

mopo

Tools for energy system modelling



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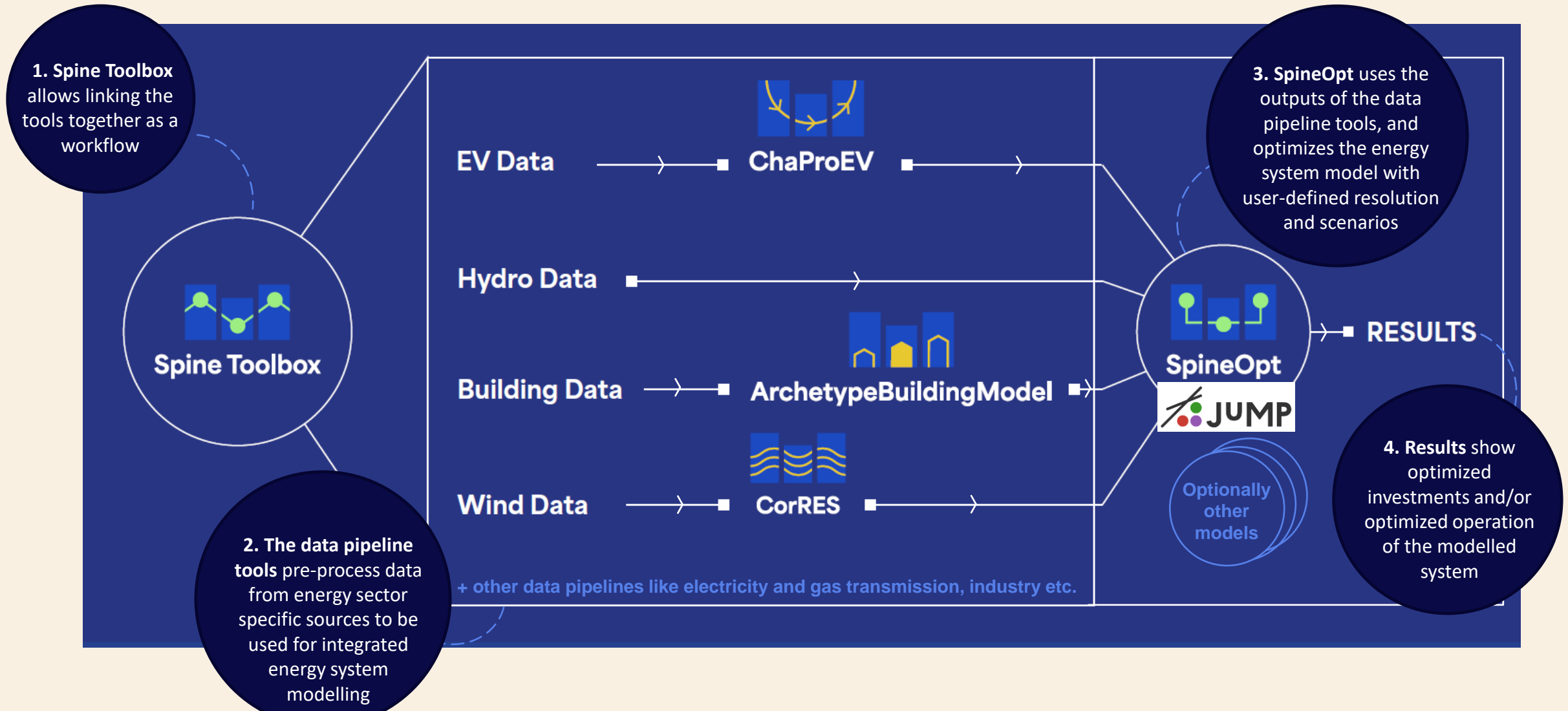
<https://tools-for-energy-system-modelling.org>

In short, Mopo will...



- 1** ...**build repeatable and configurable data pipelines from data to model** for representing different energy sectors
- 2** ...provide a highly adaptable energy system modelling tool – SpineOpt.jl – that can be used to **optimize integrated energy systems from city- to continental-level**
- 3** ...improve ease of linking complex energy system data processing chains together in Spine Toolbox to **make management of energy modelling easier**
- 4** ...**integrate user feedback** to create better energy modelling tools

