Interreg CENTRAL EUROPE

Co-funded by the European Union

HyEfRe

D.1.2.2 User Manual for Hydrogen Potential Model Tool

Version 0.2

06/2026



IMPRINT

PROJECT DETAILS

Project title	Hydrogen integration for efficient renewable energy systems
Acronym	HyEfRe
Programme	Interreg Central Europe Programme
Programme priority	Cooperating for a greener Central Europe
Programme priority Specific objective	Supporting the energy transition to a climate-neutral Central Europe
Duration	6/2024 - 11/2026
Project website	Landshut University of Applied Sciences
Lead partner	www.interreg-central.eu/projects/hyefre/
Project ID	CE0200523

SHORT DESCRIPTION

Sector coupling is a promising approach to replace fossil fuels with renewables. However, this idea of “electrifying” the entire economy requires the rollout of new technologies and rules. The HyEfRe project helps with this by establishing green hydrogen ecosystems in eight regions. Partners will foster an investment-friendly environment for renewable energy and green hydrogen technologies. They evaluate hydrogen potentials with a new model and develop and test a new tool to calculate ideal parameters for technical plants. Their action plan for policy actors will reduce regulatory barriers impeding a timely expansion of renewables and green hydrogen.

DOCUMENT DETAILS

Title of the document	User Manual for Hydrogen Potential Model Tool
Activity	A.1.2 Hydrogen potential model
Deliverable	D.1.2.2 User Manual for HPM Tool
Author	EIHP
Organization	EIHP
Version	
Date	

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EXECUTIVE SUMMARY

This deliverable presents the implemented and deployed version of the Hydrogen Potential Model tool, an easy-to-use web-based analytical tool, designed to help local decision makers perform preliminary local hydrogen generation capacity, based on the surplus renewable electricity availability.

The model estimates the hydrogen production potential from surplus renewable energy by using hourly data on renewable electricity generation and energy demand. Based on the selected hydrogen production technologies, it calculates the corresponding quantities of hydrogen carriers that can be produced.

In addition, the model supports the simulation of different renewable energy deployment scenarios. Where historical renewable generation data are not available, simulated datasets can be used. This functionality also enables what-if analyses to assess the impact of planned renewable energy installations and their contribution to future hydrogen production potential.

Leveraging prior expertise from PP6 and PP10, with collaborative support from LP, PP5, and PP7, the model is designed to be accessible to municipal and rural planning non-experts. Additionally, the model is compatible with the Decision Support Tool developed in A1.3, allowing integrated usage.

This user manual is accompanied by a video guide representing the same content in a more accessible form.

The video guide is accessible at https://hyefre.eu/tutorial.mp4

DOCUMENT HISTORY

Number	Date	Author(s)	Partner(s)	Description
0.1	28.01.2026		PP6 EIHP	The first version of the manual for the usage of the hydrogen potential model.
0.2	01.06.2026		PP6 EIHP	The second version of the manual for the usage of the hydrogen potential model.

1. Introduction

As part of the transition towards a sustainable and low-carbon energy system, green hydrogen has emerged as a promising solution for integrating renewable energy sources. Green hydrogen is produced through electrolysis using surplus renewable electricity, enabling the storage and utilisation of renewable energy that would otherwise be curtailed. However, deploying hydrogen infrastructure requires significant investment, making proper planning, siting, and sizing of hydrogen production facilities essential. Given the local nature of renewable energy resources and energy demand, regional and municipal authorities play a key role in planning and decision-making processes.

Despite the growing interest in hydrogen technologies, local stakeholders often face challenges in applying advanced decision-support tools. Such tools typically require extensive and complex input datasets, which are not always readily available. Even when alternative data sources exist, preparing the required inputs can be time-consuming and technically demanding. As a result, the use of sophisticated modelling tools is often limited, particularly in the early stages of project development. Furthermore, the interpretation of modelling results and the comparison of alternative investment and operational scenarios can be difficult for non-specialist users.

To address these challenges, this deliverable presents a simple, user-friendly analytical tool for the preliminary assessment of local hydrogen production opportunities. The Hydrogen Potential Model (HPM) evaluates the potential for hydrogen generation based on the availability of surplus renewable electricity and provides an accessible framework for assessing the feasibility of investments in hydrogen production capacity.

The HPM is intended to support preliminary decision-making, what-if analyses, and sensitivity assessments. For more advanced analyses requiring detailed technical and economic modelling, users can utilise the full-scale Decision Support Tool (DST) developed under Activity A1.3. The DST enables the optimisation of hydrogen hub design and offers extensive customisation of technical, operational, and economic parameters.

While the HPM is based on the same modelling framework as the DST, it focuses on a selected set of key local parameters that are most relevant for the initial evaluation of hydrogen production potential. This approach significantly reduces the complexity of the analysis while still providing valuable insights for early-stage planning and investment decisions.

A video tutorial accompanies this user manual on tool usage: https://hyefre.eu/tutorial.mp4

2. Getting Started with the Hydrogen Potential Model

his short introduction explains what the tool does, who it is for, and how to use this manual. If you are opening the tool for the first time, this is the place to start.

2.1. What the tool does

The Hydrogen Potential Model is a free, web-based tool that gives you a first estimate of how much green hydrogen your area could produce from its surplus renewable electricity – the renewable power that is generated locally but not immediately used.
Green hydrogen is made by using that surplus electricity to split water through electrolysis. It offers a way to store and make use of renewable energy that might otherwise go to waste. Building the equipment to produce it is, however, a significant investment, so it pays to check the potential before committing to detailed studies. That first check is exactly what the HPM is designed for.

If you're a local decision-maker with limited technical resources, this tool is for you.

2.2. Who it is for

The HPM is made for local and regional decision-makers – municipal and rural planners, regional authorities, and project developers who want to explore hydrogen production in their area. You do not need to be an energy-modelling expert, and you do not need specialist software or large, hard-to-find datasets to get a useful result.
What you can do with it
With the HPM you can:

- estimate how much hydrogen you could produce from the renewable electricity surplus in your region;
- test "what-if" ideas – for example, how a new solar or wind installation would change the result;
- compare different options side by side; and
- see indicative economics, such as the cost of the hydrogen produced, the payback period, and the size of the equipment you would need.

Because it is quick and simple, the HPM is best used **early on**, to decide whether a hydrogen idea is worth pursuing before you invest time and money in a full technical study.

2.3. What you need to get started

To use the tool you only need:

- a modern web browser – there is nothing to install; and
- a working email address, used once to register your account.

You should have **hourly data** on renewable electricity production and/or energy demand for your area, saved as simple CSV files.

However, even if you do not have this data – for example, for a power plant that has not been built yet – the tool can generate realistic wind and solar production data for you from a location and an installed capacity.

2.4. How the tool works, in three steps

Working with the HPM always follows the same three phases:
1. Prepare a scenario. A scenario is simply a container that holds everything about one analysis: the region, the production and demand data, and the settings you choose. You define your region and add its renewable production and energy demand.
2. Run the calculation. When your scenario is ready, you submit it. The tool works out the most cost-effective way to produce hydrogen from your surplus energy and prepares the results for you.
3. View and compare the results. Once the calculation is finished, you can review the outcome and compare it against other scenarios.

Each of these steps is explained in detail, with screenshots, later in this manual.

