unitgroup', 'connection', 'unittemplate', and 'unit'.
- Object:** Includes instances like 'CoalPlant', 'GasPlant', 'CHPPlant', 'ImportGas', and 'ImportCoal' under the 'unit' class.
- RelationshipClass:** Includes 'commodity', 'Heat', 'Gas', 'Electricity', and 'Coal'.
- Relationship:** Includes specific relationships like 'commoditygroup_commodity', 'commodity_node_unit_direction', 'unit_commodity', 'CoalPlant_Coal', and 'ImportCoal_Coal'.

Two tables are shown on the right side of the interface:

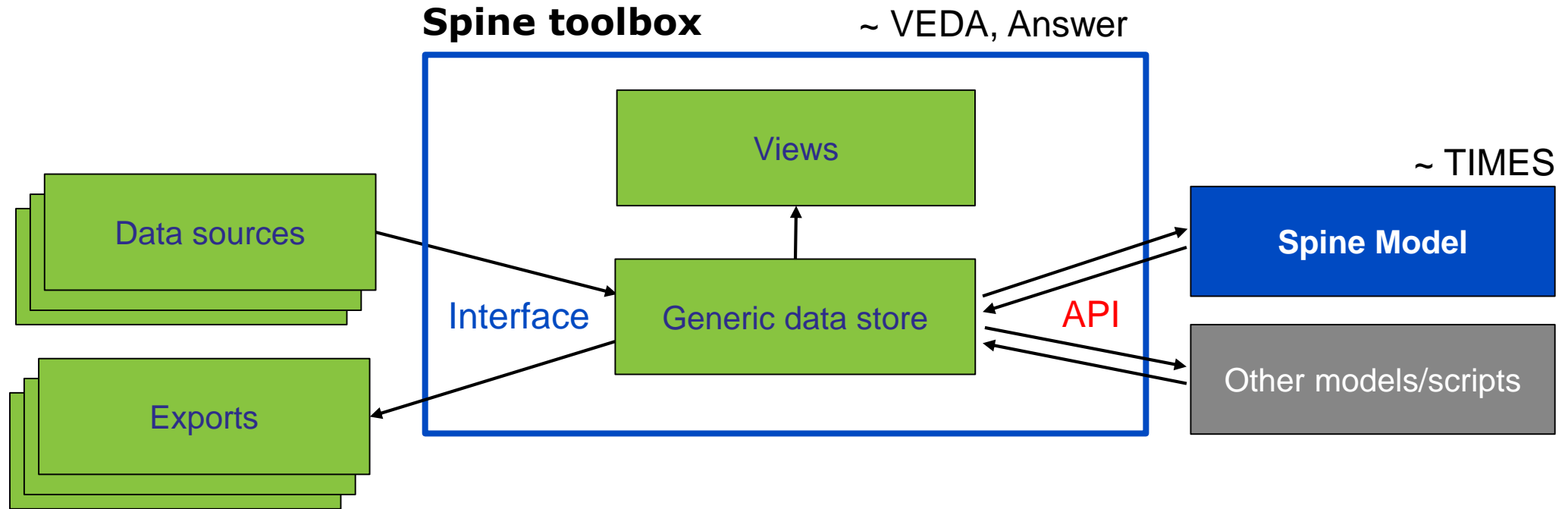
Object parameter value

object_class_name	object_name	parameter_name	index	value
unit	CoalPlant	avail_factor	1	[1,
unit	GasPlant	avail_factor	1	[1,
unit	CHPPlant	avail_factor	1	[1,
node	Leuve	object parameters	1	[3
node	BrusselsElectricity	demand	1	[6
node	AntwerpElectricity	demand	1	[4
node	BelgiumHeat	demand	1	[3
connection	EL1	trans cap	1	250

Relationship parameter value

relationship_class_name	object_name_1	object
connection_node_node	EL1	LeuvenEl
connection_node_node	EL1	LeuvenEl
connection_node_node	EL1	Antwerp
connection_node_no	EL1	Antwerp
connection_node_no...	EL1	LeuvenEl
connection_node_node	EL2	LeuvenEl
connection_node_node	EL2	BrusselsE
connection node node	EL2	BrusselsE

Spine project - scope



- **Open-source energy modeling toolbox**
- Open-source generic energy-system optimization model

