



Exploitation and IPR management strategy – final version

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List of acronyms used in this document

BESS	Battery Energy Storage System
DLC	Demand Load Control
ECEMF	European Climate and Energy Modelling Forum
EERA	European Research Alliance
ENTSO-E	European Network of Transition System Operators - Electricity
ENTSO-G	European Network of Transition System Operators – Gas
ESS	Energy Storage System
FAIR	Findable, accessible, inter-operable and re-useable
IAMC	Integrated Assessment Modeling Consortium
IP	Intellectual Property
IPR	Intellectual Property Rights
JP	Joint Program
JRC	Joint Research Centre
NECP	National Energy and Climate Plan
NGO	Non-governmental organization
ORE	Open Research Europe
PV	Photovoltaic
RES	Renewable Energy Sources
SME	Small and medium-sized enterprises
TYNDP	Ten-year Network Development Plan

Glossary of terms used in this document

Exploitation

means, in the context of Horizon 2020, the use of results in further research activities other than those covered by the action concerned, or in developing, creating and marketing a product or process, or in creating and providing a service, or in standardisation activities [1].

Intellectual property

refers to the creations of the mind, such as inventions; literary and artistic works; designs; and symbols, names and images used in commerce [1].

Results

in the context of Horizon 2020, means any tangible or intangible output of the project, such as data, knowledge or information, that is generated in the project, whatever its form or nature, whether or not it can be protected, as well as any rights attached to it, including intellectual property rights [1].

Executive Summary

Open ENTRANCE was a 4-year H2020 project (2019 -2023). Open ENTRANCE developed, applied and disseminated an open, transparent and integrated modelling platform designed to assess low-carbon transition pathways in Europe. The platform is populated with a suite of open state-of-the-art models that process data derived from multiple dimensions of the energy transition. Data is also made open available via the platform according to the FAIR principles.

This report describes the Exploitation and IPR (Intellectual Property Rights) management plan for Open ENTRANCE. There are different results from Open ENTRANCE: an open modelling platform, open models, linked models, a common format for linking of models, data, tools for processing of the data, results from analyses, reports, presentations, communications results and scientific papers. Most of the results are open and freely available to the public.

The management strategies for IPR focus on:

- Identifying project results
- Identifying the property of the results
- Making as much as possible of the project results free of use
- Identifying any licensing, copyrights etc

The exploitation strategies focus on:

- Identifying target groups for the results
- Exploitation strategies per partner

The Open ENTRANCE results are already used in at least 15 new research proposals and projects. In several of these activities some of the Open ENTRANCE partners collaborate. Examples are the HEU projects ECEMF (IIASA and Comillas), iDesignRES (NTNU, IIASA, TU Wien, TU Berlin, EDF and SINTEF), OpenMod4Africa (SINTEF, Comillas, TU Berlin, EDF and IIASA) and the Clean Energy Transition partnership proposal Man0EUvRE (SINTEF, TU Berlin/EUF, EDF, Khas, NTNU). So far, most of the projects or proposals use elements of The Open Platform like the scenarios, the nomenclature (ECEMF) or some of the models and the Scenario explorer (OpenMod4Africa and iDesignRES).

1. Introduction

Open ENTRANCE was a 4-year H2020 project (2019-2023) about modelling of the energy transition in Europe. Open ENTRANCE developed, applied and, disseminated an open, transparent and integrated modelling platform designed to assess low-carbon transition pathways in Europe. The platform is populated with a suite of open state-of-the-art modelling tools that can process data derived from multiple dimensions of the energy transition. Input data and results for modelling of the energy transition in Europe are also made open available via the platform.

This report describes the Exploitation and IPR (Intellectual Property Rights) management plan for Open ENTRANCE. Intellectual Property (IP) refers to creations of the mind, such as inventions, literary and artistic works, designs, and symbols, names and images used in commerce [1]. The intellectual property system grants a set of exclusive rights to the owner of the property. This exclusivity allows the owner to exclude others from using its IP assets and, consequently, to grant third parties the rights, partly or in full, to exploit them [2].