2.5. A preliminary tool – and where and when to go further

The HPM is designed to give a fast, approximate answer for early-stage planning, and it deliberately keeps the number of settings small so that it stays easy to use. When you are ready for a detailed design – with full technical, operational, and economic optimisation – you can move on to the companion Decision Support Tool (DST), developed in this project as well.

The two tools share the same modelling foundation – the calculation engine is the same - so your preliminary work carries over naturally.

2.6. How to use this manual

The rest of this manual takes you from background to hands-on use:

Chapter 3 explains the ideas behind the tool – how it calculates the renewable energy surplus, what a scenario is, and how the tool is built.
Chapter 4 is the step-by-step guide, from registering and logging in through to viewing your results, illustrated with screenshots throughout.

A short video tutorial accompanies this manual and covers the same material in a more visual form. If you prefer to watch before you read, that is a good place to begin.

3. Tool Usage Context

3.1. General Concept of the Tool

This chapter provides the general context for the Hydrogen Potential Model tool usage. This tool, as explained previously, is directed towards local decision makers to help in the process of proper evaluation and initial siting and sizing of the hydrogen production capacities. In this chapter, assumptions and decisions relevant for the tool usage are explained, and in the subsequent Chapter 3, the actual tool usage is illustrated with the screenshots of the tool.

There are three distinct phases of the tool usage:

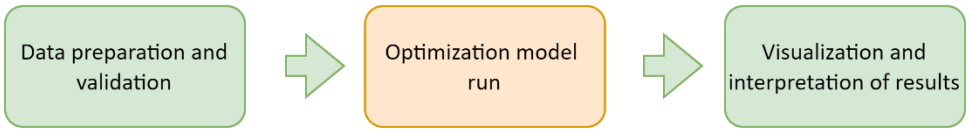


Figure 1. Three distinct phases of the tool usage

The input data preparation, validation and loading into the model serve to model the "typical year" in an hourly format. This has been chosen as a reasonable trade-off since hourly modelling for a year adequately covers the surplus time series, both during the day and considering the seasonal variations in different parts of the year. That surplus significantly depends on the types, sizes and location of renewable energy production capabilities – and modelling a typical year with 8760 hourly values represents a reasonable trade-off.

One of the challenges when sizing the equipment is to choose the right amount of capital expenses for the available renewable energy surplus. This is the task of the optimisation model, which is implemented as a mixed-integer linear program that models the whole year in one go. It utilises the mathematical solver engine and figures out the most suitable and cost-efficient topology of the hydrogen production equipment, respecting the characteristics of the renewable energy surplus and basic economic parameters supplied to the model.

Once results are available, these can be evaluated and compared to serve as decision support. The users then can continue further and more detailed evaluation of their prospective hydrogen production project, the full-scale modelling application developed within Activity 1.3 of this project.

As already stated, the mathematical optimisation model considers different topologies and configurations of the hydrogen generation capacity. The internal optimisation decision variables model this configuration, and its constraints and optimisation functions are configured by user inputs.

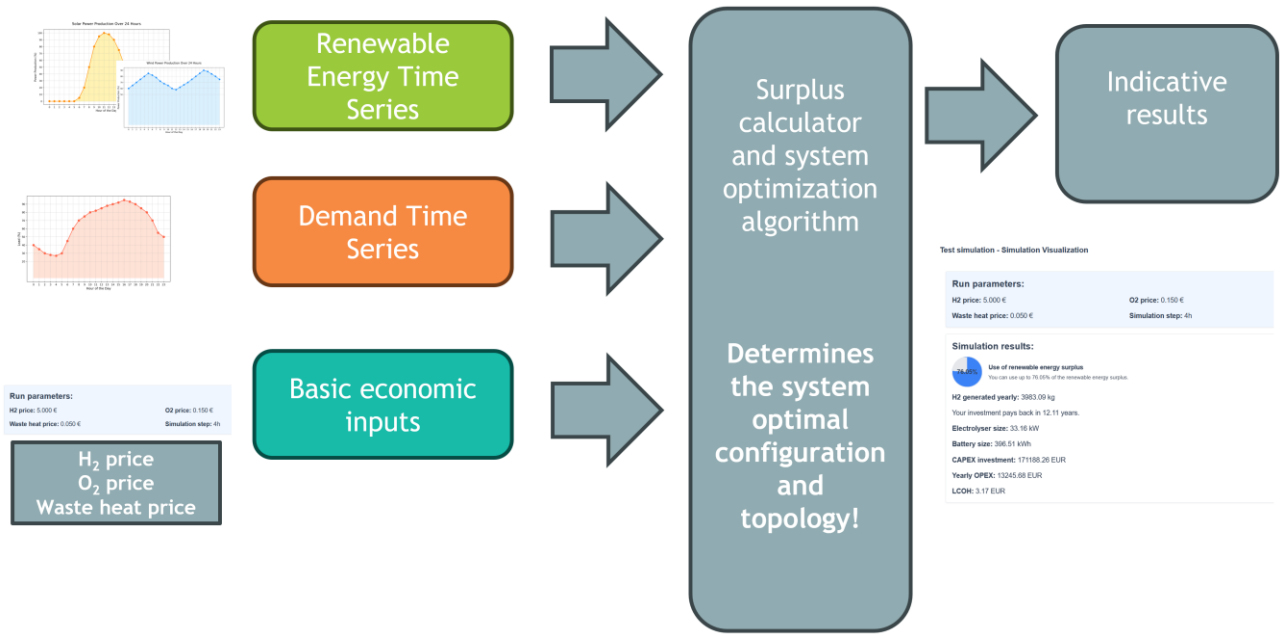


Figure 2. Illustration of optimisation algorithm implementation

3.2. Energy Surplus Calculation: Production and Demand

The first and most important information is the renewable energy surplus. This comes from the temporal difference between the production and demand.

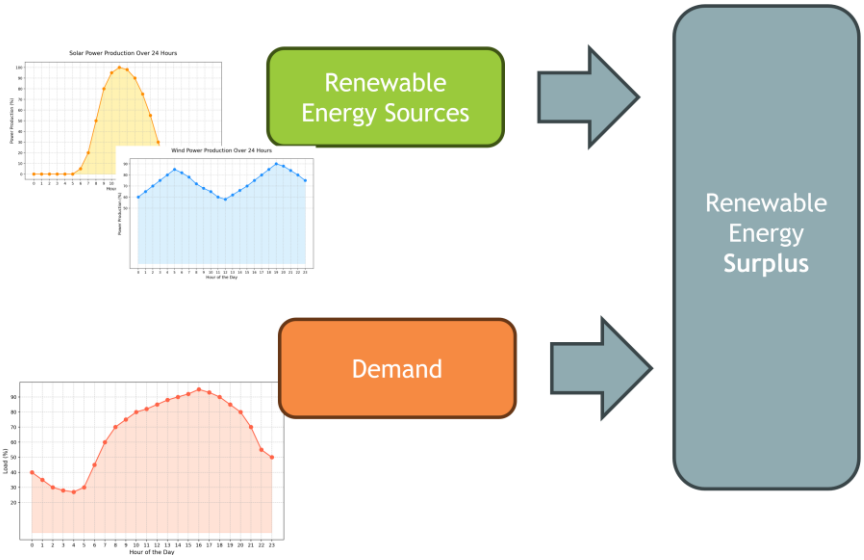


Figure 3. Illustration of the context of tool usage - Renewable energy surplus calculation

There are two main ways to input the surplus in the hydrogen potential model:

- It can be precalculated elsewhere and entered as “net demand” or

- Production from renewable sources *and* the actual demand can be input into the tool, and the tool calculates the demand on an hourly basis.

