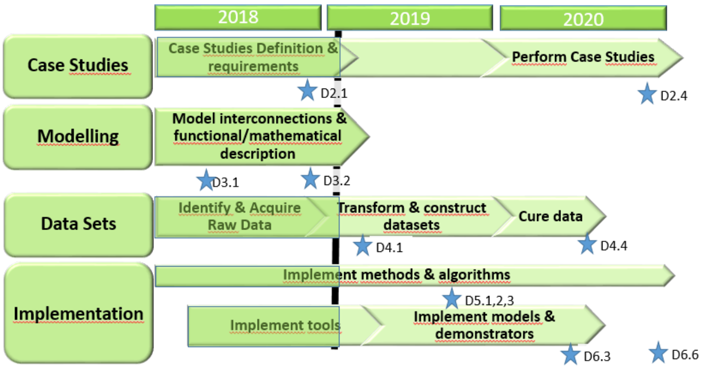
plan4res Newsletter#1, February 2019

The 2030 and 2050 EU's carbon reduction targets are calling for significant changes in our energy system: more flexibility, more active involvement of all stakeholders and more collaboration to enable least-cost integration of higher deployment of variable renewable energy sources. The **plan4res** Consortium aims at filling the gaps between the increasing complexity of the future energy system planning and operational problems, and the currently available Energy Systems Modelling tools, by implementing:

- An **end-to-end planning and operation tool,** composed of a set of optimization models based on an **integrated modelling** of the pan-European Energy System;
- An **IT platform** for providing seamless access to data and highperformance computing resources, catering for flexible models (easily replacing submodels and the corresponding **efficient solution algorithm**) and workflows;
- **A database of public data** and 3 **case studies** highlighting the tool's adequacy and relevance.

Where we are



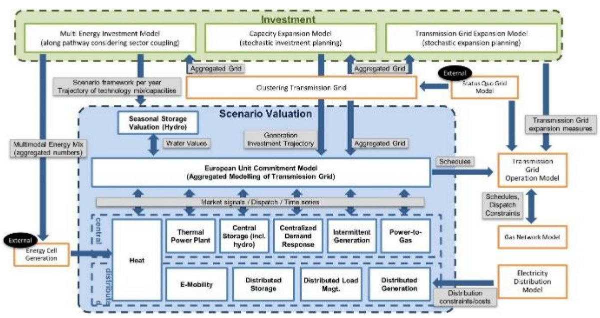
plan4res January meeting in Berlin

plan4res modelling deliverable (D3.1) published

In order to obtain a holistic assessment of the energy system, all relevant aspects have to be taken into account, e.g. investment & operation, grid & market, central & distributed, sector coupling. Since the modelling of these aspects requires customized approaches, the idea of plan4res is to develop a framework that separates the individual components of the energy system into individual model blocks.

The framework is divided into investment related models, scenario valuation/operational models and supplemental/analysis models. The goal of the investment models is to determine the optimal investment decisions for the future energy system. Since the case studies of plan4res have different key aspects, three investment models are defined that are tailored towards the needs of each case study. The core of the scenario valuation is the European unit commitment (EUC) model, which optimizes the operation of the generation units determined by the investment models. A Lagrangian relaxation approach enables to decouple the generation units and define submodels for the different assets in the energy system. This modular approach also allows to only take the submodels into consideration, that are important for the respective case study. Supplemental models are needed to either make input data available that are needed within the investment or valuation models (e.g. clustered version of the transmission grid, distribution reinforcement cost curves) or to perform ex-post analysis e.g. transmission grid calculations for electricity and gas. The latter enables the analyzes of the electric transmission grid regarding congestions, the amount of redispatch to clear these congestions and the capability of the gas grid to include gas provided by power-to-gas units.

Having separate models allows the use of the most promising techniques regarding the mathematical formulation and solving methods for each specific model, thus increasing the computational efficiency of every single model within the framework. However, to secure the functionality of the overall framework, the interconnections between the models have to be well defined.