This report also describes the exploitation plans for the Open ENTRANCE results. Exploitation means, in the context of Horizon 2020, the use of results in further research activities other than those covered by the action concerned, or in developing, creating and marketing a product or process, or in creating and providing a service, or in standardisation activities [1]. All partners in Open ENTRANCE except one, are universities or research organisations. Thus, for most of the partners it is further use of the result in research and education/teaching activities that are most relevant.

Chapter 2 describes the Open ENTRANCE's Intellectual Property Rights, while Chapter 3 is about the exploitation plans per partner.

2. Intellectual Property Rights (IPR)

2.1 In general for Open ENTRANCE

The primary objective of Open ENTRANCE was to contribute to an improved and robust understanding of the transition to a low carbon energy system in Europe by developing, demonstrating and using an open energy modelling platform. The Platform is populated with a suite of open¹ integrated mathematical models and a common database including all necessary data for conducting, among others, scenario building exercises and macro-economic analyses of pathways to a low-carbon energy system at regional, national and, pan-European level. One of the sub-objectives of Open ENTRANCE was:

Share integrated tools, input data and outcomes, and compare results among consortium partners and non-members of the consortium.

The Open ENTRANCE project was dedicated to the goal of the European Commission and the Horizon 2020 programme to make all academic work FAIR (Findable, accessible, inter-operable and re-useable):

- The suite of modelling tools for the energy transition. Models are made open via GitHub or similar. However, Open ENTRANCE did not require that all partners should make all models openly available.
- The suite of integrated models and the combined functionality of the platform support consistent data exchange among models with different spatial, temporal and sectoral scales. Third parties are allowed to integrate their own models in the modelling suite.
- All historical and scenario data sets are made available via The Open Platform, with references to supporting literature and hyperlinks (where possible) to the open-source modelling frameworks used to generate the scenarios. The Open Platform enables third party access to input data and modelling results within the project and for at least 10 years (i.e., to the end of April 2033) beyond its lifetime.

¹ Open ENTRANCE used the term “open model” for the combination of a software tool and the required data that is released under an established open-source license (cf. opensource.org/licenses). The open model must satisfy the four freedoms: any user must be allowed to run the model; to study how it works and modify it; to redistribute it; and to distribute copies of any modified version. The published dataset must include all required information to replicate the scientific analysis. Open ENTRANCE included in this definition, models that are released under an appropriate license but require proprietary software (e.g., GAMS) to execute.



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- All academic publications and policy briefs from the project are made available either following the green or gold open access standard.

The Open Platform facilitates the re-use of results from Open ENTRANCE as reference in scientific work by other modelling teams and for science communication activities by NGOs and other organizations working on related topics. The data are useful for policymakers and researchers to assess quantified scenarios of the energy transition and related policy measures [3].

When it comes to Communication results, such as reports and presentations including tables and figures, Open ENTRANCE also made all these free to use based on the Creative Commons CC-BY4.0 license [4]. This license says that anyone can make any change as long as they cite the original work and the copyright owner. [5] describes licenses used for the open models in Open ENTRANCE.

2.2 IPR for different results

Table 2-1 gives an overview of the categories of results from the Open ENTRANCE project. For each result, there is a short description and a comment related to IPR.