In all cases, we are modelling the whole year; what the user needs to provide is a time series of 8760 values in kW. The file format is a simple CSV format with 8760 rows, with a numeric value in each row. It is reasonably simple to prepare such a file in Excel, and one can use Notepad or another plain text editing application to confirm the format is correct. The time stamps are not considered, as we consider “a typical year” in the model.

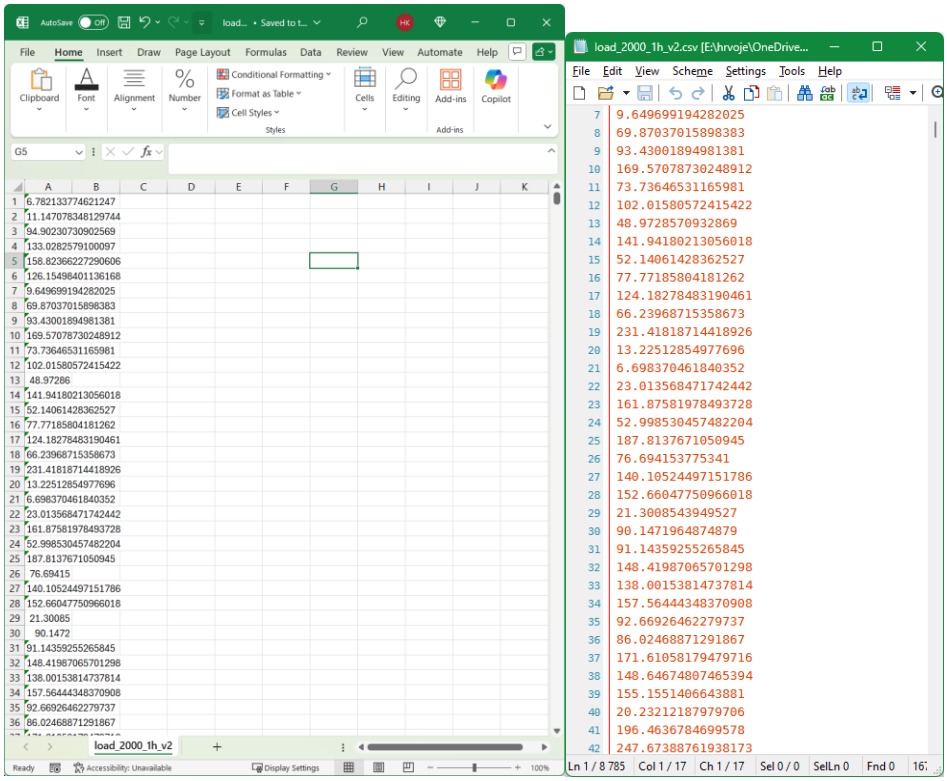


Figure 4. Time series data in a CSV format - Single value per line

The data source for the production data may vary.

The actual, already existing power plants in operation, the production data can be recorded from the energy meters metering the exported energy or, as is typically the case, exported from the inverter cloud manufacturer software. In the case of larger power plants, relevant measurements may be exported from SCADA software. In these cases, the users only need to resample a typical year of operation to hourly values and save the data in CSV format.

In cases where we consider a prospective power plant or a power plant where actual data is not available, there is an option to use simulated data, derived from meteorological reanalysis. Meteorological reanalysis is an approach where a numerical weather forecast model is used together with actual measurements to get a consistent set of longer-term weather data. Reanalysis systems use advanced computer models to "replay" past weather events, incorporating the recorded historical data (such as surface measurements, satellite observations, and weather balloons) into a single, coherent dataset. This way,

reanalysis provides a uniform dataset, making it easier to compare conditions over time and space. By using consistent atmospheric models, these models cover the Earth's surface – indirectly for locations with no recorded data. From the atmospheric data obtained this way, initial evaluations of performance for renewable technologies such as wind or solar power can be done.

The hydrogen potential model described here already includes a feature to synthetically generate solar and wind power. The data is synthetically generated from the meteorological data for insolation and wind power, and using a typical power curve, hourly values of production are calculated. The inputs required are the power plant location, technology type (wind or solar) and the peak installed power. This does not offer the same level of data quality as the actual data, but it is a reasonable fallback – particularly when eventual new investments in new power plant developments are considered. Here, the data sources are MERRA-2[1] reanalysis data originally developed by NASA, processed by the Renewables.ninja[2] website and finally with additional customisations developed by the authors of the PyPSA open-source modelling tool[3].

For the demand data, as this is highly dependent on the actual region being modelled and a synthetic, generally valid model of the demand is not possible, but the users can prepare the data in virtually any type of energy modelling software they already use and export the data in the simple CSV format described above. There is an option to preprocess the data and calculate the surplus in another modelling software that may be available to the users. The HPM model can use this data as well – then the users don't need to input explicit demand into the model.

[1] https://climatedataguide.ucar.edu/climate-data/nasas-merra2-reanalysis
[2] https://www.renewables.ninja/
[3] https://github.com/PyPSA/atlite

3.3. The Notion of a Scenario

The application revolves around the concept of a **scenario**. A scenario is a "data bundle", a "container" that groups all the **input data** (geographical extents of the region, locations and time series of production and demand points) considered for this scenario, as well as all the **other parameters** (such as the main cost parameters for the produced hydrogen), and finally the **simulation results**.

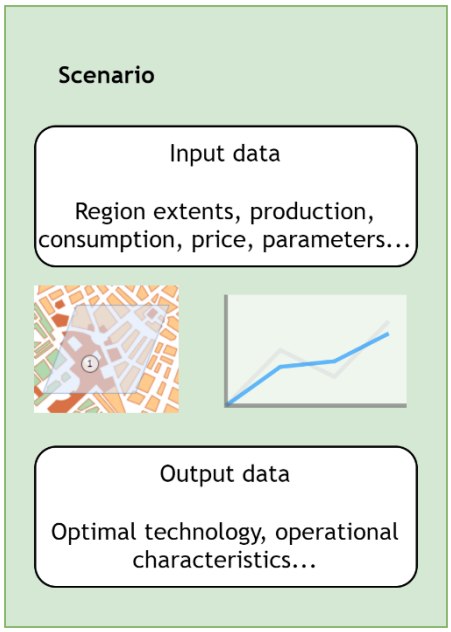


Figure 5. The concept of a scenario as a container for one analysis run

This container or data bundle approach allows easier replicability and what-if analyses. The output data are repeatable – with the same input data and all the same parameters, the results should always be the same, as the mixed-integer optimisation problem at the heart of this tool is an exact model – all the modelling approximations and assumptions considered. To model a what-if or a sensitivity analysis, one starts with a base case scenario and then varies the inputs. Examples are adding a new planned renewable power plant and comparing the results of that scenario with a base case scenario or altering the pricing parameters for the produced hydrogen.

3.4. Technical details on tool implementation

The tool is designed as a web application, requiring no installation on client computers, and uses open-source technologies in all parts of the technology stack.