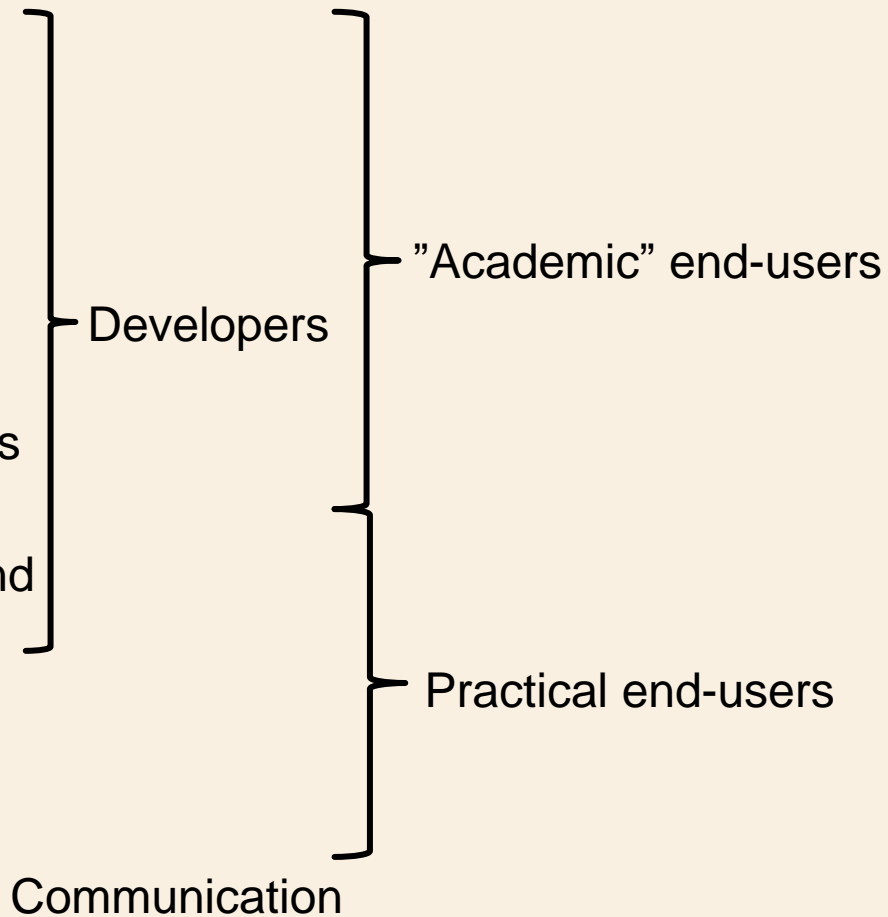
Spine workflow for integrated energy system analysis



The Mopo research project consortia

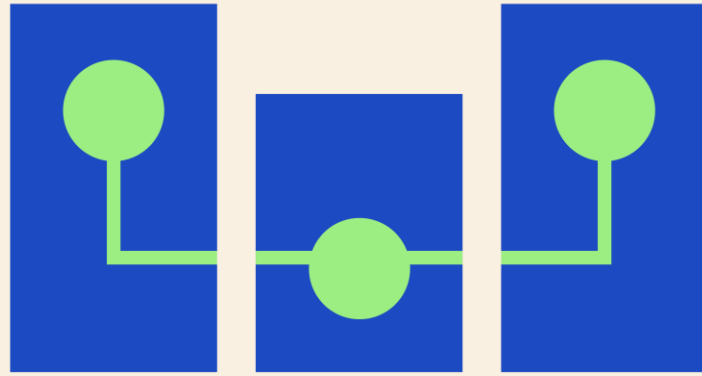
Mopo consortia

- VTT, Finland
- DTU, Denmark
- TNO, Netherlands
- KU Leuven, Belgium
- KTH, Sweden
- UCD, Ireland
- eScience, Netherlands
- VITO, Belgium
- Energy Reform, Ireland
- EPRI, Ireland
- PBL, Netherlands
- Fluxys, Belgium
- Fortum, Finland
- ICONS, Italy



Advisory board

- EnergiNet (TSO, Denmark)
- E-REDES (DSO, Portugal)
- Energimyndigheten (Sweden)
- Sustainable Energy Authority of Ireland
- ESIG
- IRENA
- NREL



SpineOpt

Energy system model generator



Funded by the European Union

SpineOpt.jl main goal



- SpineOpt prioritizes flexibility and user-friendliness for energy system modellers, supports a broad research audience, and focuses on community building.
- The European Commission funds its development as a model solution for widespread adoption.
- It is already supporting stakeholders across Europe by providing an intuitive user experience and a diverse ecosystem of complementary tools.

