Abstract—EU project Spine [1] is developing an open source toolbox and model for energy system modelling. The purpose is to offer a platform for data acquisition tools, data processing tools, and models of different temporal and/or geographic scope. The toolbox will help users to manage data, scenarios and modelling projects. It will allow connecting models of different scope through the toolbox interface. The poster presents the Spine Toolbox user interface, data structure and the interface for connecting external tools and models. It will also introduce the Spine Model, which is an adaptable energy systems optimization model integrated with the Spine Toolbox.

Keywords- Energy; Modelling; Optimization; Toolbox; Scenario; Interface

I. INTRODUCTION

Spine Toolbox [2] is an application, which provides means to define, manage, and execute energy system models that are becoming increasingly complex. It gives the user the ability to organize, collect, create and validate model input data, execute a model with selected data and then archive and visualize the output data. Spine Toolbox provides the following features for the energy system model developer:

- Scenario construction
- Data management and validation
- Data conversion and verification
- Energy system model execution
- Result data visualization

Spine Toolbox is being implemented as a cross-platform desktop GUI application for Windows, Macintosh and Linux platforms. Application architecture is designed to support also other user interfaces, such as a command line interface or a HTML5 based interface. However, desktop application is the first priority. Spine Toolbox will be released as an open-source project to the public in the fall of 2018. The envisioned license for the application and its code is GNU Lesser General Public License (LGPL). You can find details about the license on the Free Software Foundation (FSF) website. Spine Toolbox documentation, manual and all original graphics and icons will be released with the Creative Commons BY-SA 4.0 license.

II. SYSTEM OVERVIEW

A. Spine Toolbox

The objective of Spine is to allow the implementation of a wide range of energy system models that will vary significantly in geographical, sectoral and temporal scope. To support this, Spine Toolbox will utilize problem independent data and user interface structures. A problem independent structure will be able to support many kinds of modelling problems, which is important, as the types of modelling problems are likely to change significantly over time. Even though the structure will be problem independent, Spine still aims to make it easy and intuitive for the user to define the problem to be solved.

The main idea for the application 1 is to give the user a set of building blocks that can be used to construct a project that can solve a problem. Projects contain the necessary input data and the selected external model(s) and it can be executed to produce results. An external model is an external program that the application is able to execute. In Spine, external
models are called tools. A tool object contains a reference to the tool code, external program that executes the code, and input data (e.g. files) that the tool requires. Spine Model will be one of the tools that Spine Toolbox supports.

Spine Toolbox – Simple project

Figure 1. Simple project in Spine Toolbox

Constructing Modelling Tasks from Building Blocks. Figure 1 shows an example of a simple modelling task that could be represented in Spine Toolbox as a project. An initial working name for the part of the application where the building blocks are inserted is called a project canvas. Data store on the left hand side of the project canvas contains the base scenario data. This is combined with a data collection with model definitions and sensitivities by using a recipe block. The output of the recipe block is given to the external model block (tool) for execution. Tool output is saved into another data store block that contains the results. The example is of a simple project that just passes data through the tool to produce results.

B. Data in Spine

Spine will allow Data Connections, which are links to external files that follow a format that the Spine API can access. This data can be used by the Toolbox directly or converted into Spine Data Store. The Spine Data store is a database that uses a generic data structure (entity-attribute-value with relationships and classes) and it allows the Spine Toolbox to display and edit any kind of data. Spine Model uses a specific data structure that is embedded into the generic data structure.

C. Spine Model

Spine Model is under development to become a generic energy systems model that is highly adaptable for different modelling purposes. It will be embedded within Spine Toolbox, which helps the users to manage data, tools and scenarios. Spine Model will take inputs from the Spine Toolbox and translate them into a (multi-stage) optimization problem that uses the equations defined in the Spine Model. After optimization, it outputs the results to the Spine Toolbox. Spine model will use the Spine data structure for the input and output data.

Spine Model is a modelling framework that enables the user to relatively easily build models for different purpose, e.g. investments, scheduling or process optimization. In order to achieve this it will have several features that make it adaptable and flexible:

- Adaptive equations
- Temporal flexibility
- Flexible spatial structure
- Flexible representation of rules and regulations
- Investments included:
- Comprehensive representation of uncertainty
- Generic data structure

Model set-up and data structure. The objective of the model is to determine an ‘optimal’ energy provision. Consequently, it satisfies specified energy services with relevant temporal and spatial constraints corresponding to a classic supply chain problem. However, energy carriers typically have specific characteristics: they typically require a physical network to be transported (network industries) (e.g., electricity or heat cannot be transported by trucks); the time scales for transport are very short (electricity travels almost instantaneously; gas and heat travel slower, but still relatively fast).

The model is fully generic. Equations governing flows or conversions are made as generic as possible in this regard. If required/necessary, certain energy carrier specifics can be added to these, to account for specific dynamics/effects. This also means that none of the objects as listed above is fixed or exhaustive (energy carriers, conversion devices, network/flow characteristics all can be modified/added). User
can always specify additional limitations/options etc. in the data or as additional model code.

The current Spine Model structure uses following categories. Units convert and store energy between different forms. Nodes maintain balance of energy and materials. Connections transfer energy and materials. Commodities are what is being converted, stored and transferred. In addition, there are supporting classes like unit templates and unit groups that help to setup parameter values and give the possibility to change values for multiple units at once.

III. CONCLUSION

Spine Toolbox provides a modelling framework that can combine multiple data sources and tools while giving the user a full view on the modelling process from sources to outcomes. Spine Model is one tool within the Spine toolbox meant for wide range of energy system modelling tasks. Given certain input data set, the model can determine the optimal flows and conversions for different energy carriers, in order to meet the desired end-energy services (with temporal and spatial restrictions). Dependent on the use of the model, parts of the model can be simplified in certain regards, or the model can focus only on a selected setting (e.g., only considering one specific energy carrier).

REFERENCES