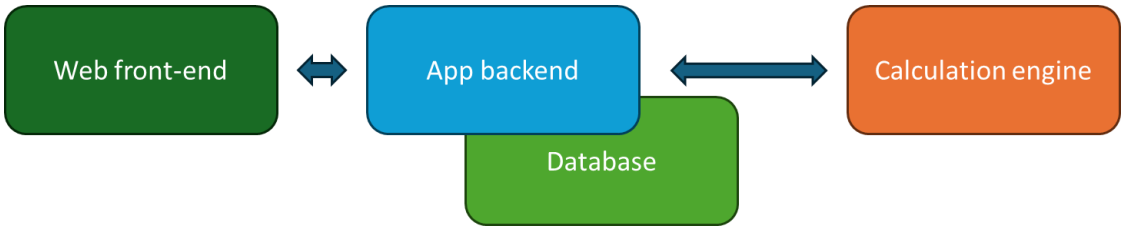


Figure 6. The four main modules of the HPM tool

There are four modules of the application:

- **Web front-end** client, developed using Vue.js[4] progressive JavaScript framework and compatible with all modern Web browsers; served as static web pages using Caddy web server and running within the client web browser
- **App backend** developed in Python programming language using FastAPI[5] interfacing technology
- **Database** serving as a storage for the user-defined scenarios, implemented as a PostgreSQL[6] database extensions to reliably handle time series data
- **A calculation engine** that runs on a separate machine is implemented in Python, and uses a high-performance open-source HiGHS[7] solver engine; its modelling core is the same as the tool developed by UNIZG-FER in Activity 1.3 of this project

The web server and the app backend are implemented in a virtual machine hosted in Europe[8], and the calculation engine runs on a separate, on-premises machine running on premises of EIHP. The reason for this split is the high computational power and memory requirements of the optimisation algorithm. The algorithm models the whole year and additionally needs to model different topologies within the optimisation algorithm and thus has very high requirements on RAM memory and computing power.

As the best trade-off between flexibility and security, this hybrid cloud + on-premises configuration has been chosen for this implementation. The optimisation algorithm operates on a queue principle – it processes the scenarios in the order of their preparation, so the typical workflow consists of preparing the data, submitting the scenario for

[4] https://vuejs.org/
[5] https://fastapi.tiangolo.com/
[6] https://www.postgresql.org/
[7] https://highs.dev/
[8] https://www.hetzner.com/

execution, and, once the execution is completed, inspecting the results. This means the optimisation happens asynchronously.

The application security is implemented according to the best practices. All traffic is transport layer encrypted (encrypted in transit); the freely available HTTPS certificates issued by LetsEncrypt[9] Are used on all servers. When the user authorises, the server issues a temporary authorisation token to the user. This token is valid for half an hour and is sent as a bearer token for each API request to the app backend.

Additionally, the communication between the calculation engine and the app backend is ensured via a VPN connection, using OpenVPN[10]. No plain text storage of passwords is implemented anywhere, and servers are accessible using SSH key pairs.

[9] https://letsencrypt.org/
[10] https://openvpn.net/

4. Tool Usage Manual

4.1. Accessing the tool

No prerequisites for installation on any user's computer are necessary beyond a reasonably modern web browser.

The tool is accessible at https://hyefre.eu

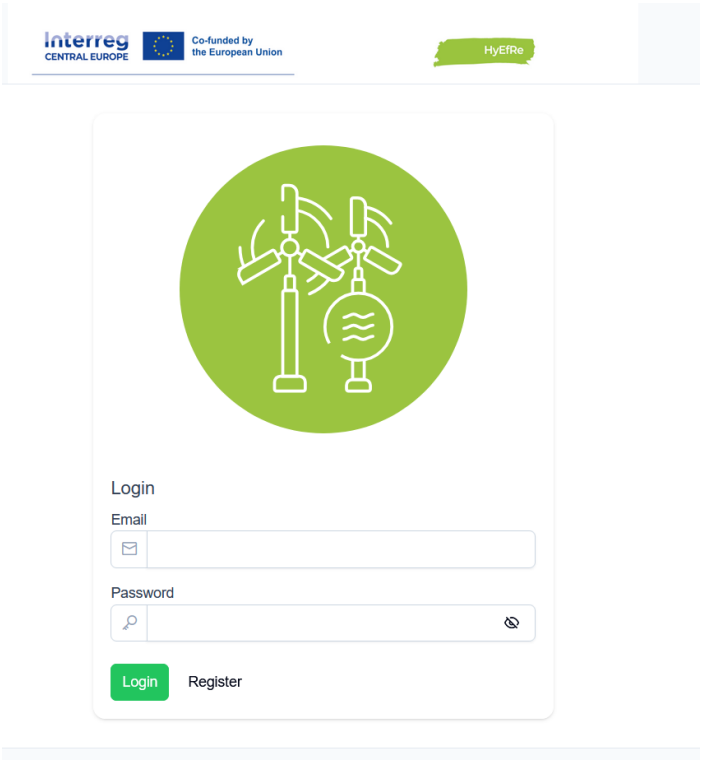


Figure 7. The tool landing page

The user is then presented with a landing page. The tool supports multiple user interface languages, and you can choose the language directly on the landing page in the upper-left corner. To use the application, you need to become a registered user of the application, but the registration process is simple and only requires the user to have a working email. This process is required only once.

After visiting the landing page, on the first page, choose the Register button.

Once you enter a valid email in the email field, click Register.

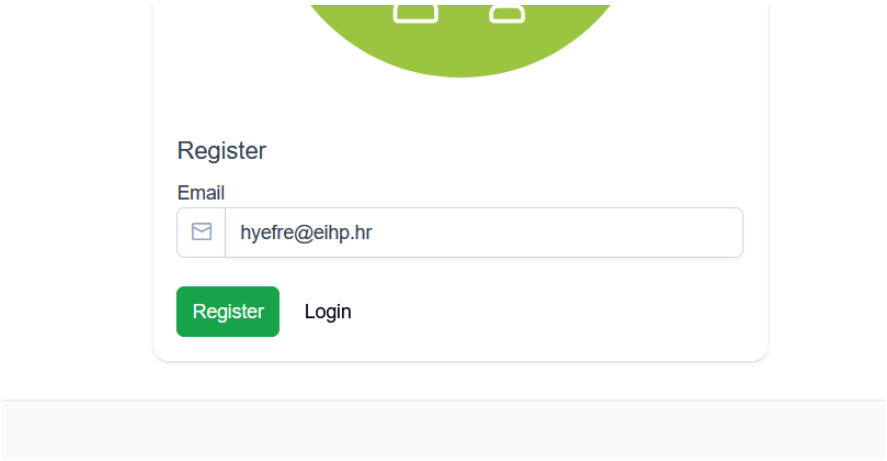


Figure 8 The tool landing page – registration

You'll then be presented with a window to activate your user account and choose a password.