CRAY THE SUPERCOMPUTER COMPANY · ICOOR · SIEMENS Ingenuity for life · EDF · RWTH AACHEN UNIVERSITY · ZIB · Imperial College London

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773897. It is funded under the H2020 LCE-05–2017 Program – "Tools and technologies for coordination and integration of the European energy system" for 3 years (01-11-2017 to 31-10-2020

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3 real-size Case Studies simulating pathways for the European Energy Transition will be conducted using plan4res tools

Background

To meet the Europe's COP21 carbon targets, much more renewable energy sources need to be installed; this requires an integrated pan-European system promoting strong cooperation and alignment between the individual countries. Within this framework we identified four explicit levers which should be highlighted:

• Maximize the electric grid capacity to host large shares of RES by optimizing the best balance between infrastructure investments and optimum use of all assets

• Maximize the use of all available system flexibilities, including traditional (electricity generation plants….) and emerging (distributed assets, multi energy synergies, …)

• Maximize and raise the potentials that sector coupling may provide to an integrated multimodal energy system to enable an inexpensive transition towards an optimal energy mix while enhancing flexibility and system stability, too.

•Assess uncertainties that climate change, future trends and developments may bring.

Main objective of plan4res

… is to provide enhanced end-to-end planning and operational tools to European system planners, operators, decision makers, regulators to support them when they are dealing with technological and market uncertainty, emerging technologies and sector coupling of multi-energy vectors such as heat, cold and transport. The tool framework can be tailored to the specific needs of different entities and granularity.

Objective of the 3 case studies

To highlight this 'tool flexibility' 3 exemplary case studies focusing on different viewpoints on the energy system and using methods and tools necessary to solve their specific use cases, questions and challenges. A scenario following a common story line and using a joint data set will be analysed to make results comparable and interoperable. Besides this specific sensitives are analysed.

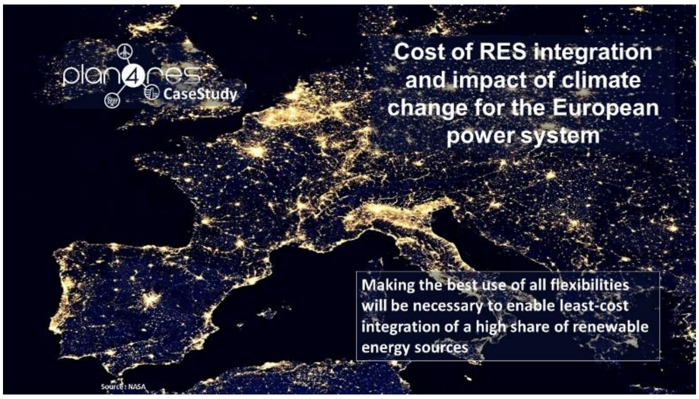
In the document deliverable D2.1 are described …

- Specific questions that each case study aims at answering to;
- Methodology for answering the questions, including a description of the used tools and models used per case study;
- A description of the various sensitivities planned per case study;
- Common assumptions, as well as specific data & data sources;
- Expected results from 3 case studies.

Case Study 1: Multi-modal European energy concept for achieving COP 21 with perfect foresight, considering sector coupling of electricity, heat and cold, traffic, and gas (grid)

Case Study 2: Strategic development of the pan-European network without perfect foresight and considering long-term uncertainties

Case Study 3: Assessing cost of RES integration and impact of climate change for the European electricity system in a future world with high shares of renewable energy sources



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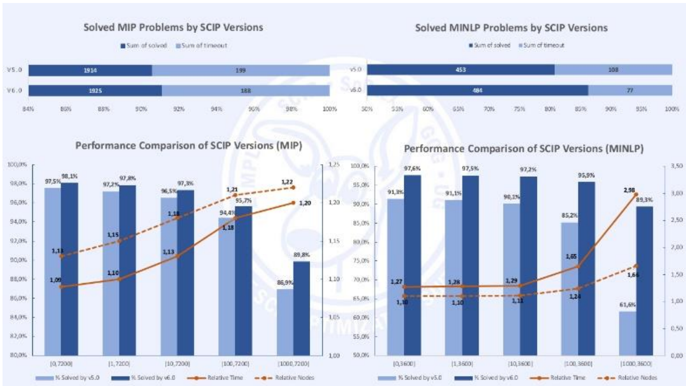
plan4res will rely on SCIP (ZIB), StOPT (EDF) and NDOSolver/FiOracle (ICOOR Pisa) for solving its large scale difficult optimisation problems