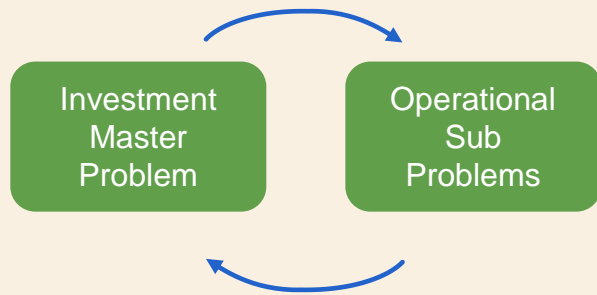


SpineOpt.jl is a generic and flexible energy system model generator

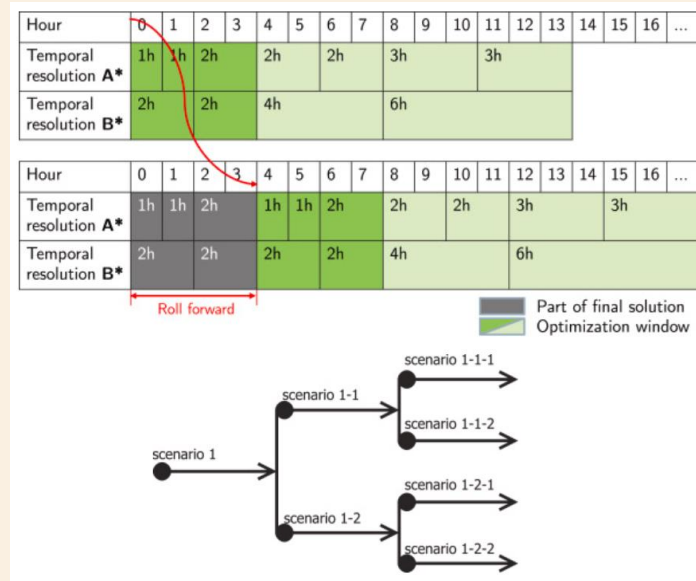


SpineOpt is an energy systems optimization framework built with Julia. It has diverse capabilities and substantial adaptability, and allows sector-specific modelling inside a single model with a highly adaptable temporal and stochastic structure.

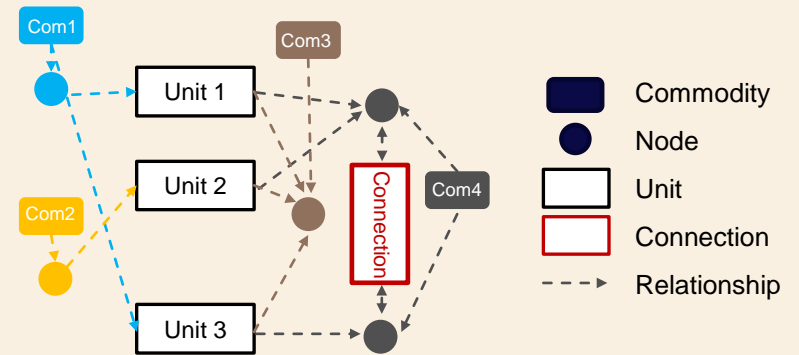
Capabilities include:



Including operational detail in investment planning



Highly flexible temporal and stochastic structures



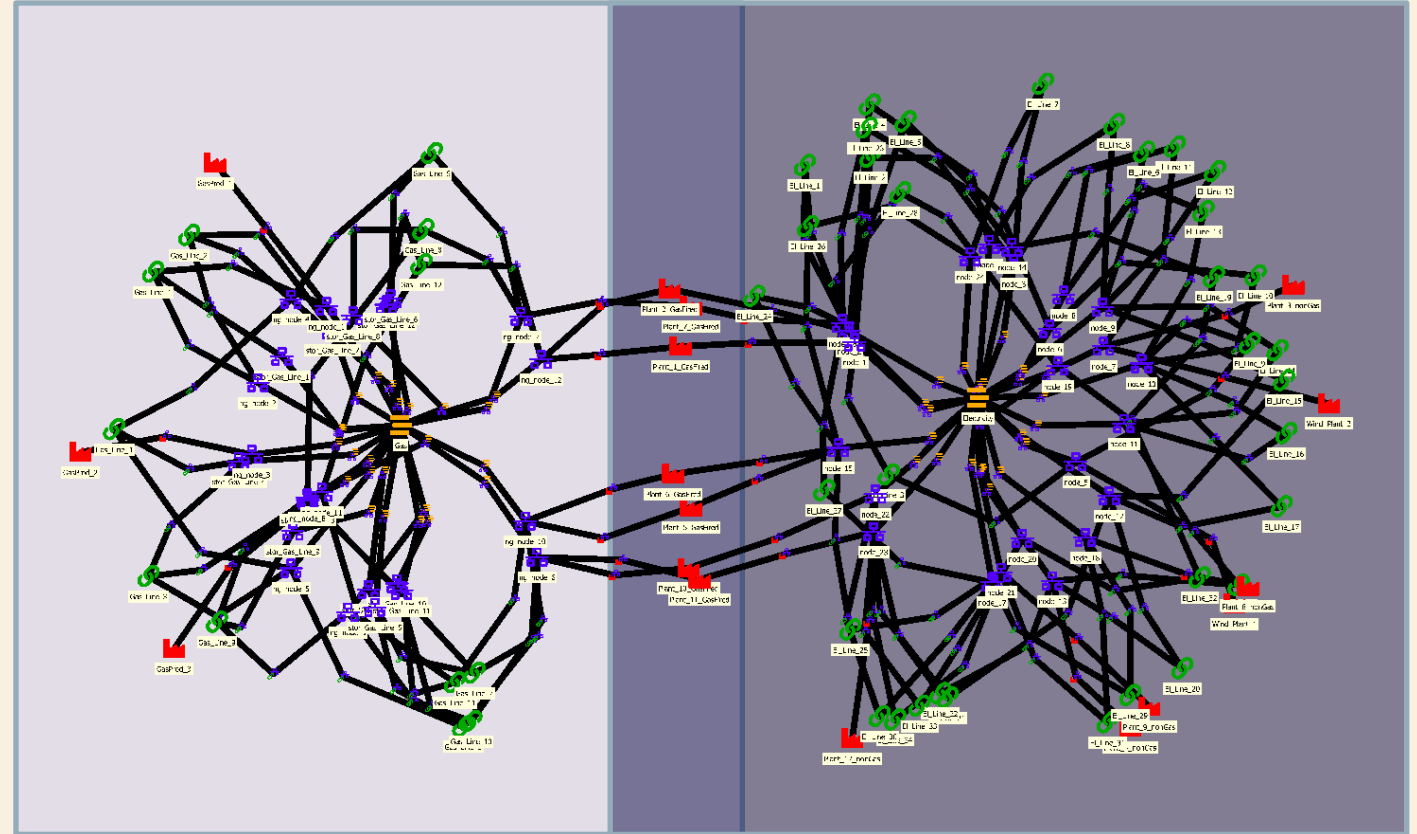
Detailed modelling of different energy vectors including power flows, heat transfers, gas pipelines, river systems as well as energy conversion units