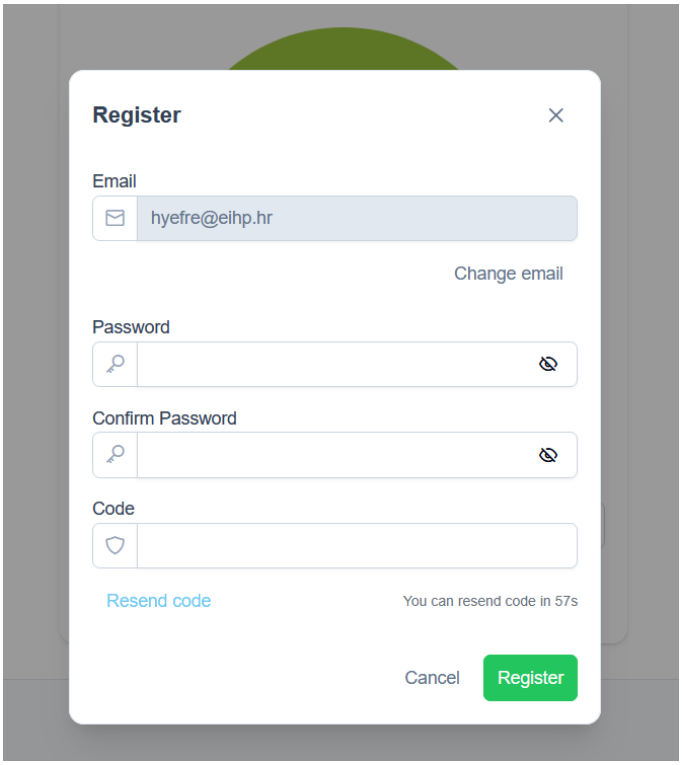


Figure 9 Password confirmation and validation

We suggest not reusing any passwords you use for other websites, and it's best not to use passwords beginning or ending with whitespace. Passwords are case-sensitive.

You need to enter the password twice to confirm, and if the passwords differ, you won't be able to proceed. Finally, by checking your e-mail account, you'll get a numeric code to be entered in the third field.

Although we're using a mailing provider that shouldn't end up in your spam mailbox, please also check your spam mailbox if you haven't received the code in a minute or so. Finally, you can resend the code if you have mistakenly deleted it.

Once you complete this process, you can log on to the application and begin modelling.

4.2. Scenario List

Once the user logs in, the main tool page is shown. It is a list of scenarios that can be easily filtered using the search box above the scenario list.

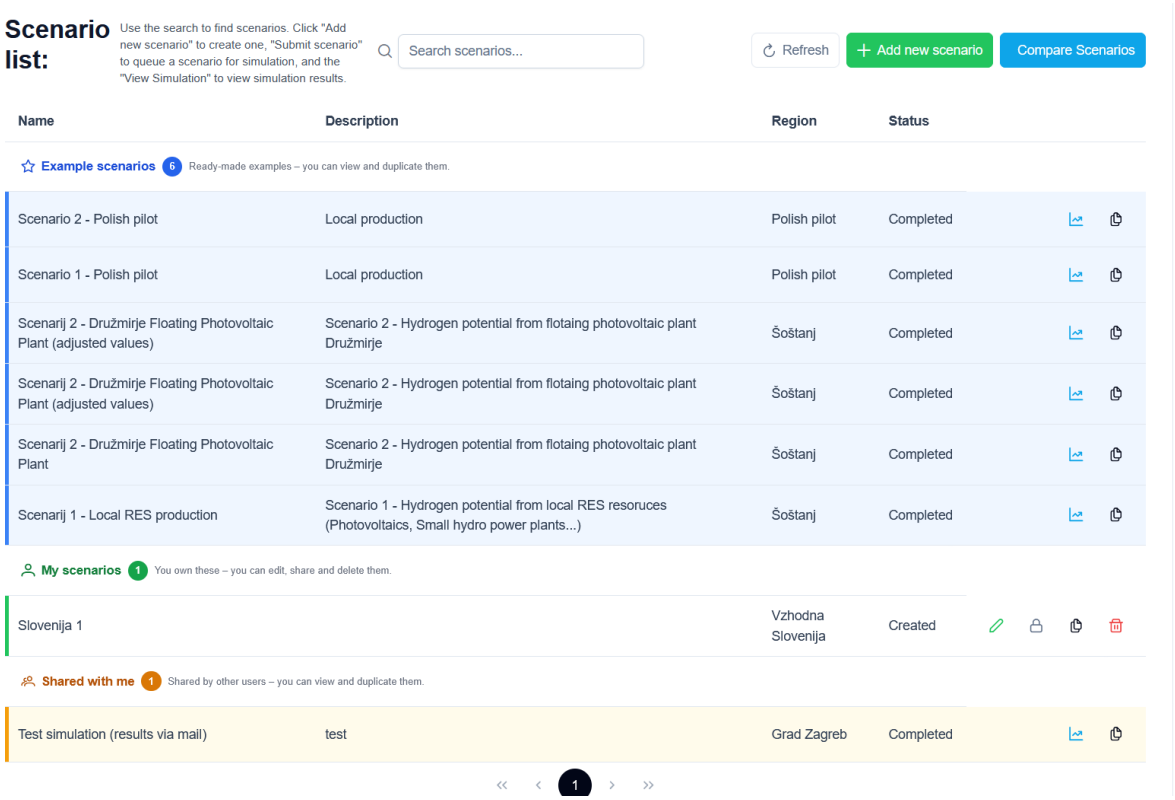


Figure 10. The list of scenarios

The scenario list shows:

- The scenario name
- Short description of the scenario
- The region relevant for this scenario
- The scenario status
- Icons to control and manage the scenarios.

The scenario list clearly identifies three types of scenarios:

- Example scenarios related to the project pilot
- Your own scenarios
- Scenarios eventually shared by other users with all users of the tool.

You can only edit and delete your own scenarios. For the other two types of scenarios, you can only view the scenario and make a copy, which replicates the scenario and makes your own copy that you can edit as you wish.

The search box applies to all the fields, so the user can easily filter the scenarios by any of these fields. Scenarios are sorted so that the latest created scenario is on top of the list.

The scenario status can be one of the following:

- **Created** – a scenario that has been created and has not yet been prepared to run in the optimisation algorithm (refer to Chapter 2 on the three phases of working with the tool)
- **Waiting** – a scenario whose input data collection phase has been completed and has been submitted for execution by the user, and finally
- **Completed** – a scenario that has been completed and includes the simulation results.

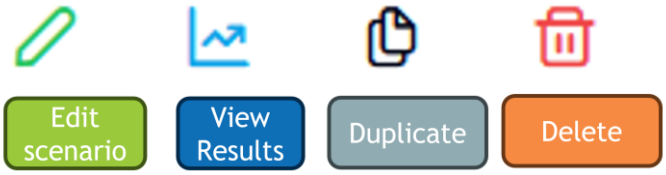


Figure 11. Scenario controls

At the right side of each of the scenarios in the list, there are context-specific controls for each of the scenarios, indicated by a tooltip if the mouse arrow is placed above the icon:

- **Edit scenario** - opens the scenario editor
- **View scenario results** – displays the results viewer (valid and visible only for the scenarios in the **Completed** state)
- **Duplicate scenario** – an essential tool for what-if and sensitivity analyses – this makes a "deep copy" of the scenario and all the associated data, allowing a rerun of the scenario with additional input data or different parameters and
- **Delete scenario** – removes the scenario and **all** accompanying data from the database.

These functionalities are elaborated below.