The latest SCIP release will help to solve large-scale MIP problems within plan4res

SCIP Optimization Suite 6.0 released on July 2nd, 2018. Compared to the SCIP Optimization Suite 5.0, which is the previous release, SCIP Optimization Suite 6.0 provides 18% and 66% speedup on hard MIPs and MINLPs, respectively, by introducing new primal heuristics and a new selection criterion for cutting planes. Besides these performance improvements of the MIP and MINLP core, decomposition methods are one other focus of this release.

A brand new generic Benders' decomposition framework is released with SCIP Optimization Suite 6.0. This framework eliminates much of the implementation effort for users when implementing Benders' decomposition, a popular and yet difficult to implement method for solving large-scale optimization problems. SCIP Optimization Suite 6.0 provides flexibility for the user to implement Bender's decomposition via alternative methods ranging from completely automatic, i.e., using the automatic decomposition solver GCG, to a flexible approach that allows users customize the algorithm according to their problems. A new version of the generic column generation solver GCG, whose aim is to make decomposition methods more widely applicable also to non-experts, is released within SCIP Optimization Suite 6.0 with a full redesign of automatic structure detection scheme. The new Bender's methods and updated GCG solver are integrated so that they can be used conveniently in combination with GCG's automatic structure detection.

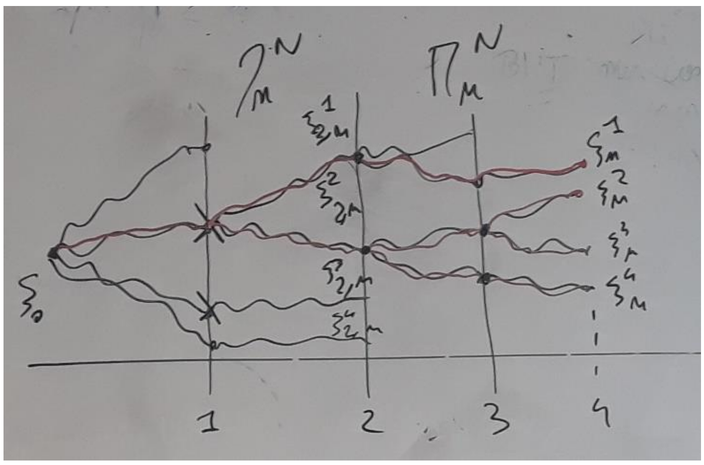


StOpt, an open-source stochastic optimization library for solving large seasonal storage problems

In energy management systems an important question is related to how to appropriately manage resources with a long usage cycle. This question, in particular regarding the management of hydro resources is not new and the foundational principles were laid out already in the 1940s by Pierre Massé. Indeed, in the 1940s he laid the foundations of many principles of optimization, in particular to hydroelectric reservoir management

The fundamental underlying principle of valuing such resources is to account for their best usage in the future, through the computation of a ``substitution cost". Although in the particular case of water, the underlying ``fuel" is costless, it acquires a value through being able to substitute at an appropriate time and situation (it is flexible) for another costly or unavailable recourse. This leads to a fundamental tradeoff between using the resource now or at some moment in the future. Computationally speaking this tradeoff is reflected in a recursive equation, frequently called the Bellman equation, which links value at current time to future value. This recursive equation is of the following type: the value at the current time and current level of available resources is the cost minimum over currently available actions implying an instantaneous cost to which we add the future value with updated level of resources. Obviously over long-time spans uncertainty has to be accounted for, which thus modifies the above principle by adding additional (conditional) expected costs. Technically speaking, managing these hydro resources requires using tools from stochastic optimization.