Table 2-1 Overview of the results from Open ENTRANCE

Result	Description/example	Relevance for IPR
The Open modelling Platform	The platform is populated with a suite of open integrated models and a common database including all necessary data for conducting, among others, scenario building exercises and macro-economic analyses of pathways to a low-carbon energy system at regional, national and pan-European level. The platform is accessible via https://openenergymodels.net .	The open modelling platform is free of use for anybody. IIASA will host the data exchange portal for at least 10 years following the end of the project.
A common data format for linking of models	Open ENTRANCE developed a tabular data exchange format based on the standard developed by the IAMC. A description of the format and the common nomenclature used in the project is available at [6].	The format and nomenclature are released under the open-source Apache License, Version 2.0
Open models	A suite of models for analysing the transition to a low carbon economy is made open in the project. However, some of the models used are not openly available.	Table 2-2 shows both the open and the closed models used in Open ENTRANCE. Each open model is accessible via GitHub or similar.
Linked models	Models are linked to each other by being able to exchange data via the common data format.	The code developed per model for exchange of data with other models is made openly available.
Data	Input and output data from running the models. Output from one model may be input to another (linking).	Most of the input and output data from the Open ENTRANCE analyses are made open available
Tools for processing of data	A suite of tools and functions for analyzing and visualizing input data and results of integrated-assessment models, macro-energy scenarios, energy systems analysis, and sectoral studies.	The tools can be used by anyone, and the code is open source. See Table 2-5 Overview of other results from Open ENTRANCE
Reports, including tables and figures	Reports presenting analytic results and describing the models and the data used to obtain the analytic results.	These results are free for use by anyone, see Table 2-3 Overview of the deliverables in Open ENTRANCE



Presentations, including tables and figures	Presentations presenting analytic results and describing the models and the data used to obtain the analytic results.	All presentations from Open ENTRANCE can be re-used based on the Creative Commons CC-BY4.0 license.
Analytic results	Interpretation of output data from running the models.	The analytic results are free for use by anyone
Scientific publications	All the scientific publications published based on the Open ENTRANCE results	Open ENTRANCE will grant open access to all its scientific publications.
Communication results	E.g. the Open ENTRANCE web page, tweets on the Twitter, newsletters etc.	These results are free for use by anyone, see Table 2-5 Overview of other results from Open ENTRANCE

Table 2-2 shows the models used in Open ENTRANCE, and Table 2-3 gives an overview of the deliverables. A major part of the deliverables are reports. Table 2-4 gives an overview of the scientific papers published by the end of April 2023 and their accessibility. Table 2-5 describes the licenses for the other results identified in Table 2-1.

Table 2-2 Overview of the models used in the Open ENTRANCE project

Name of model	Short description	License	Link to model	Open/ Closed	Contact
GENeSYS-MOD	Cost-optimising linear program, focusing on long-term developments of the energy system, with a detailed approach to sector coupling of the sectors electricity, heat, and transportation.	Apache License 2.0	GENeSYS-MOD	Open	Konstantin Löffler kl@wip.tu-berlin.de
EMPIRE	EMPIRE is a comprehensive power system model including generation, storage, and transmission capacity expansion. It is designed to determine optimal capacity investments under operational uncertainty, while also incorporating long- and short-term dynamics.	MIT License	https://github.com/ntnuenergy/OpenEMPIRE	Open	Pedro Crespo del Granado pedro.crespodelgranado@ntnu.no
Open-TEPES	The Open Generation and Transmission Operation and Expansion Planning Model with RES and ESS determines the investment plans of new facilities (generators, ESS and lines) to supply the forecasted demand at minimum cost. Tactical planning is concerned with time horizons of 10-20 years.	GNU General Public License v3.0	https://opentep.es.readthedocs.io/en/latest/	Open	Andrés Ramos andres.ramos@comillas.edu
Plan4EU	European electricity system optimisation and simulation	GNU General Public License v3.0	https://gitlab.com/cerl/plan4res/p4r-env	Open	Sandrine Charousset sandrine.charousset@edf.fr