4.3. Scenario Creation

By clicking on the **Add new scenario** button above the scenario list, the user initiates the process of scenario creation. Here, the very first step is to select the geographical region of the scenario from the menu, give the scenario a name and optionally add a description.

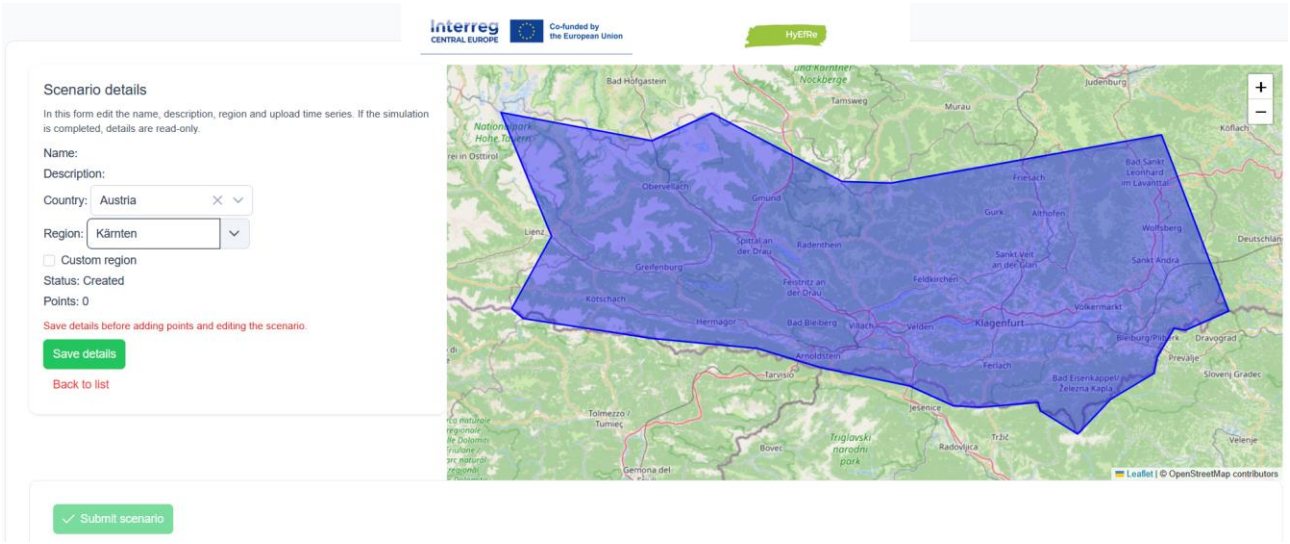


Figure 12. The scenario creation – Scenario name and geographical extents

In this phase, it is important to select **Save Details** to complete the scenario's initial creation. The map is at this point only indicative and does not allow editing. If the user clicks on the map, a warning appears notifying the user that the scenario details must be saved for the first time.

The scenarios include the pilot sites and also all the NUTS2 regions in Europe. If you select a country from the drop-down menu, only the regions from that country will be shown in the search.

4.4. Adding Regional-Level Demand and Production

Once the geospatial boundary of the modelled area is defined, the user can define the production and demand **at the regional level**, as opposed to defining points on the map and assigning production or demand time series to those points.

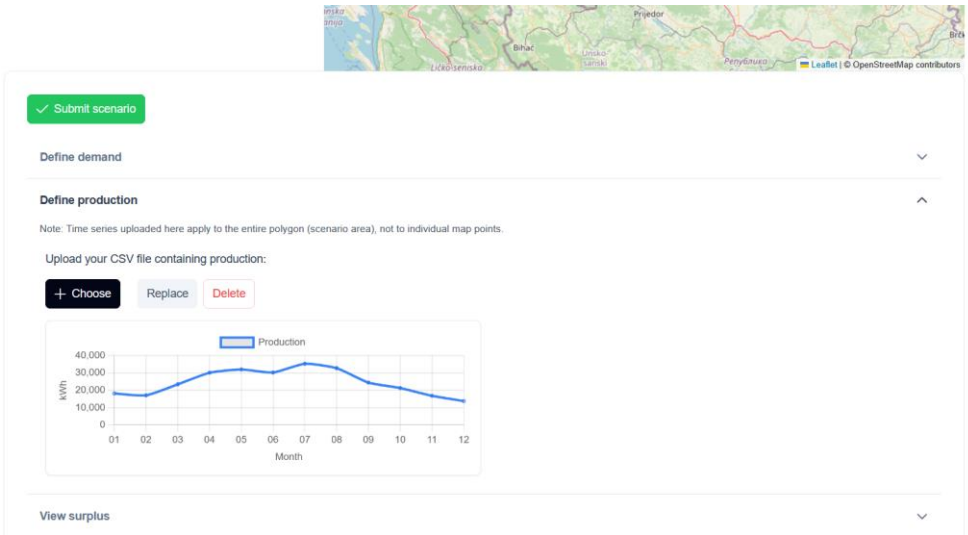


Figure 13. Regional-level production upload capability

For the simplest simulation case, the user then defines total aggregated production and demand at the regional level and runs the simulation. Furthermore, if the renewable energy surplus is precalculated externally, then it can be imported as regional-level production, with no demand defined.

Production or demand is uploaded by clicking **Choose**, finding the CSV file on the computer and then **clicking the upload button**. The file won't be uploaded until the upload button is invoked.



Figure 14. CSV file upload - File not uploaded yet

Once the file is uploaded successfully, a green notification that the upload has been successful is shown, and there is a graphical depiction of the uploaded CSV below.

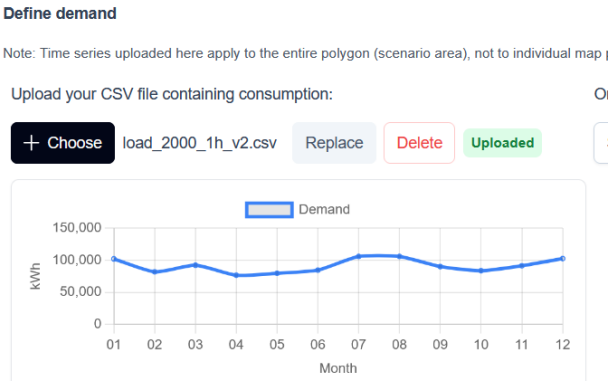


Figure 15. CSV file upload - File successfully uploaded

The uploaded time series can be deleted (removed) or replaced with another CSV upload here. The same mechanism applies for all-time series files upload.

4.5. Adding Points Interactively

It is possible to interactively add production and demand points to the map of the modelled area simply by clicking on the map and selecting **Add Marker** in the pop-up that appears.