EDF has recognized the value of stochastic optimization and developed appropriate tools since the 1940s, and recently the developed the StOpt library, an optimization toolbox for handling various stochastic optimization problems. It includes a set of solving methods among which stochastic dual dynamic programming (SDDP), which will be used in plan4res.



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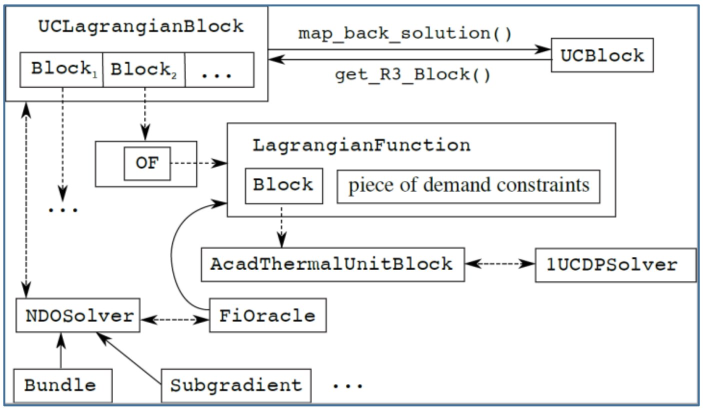
NDOSolver/FiOracle, for solving problems induced by decomposition algorithms

The NDOSolver/FiOracle C++ suite of NDO solvers has been developed at the Department of Computer Science of the University of Pisa over the last 25 years. The structure of the software centers on a very clean separation between the problem to be solved, i.e., an "oracle" for a nondifferentiable function, and the algorithm that solves it. For specific applications like decomposition of structured programs, information has to flow between the two not necessarily in the "obvious" direction (variable values from solver to oracle, function results from oracle to solver), but also in the opposite one to allow implementation of sophisticated algorithms that exploit all the generated information to produce solutions to the original problem.

The interface set by the NDOSolver/FiOracle pair allows for all the necessary information exchange, allowing strategies such as dynamic variables generation, in turn dependent on the computation of "convexified" primal solutions that are also useful for branching and/or heuristics. Yet the interface cleanly separates solver from oracle, allowing to seamlessly test on the same problem algorithms belonging to different classes, like different variants of cutting-plane-type and subgradient-type methods. This is important because which algorithm is more efficient depends on the specific application, as well as on fine details about how the information gathered while computing the function is used to construct its model(s) that drive the solution process. In particular, more sophisticated models can significantly improve the convergence rate of algorithms, also specifically on energy applications, albeit possibly at a significantly increased cost for the so-called master problem.

The flexibility provided by the general NDOSolver/FiOracle interface allows to navigate the complex trade-offs between master problem time, convergence speed (number of iterations) and function evaluation time by developing the problem-specific code (the FiOracle) only once, and then deploying whatever general-purpose NDO approach (the NDOSolver) is better suited for this task. The algorithms implemented in the framework are state-of-the-art and offer several features that either only a few other comparable solvers provide, like dynamic variables generation and inexact function computation, or are even unique, like complete support for reoptimization after all possible kinds of changes in the problem and the use of nonstandard models like the "easy components" one. Therefore, this software framework provides a solid foundation upon which to construct the approaches for the extremely demanding, very-large-scale problems required by the plan4res project.



European clustering

We are very proud and happy of being part of the European cluster on Energy System Modelling, which is organising events and discussions involving 8 H2020 funded projects and Officers from INEA.

The major event will be the EMP-E 2019 conference, co-organised by the 8 projects, to be held on 8-9 October, 2019 in Brussels, as part of the Energy Modelling Platform for Europe.

http://www.energymodellingplatform.eu/home-emp-e-2019.html

To know more

Visit our website and follow us on LinkedIn and Twitter

www.plan4res.eu

contact@plan4res.eu

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