SpineOpt.jl offers flexible temporal and spatial structures



Example of gas-electricity system model in SpineOpt.jl

- Allows different resolutions across the model
- Time resolution can vary over time (e.g. lower resolution further in the time horizon)
- Stochastics only where you need them (e.g. power system)

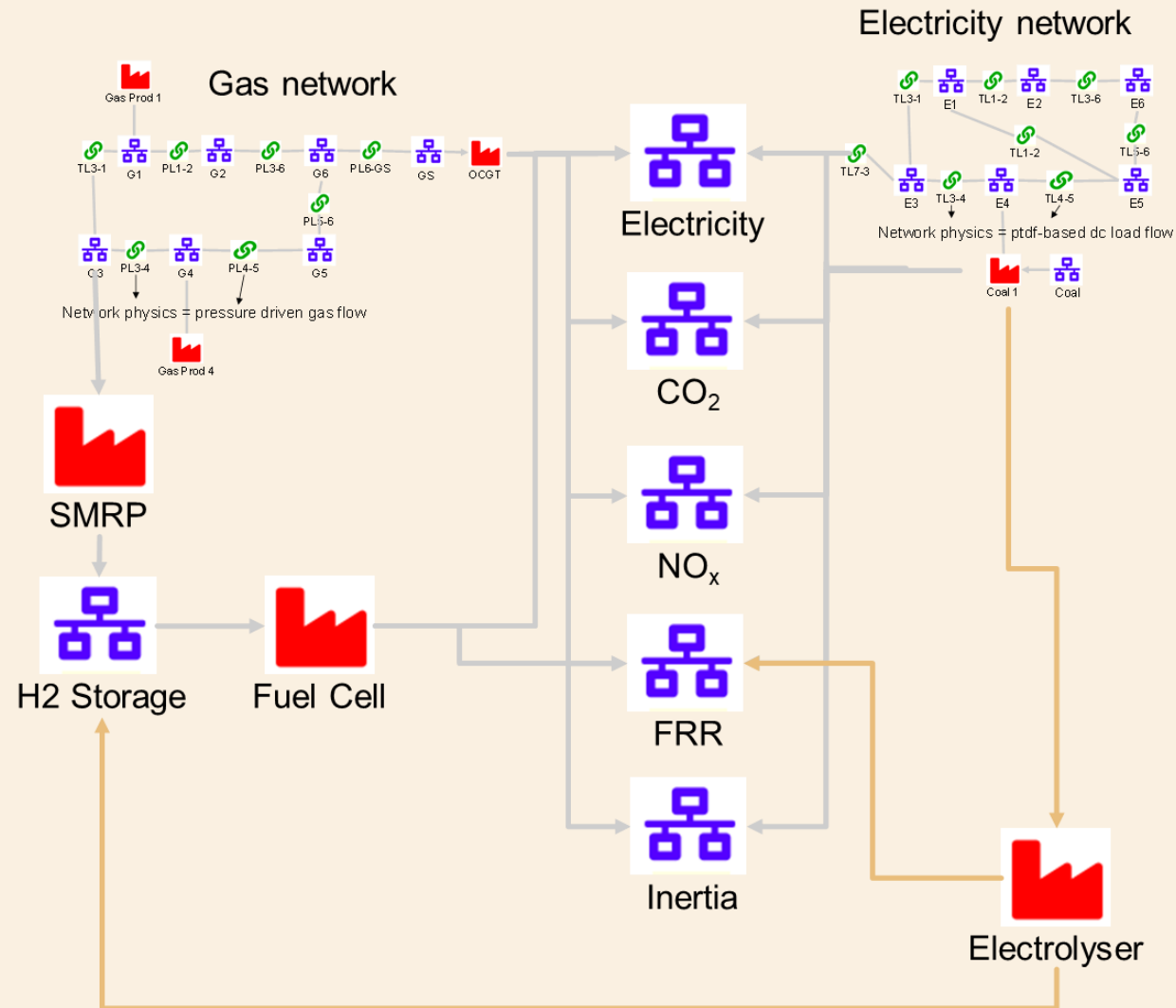


Gas network:
6-hour resolution
Pressure-driven gas flow

Gas-fired
power plants

Electricity network:
30-minute resolution
DC power flow

SpineOpt.jl: Different network physics in one model



SpineOpt.jl: Summary of the main features



Temporal
framework

Stochastic
framework

Unit
Commitment

Ramping and
reserves

Investment
(Multi-year
investment on
the way)

User Constraints

PTDF-based
Powerflow

Pressure-driven
gas transfer

Lossless nodal
DC power flow

Representative
periods with
seasonal storage

Modelling to
generate
alternative
(MGA)

Bender's
decomposition

Multi-stage
optimization

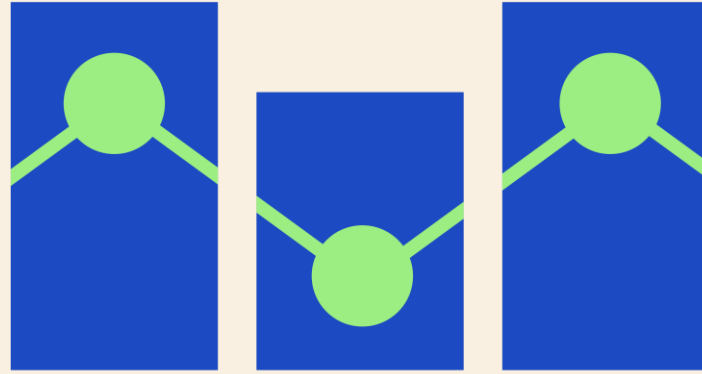
Rolling horizon
optimization

SpineOpt.jl: Speed & Memory Improvements



- Faster save for rolling horizon
<https://github.com/spine-tools/SpineOpt.jl/issues/537>
- Speed up calculation with contingencies
<https://github.com/spine-tools/SpineOpt.jl/issues/574>
- Solve Dual LP problem in parallel for MIP
<https://github.com/spine-tools/SpineOpt.jl/issues/463>
- Resume run after mid-run failure of rolling horizon
<https://github.com/spine-tools/SpineOpt.jl/issues/477>