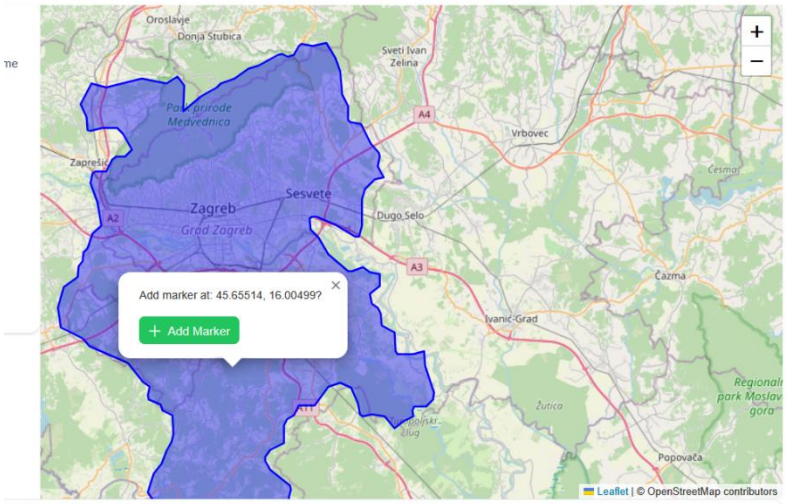


Figure 16. Adding a point to the map

Once **Add Marker** is selected, the main point characteristics must be defined: name, type, and installed power (production capacity), if applicable.

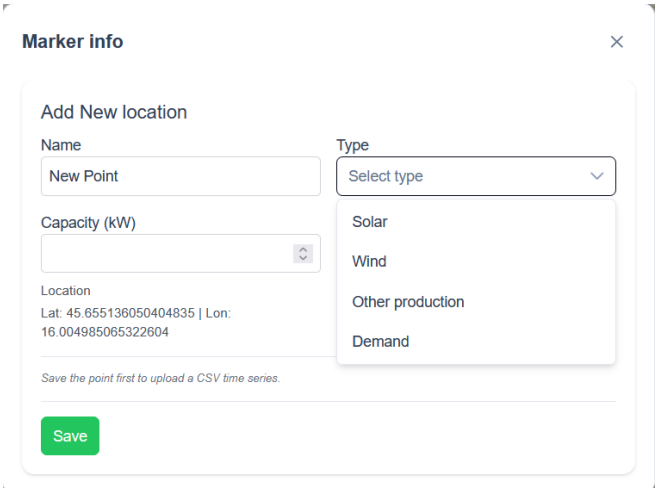


Figure 17. Adding a point to the map - Point details

The point type can be: **Solar, Wind**, **Other production** or **Demand.**

When the point is Solar or Wind, this allows creating a synthetic time series of production data – for this reason, it is possible to define the actual installed power in kW here. Production points contribute towards the renewable energy production, and the demand points can model specific industries, export from the region or fixed contracts that all affect the calculated surplus by increasing the total considered demand.

Once the point is created, the popup menu that allows invoking appears when the point is clicked. For each of the point types, once the point type and name are selected and details saved, in the point editing dialog, it is possible to upload the CSV data of production or demand. It is, of course, also possible to delete the point.

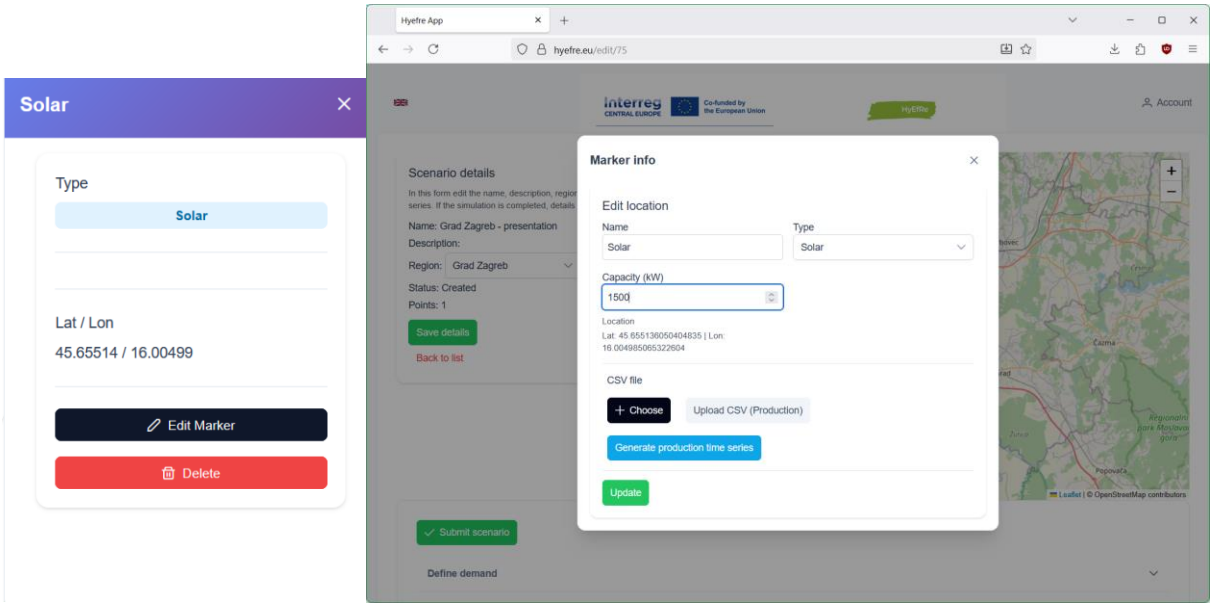


Figure 18. Editing the point information

4.6. Synthetic Time Series Generation (for Wind and Solar)

As explained earlier, for wind and solar production points, the user can choose to generate a synthetic production time series based on a modified reanalysis model and a simplified technical model of the production power plant.

For the point, its location is directly known from the location clicked on the map when the point is created. The installed capacity should be entered in the point data, and then the synthetic production time series is generated by clicking **Generate production time series.**

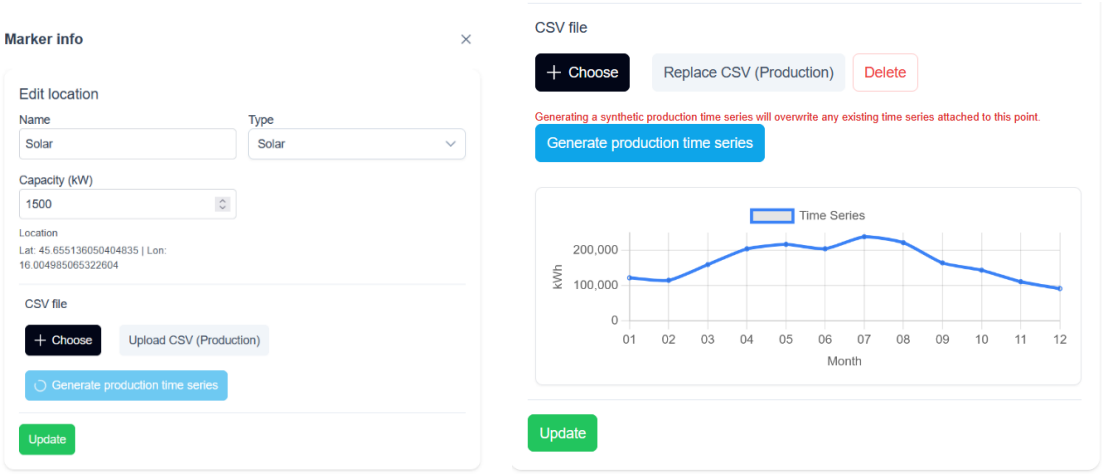


Figure 19. Synthetic time series generation for the solar power generation point

If the point had a time series assigned earlier, this operation would **replace** the previously uploaded (or generated) time series with a new one.

4.7. Indicative Surplus Display for the Scenario

Once the renewable data and demand data is uploaded, below the map viewer, the user can see the indicative renewable energy surplus.