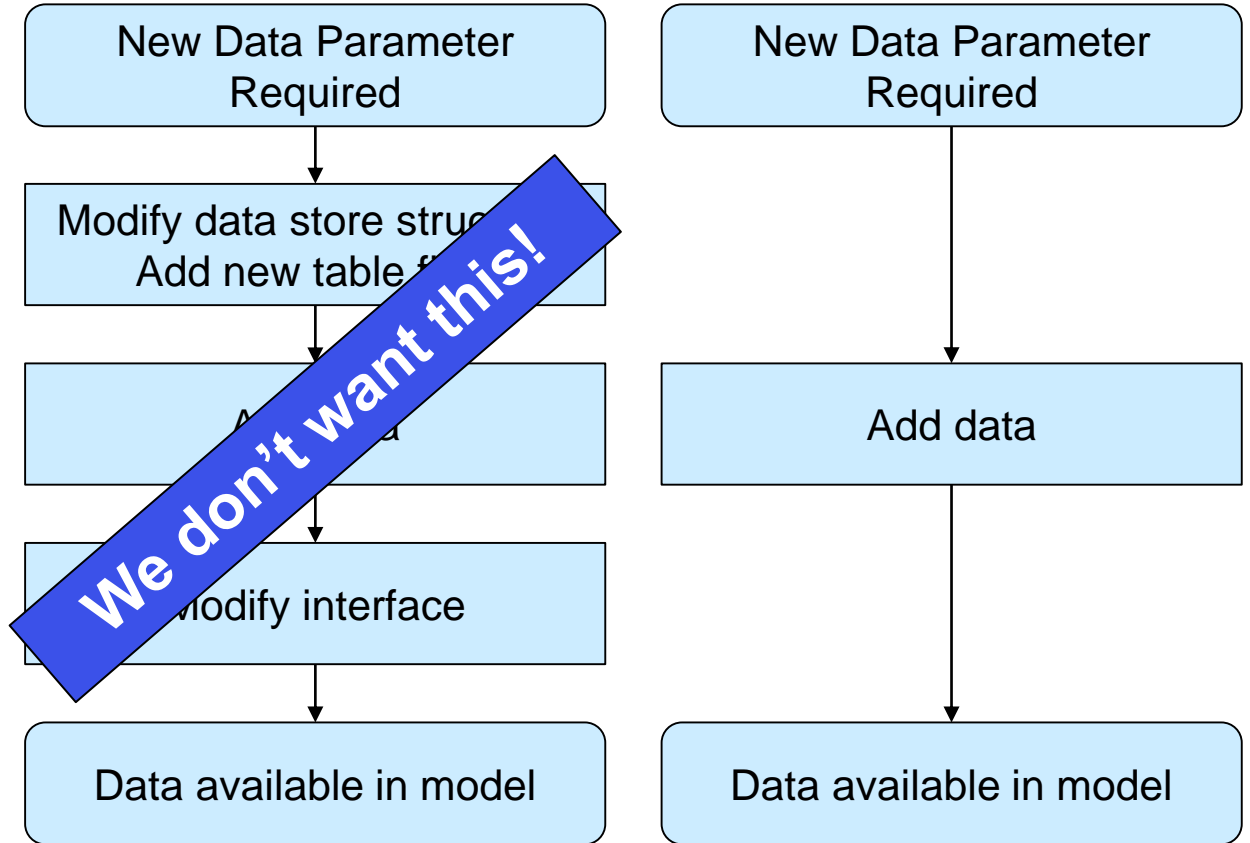
Spine database API: convenience functions

Problem specific data structure:

- Addition of new parameter or new entity requires changing:
 - data structure
 - interface

Problem independent data structure:

- Parameters/entities entered in the toolbox can directly be accessed in the model