- Reducing variable history
<https://github.com/spine-tools/SpineOpt.jl/issues/910>





Spine Toolbox

Workflow management software



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Spine Toolbox GUI and Spine DB Editor



File Edit View Plugins Consoles Server Help

Execute Project Selection Stop Run SpineOpt Load template Run SpineOpt detached SpineOpt To Table

SpineOpt plugin

Design View

Generic items Data Store Data Connection Data Transformer Exporter Importer Merger Tool View Specifications New...

Event Log [03-06-2024 15:22:46] Project run_spineopt saved [03-06-2024 15:22:46] New project run_spineopt is now open

Console Select an executing item to see its console

Spine DB Editor

Old Input Data Store

Specification: Load Sysimage Command line arguments Specification arguments Tool arguments

Available resources db_url@Data Store db_url@Results

Execute in Source directory Reuse console id: [Basic console] C:\Use Kill consoles at the end

Entity tree

- root
 - commodity
 - connection
 - connection_from_node
 - connection_from_node_investment_group
 - connection_from_node_user_constraint
 - connection_investment_group
 - connection_investment_stochastic
 - connection_investment_temporal
 - connection_node_node
 - connection_to_node
 - connection_to_node_investment_group
 - connection_to_node_user_constraint
 - connection_user_constraint
 - investment_group
 - model
 - model_default_investment_stochastic
 - model_default_investment_temporal