Figure 20. Indicative surplus viewer

4.8. Submitting the Scenario for Execution

When all the data is ready and the user is satisfied with the setup, the scenario can be submitted for execution. This is done by clicking the **Submit scenario** button in the scenario editor.

This presents the user with the basic run parameters.

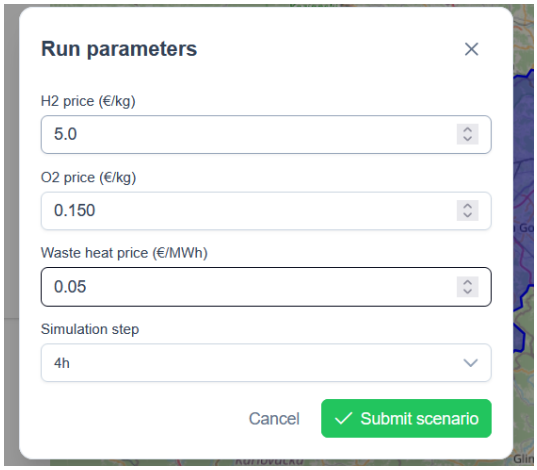


Figure 21. Scenario running: Basic economic inputs

Here, there are three main parameters, all in € per kilogram, that govern the simulation and should be chosen according to the user's preferences:

- H_2 price
- O_2 price

- Waste heat price

These parameters are important since they define the behaviour of the algorithm regarding the increase in capital expenditures, compared to the gains possible by selling the produced hydrogen. The actual price should reflect how much the hydrogen is worth to the user in a particular setting.

For instance, if there is an industry that requires hydrogen to operate, then this price practically reflects the opportunity cost of *not* producing enough hydrogen – as each kilogram of hydrogen not produced would have to be purchased elsewhere.

The simulation step parameter defines the actual granularity with which the modelling steps and internal constraints are modelled. The higher this step, the faster the simulation finishes quicker as there are fewer constraints and decision variables in the optimisation problem. However, there may be modelling errors, and a scenario simulating with an 8-hour time step may be too optimistic regarding the produced hydrogen.

A general rule of thumb here is – use 4h or 8h for rough experiments and then run the simulation once again with a time step of 2h or even 1h to confirm the results. 4h simulations take a couple of minutes to complete, while 2h and 1h simulations can take more than 10 minutes to successfully complete.



Figure 22. Scenario submitted and locked from editing

All these parameters are stored in the scenario bundle of data and are shown in the results viewer.

Once the scenario is submitted, no further edits are permitted to ensure that the results shown correspond exactly to the set of input data. An attempt to edit the finished scenario from the scenario list by clicking the pencil icon presents the user with an option to either **drop the results** and edit and eventually rerun the scenario, **duplicate** this scenario, dropping the results in the copy, but leaving the original scenario intact, or cancel the edit operation if invoked by mistake.

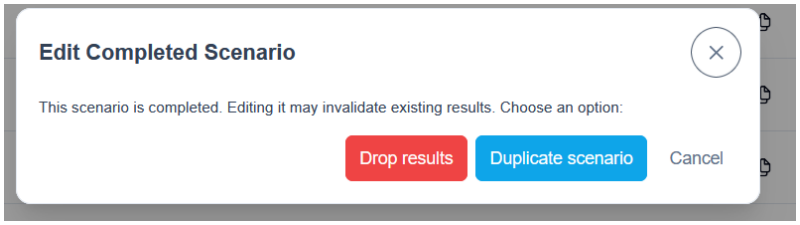


Figure 23. Scenario submitted and locked from editing

4.9. Results Viewer

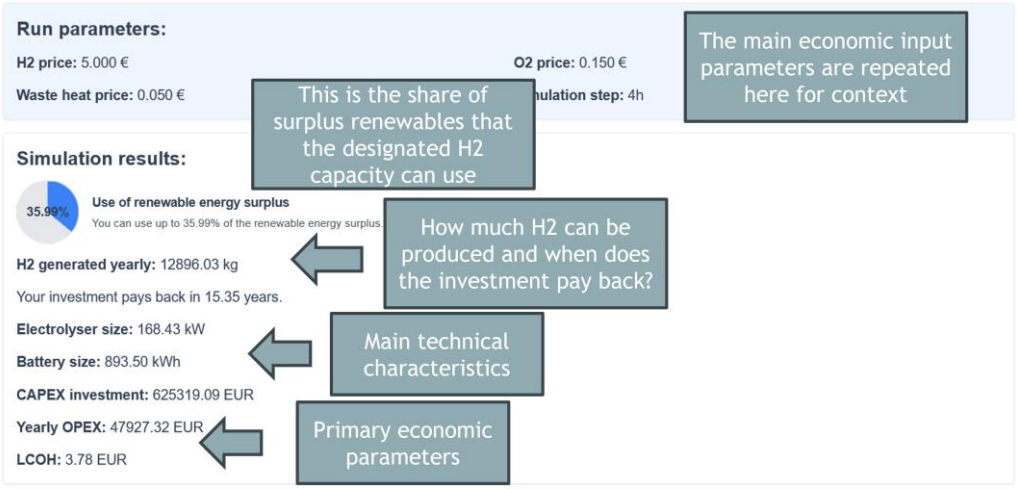


Figure 24. Scenario simulation results viewer

For completed scenarios, simulation results can be shown.

The main characteristics of the solution are shown:

- the **share** (percentage) of total renewable energy surplus that can be used by the optimised hydrogen-producing capacity
- the **amount of hydrogen** generated yearly
- the **payback period** when the initial investment pays back
- main **technical characteristics** - indicated **electrolyser size** and **battery size**
- economic parameters: total **CAPEX** and yearly **OPEX,** and finally
- **Levelized cost of hydrogen** produced in this capacity
- The **CO2 emissions avoided** by the installation of proposed hydrogen producing equipment, yearly.

The results viewer also shows the total aggregated production and demand.

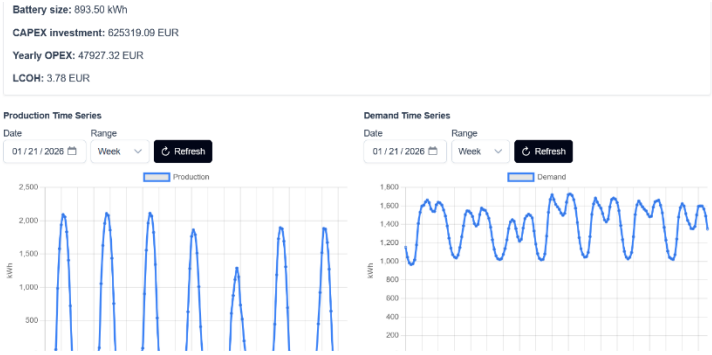


Figure 25. Results viewer - aggregated production and demand



Figure 26. Scenario comparison tool

To make the scenario comparison and sensitivity analyses easier, in the scenario list, a scenario comparison tool can be invoked. This shows the aggregate demand and production for the scenarios, and the user can use this feature to confirm the correct setup of scenarios in a sensitivity analysis context – for instance, if there's an additional power plant added in a scenario compared to the base case, then that scenario should have more surplus energy compared to the base case.

5. Conclusion

This document provides a general context of the Hydro Potential Model tool and illustrates the tool's usage.