Example: Spine database API & convenience functions

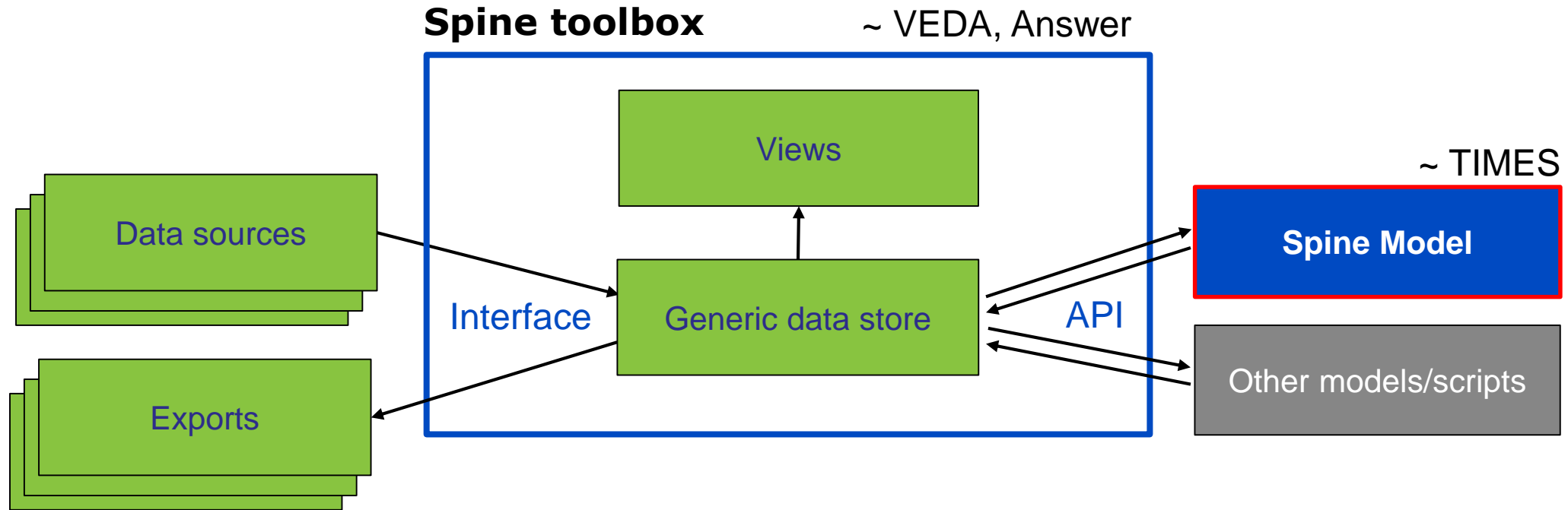
- Convenience functions:
 - Use database structure to **automatically** generate functions to access objects/relationships/parameters

```
function max_flow(m::Model, flow)
  @constraint(
    m,
    [
      u in unit(),
      c in commodity():
      max_flow(unit=u, commodity=c) != nothing
    ],
    flow[c, u, t] <= max_flow(unit = u, commodity = c)
  )
end
```