Parameter value

entity_class_name	entity_byname	parameter_name	a
unit	U_nuclear	online_variable_type	init\$
unit	U_nuclear	unit_availability_factor	init\$
unit	U_nuclear	unit_investment_cost	testi
unit_from_node	U_nuclear nuclear	fuel_cost	testi
unit_from_node	U_nuclear nuclear	unit_capacity	testi
unit_from_node	U_nuclear nuclear	vom_cost	testi
unit_node	U_nuclear A nuclear	fix_ratio_out_in_unit_flow	testi
unit_node	U_nuclear nuclear A	unit_idle_heat_rate	init\$
unit_node	U_nuclear nuclear A	unit_incremental_heat_rate	init\$
unit_to_node	U_nuclear A	fuel_cost	testi
unit_to_node	U_nuclear A	initial_unit_flow	init\$
unit_to_node	U_nuclear A	minimum_operating_point	init\$
unit_to_node	U_nuclear A	unit_capacity	init\$
unit_to_node	U_nuclear A	unit_capacity	ocg
unit_to_node	U_nuclear A	vom_cost	init\$

Alternative

- Old Input Data Store
 - Base
 - batterySelfDisch
 - batteryTransferL

Scenario tree

- Old Input Data Store
 - batterySelfDisc
 - batteryTransfer
 - nuclearMustRun

Parameter value list

- Old Input Data Store
 - balance_type_list
 - boolean_value_list
 - commodity_physical

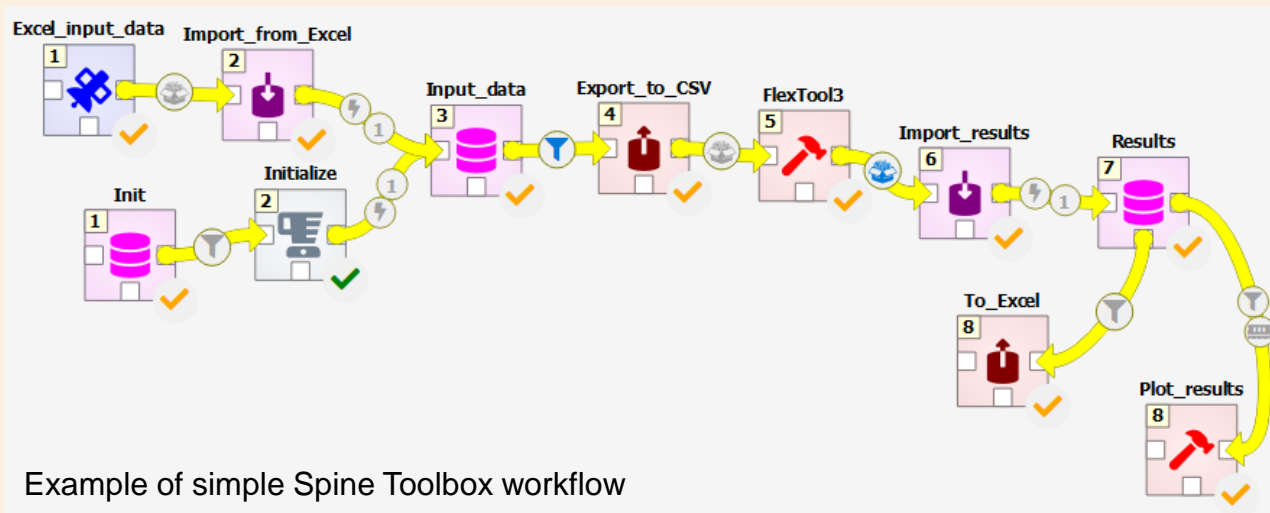
Parameter value Parameter definition Entity alternative Param... M... It...

Spine Toolbox manages workflows and scenarios



Spine Toolbox is an interface to manage data and modelling workflow and acts as a front-end to the other models and Spine packages.

Allows maintaining and sharing repeatable workflows to supply data to different modelling tools. Toolbox includes tools to manage and transform data, data structures, and data formats.



Create scenarios from alternative values and parallelize the execution:

Pivot table			
	lowCost	base	highCost
alternative ▶			
scenario ▼			
base	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
highCost	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
lowCost	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

Spine Toolbox can be used to build new applications. Additional services include:

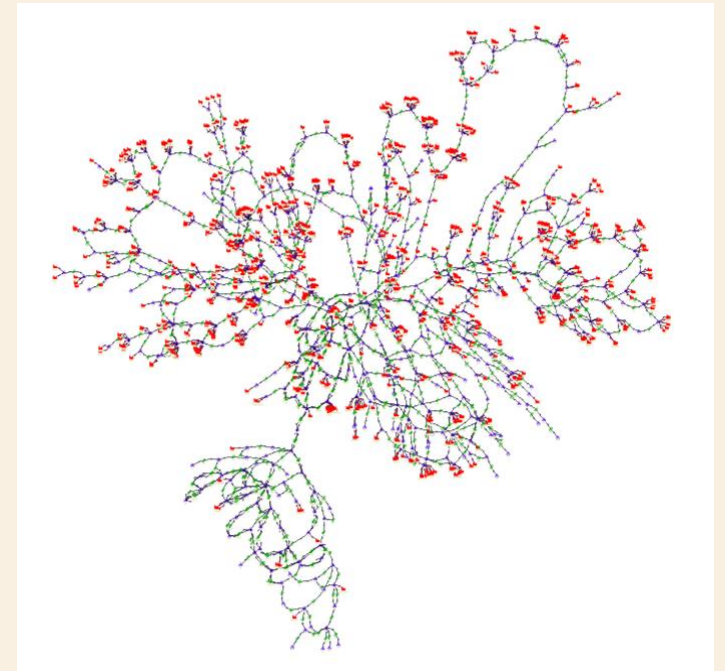
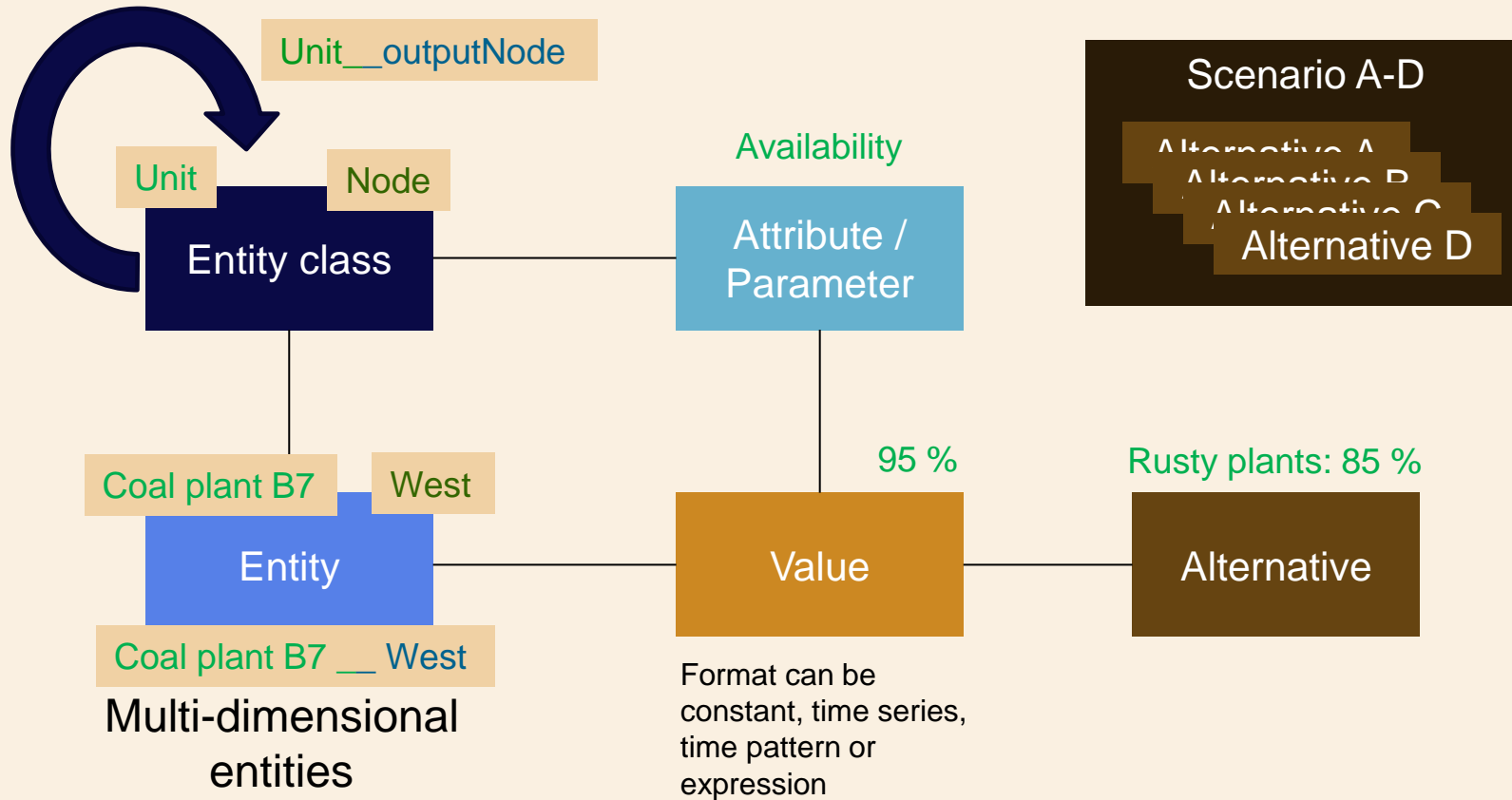
- Visualization
- GIS-based aggregation
- Time series manipulations
- Data structure transformations
- Model/tool couplings etc.

Spine Toolbox has a common data model (Spine based)



This data model allows user-defined entity classes and parameters. Alternative values can be used for scenario building. See examples of each structural item in green.