Functions to access set of all object of a certain object class

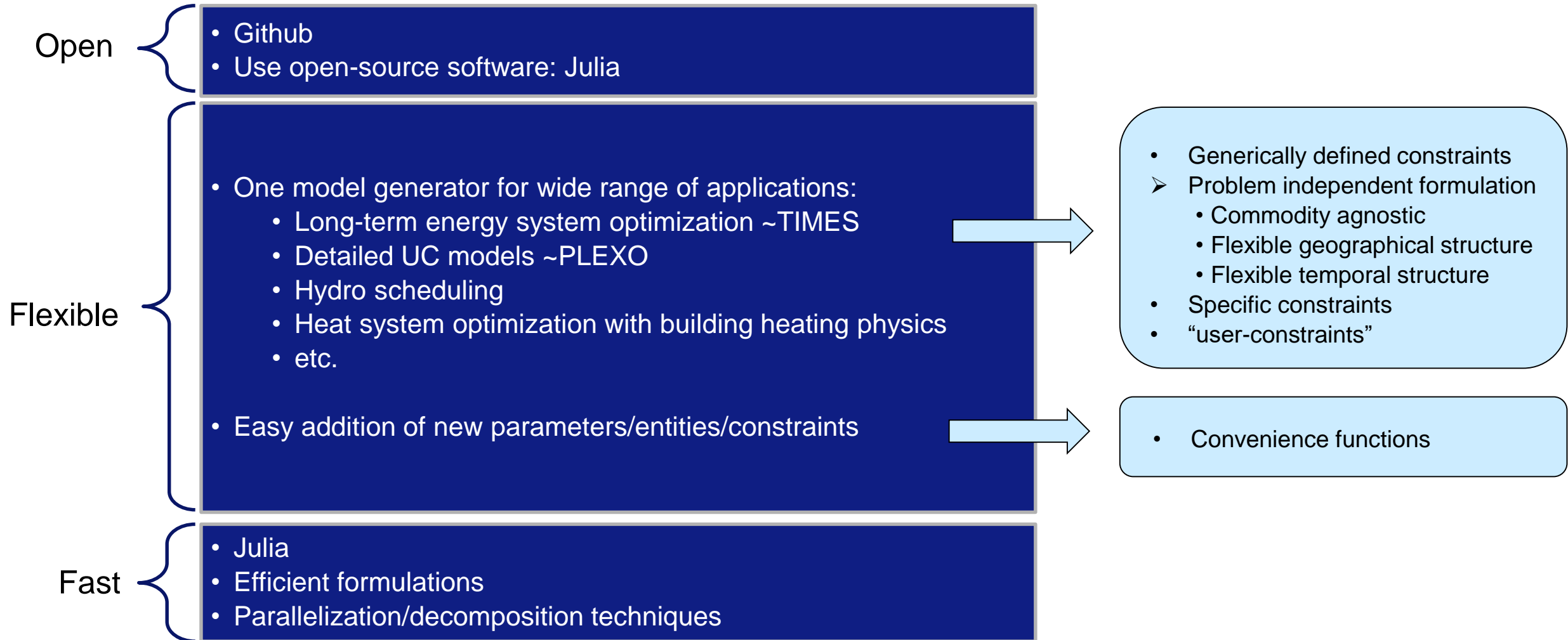
Functions to access parameter values

Spine project - scope

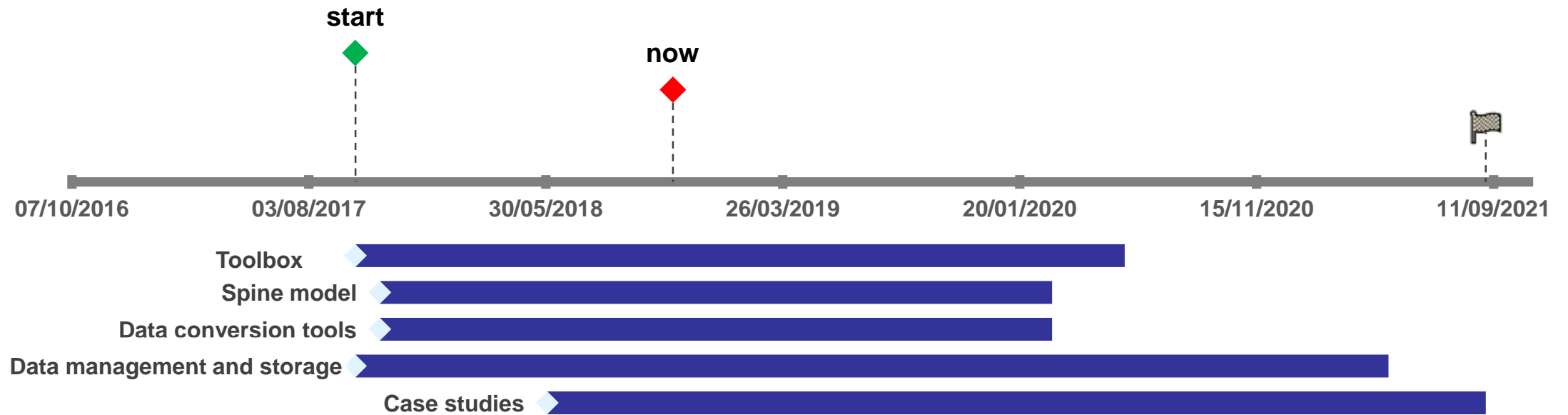


- Open-source energy modeling toolbox
- **Open-source generic energy-system optimization model**

Spine Model: design goals and approaches



Project status



- Spine database API: [git@github.com:Spine-project/Spine-Database-API.git](https://github.com/Spine-project/Spine-Database-API.git)
- Spine Toolbox: [git@github.com:Spine-project/Spine-Toolbox.git](https://github.com/Spine-project/Spine-Toolbox.git)
- Spine Model: [git@github.com:Spine-project/Spine-Model.git](https://github.com/Spine-project/Spine-Model.git)



www.spine-model.org

spine_info@vtt.fi



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 774629.