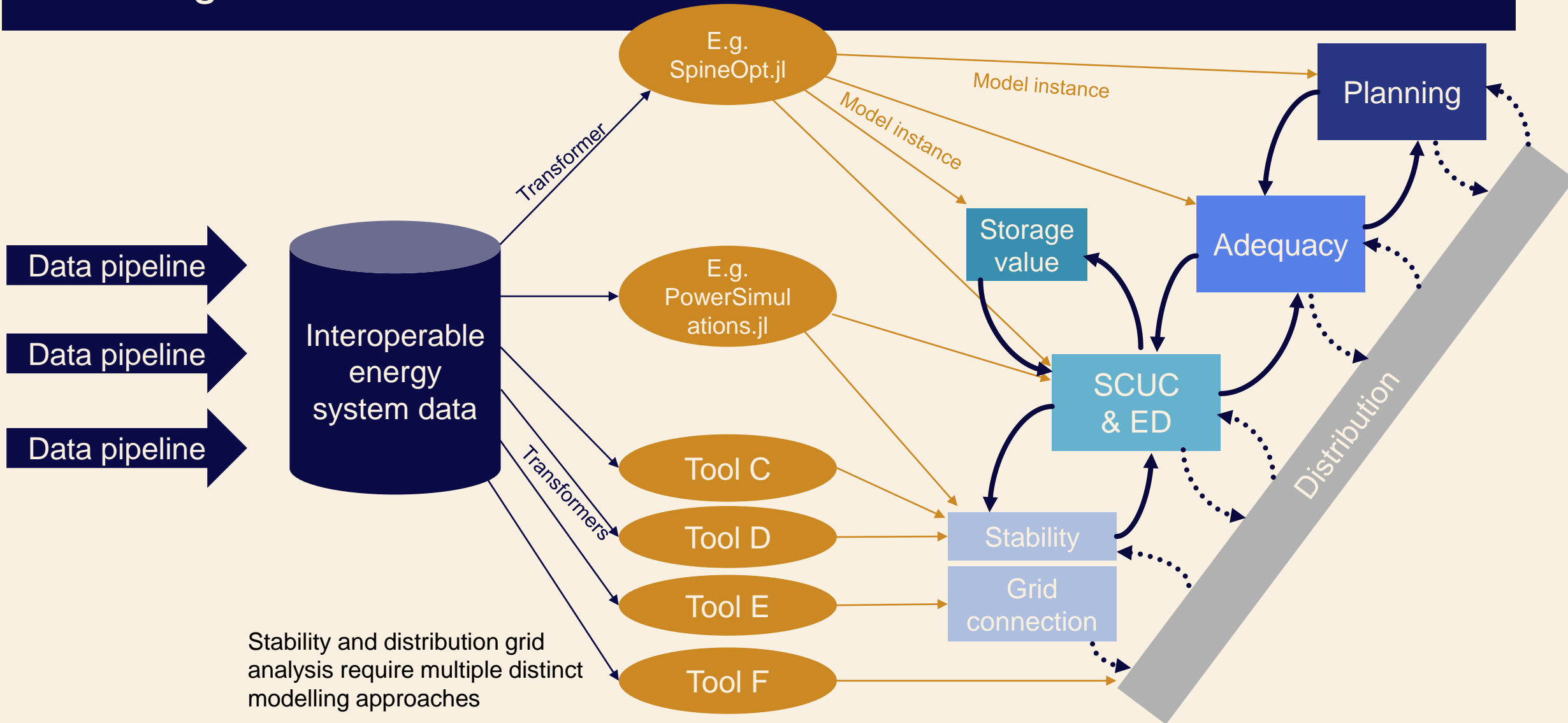
Multi-dimensional entity classes

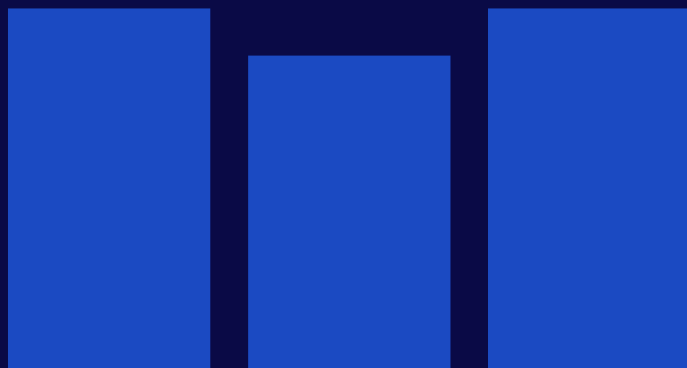


Example entity relationship graph

Enabling this...

Techno-economic optimization can be implemented with one model generator that is configurable for different purposes





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Try out our tools and discovered more:

<https://tools-for-energy-system-modelling.org>

<https://github.com/spine-tools/>



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