GUSTO	The GUSTO model is optimizing the energy technology investment and the technology dispatch on a local level such as neighbourhoods and energy communities	GNU General Public License v3.0	https://github.com/sebastianzwickl/GUSTO	Open	Sebastian Zwickl-Bernhard zwickl@eeg.tuwien.ac.at
FRESH:COM	FRESH:COM (FaiR Energy SHaring in local COMmunities) is a linear optimization model maximizing the social welfare of a local energy community (EC). Members are private households and SMEs participating on a voluntary basis. Technologies included are Photovoltaic (PV) and Battery Energy Storage Systems (BESS).	Apache License 2.0	https://github.com/tperger/FRESH-COM	Open	Sebastian Zwickl-Bernhard zwickl@eeg.tuwien.ac.at
REMES	REMES is a Computable General Equilibrium model that represents the economy with a particular focus on the energy system. REMES is used to study the effects of macroeconomic policies on the economy.	Apache License 2.0	https://github.com/paopis/REMES-EU	Open	Paolo Pisciella paolo.pisciella@ntnu.no
EXIMOD 2.0	EXIMOD is an economic model able to measure the environmental impact of economic activities. As a multisector model, it accounts for the economic dependency between sectors. It is also a global and multi-country model with a consistent trade linking between countries at the commodity level.	Custom License model	https://github.com/TNO/EXIOMOD-open	Open	Hettie Boonman hettie.boonman@tno.nl
SCOPE SD	The »SCOPE« model approach is a modularly constructed fundamental model for the generation and analysis of cross border and multi-area energy scenarios. The model determines the minimum cost of covering demand profiles from the electricity, heat and transport sectors by the various energy units from a macroeconomic perspective. In order to determine a cost minimal technology mix for future scenarios, investment decisions based on annuitized technology costs can be taken into account in the objective function.	-	https://www.iee.fraunhofer.de/content/dam/iee/energiesystemtechnik/de/Dokumentation/Broschuere/2018_F_SCOPE_Einzelseiten.pdf	Closed	Philipp Härtel philipp.haertel@iee.fraunhofer.de



EMPS-W	EMPS-W is a tool for forecasting and planning in electricity markets. It has been developed for optimization and simulation of hydrothermal power systems with a considerable share of hydro power. It takes into account transmission constraints and hydrological differences between areas or regional subsystems.	-	https://www.sintef.no/en/software/emps-multi-area-power-market-simulator/	Closed	Birger Mo birger.mo@sintef.no
INTE-GRATE	Integrate is a software system for the planning of energy systems	-	https://www.sintef.no/en/software/integrate/	Closed	Magnus Askeland magnus.askeland@sintef.no
Frigg	Modelling framework for integration of demand response into energy system models	-	https://frigg.energy/	Closed	Amos Schledorn amosc@dtu.dk

Table 2-3 gives an overview of the deliverables developed in Open ENTRANCE. All the public Open ENTRANCE reports are licensed under a Creative Commons Licence Attribution 4.0 International License.

Table 2-3 Overview of the deliverables in Open ENTRANCE

No	Title (R-report)	Short description	PU=Public, CO=Confidential
D8.4	Project Management Plan - initial version (R)	A plan for internal use in the project. Used for detailed planning of the activities and for following up progress of the research and the deliverables.	PU
D8.1	Project Management Handbook (R)	The Handbook describes the tools and procedures for management of the project.	CO
D9.1	H - Requirement No. 1	Describes the routines and procedures that are implemented for the participation of humans	CO
D9.2	POPD - Requirement No. 2	Describes the routines and procedures that are used to gather and safeguard data supplied by the stakeholders.	CO
D2.2	Visual identity	The project's visual identity in terms of logo and templates.	
D4.1	Data Management Plan (R)	A plan for how to make all data used and produced in Open ENTRANCE compliant with the FAIR principles	PU
D4.2	Data exchange format and template (R)	Data format used by scientific models for writing to and reading from the Scenario Explorer	PU
D7.1	European storylines for low carbon futures of the European energy system (R)	Storylines of realistic and possible energy futures in Europe	PU
D4.1	Platform operational for scenario and exchange of case study data	A Scenario explorer for exchange, storage and verification of data. Furthermore, the Scenario explorer can be used for search for and presentation/visualisation of data. D4.4 is a public version of D4.1.	CO
D8.3	Exploitation and IPR management plan - initial version (R)	Initial version of exploitation and intellectual property rights management plan. D8.2 is a public and final version of this report.	CO
D3.1	Quantitative Scenarios for Low Carbon Futures of the pan-European Energy System (R)	Presents the methodology and the quantitative results of the four Open ENTRANCE scenarios at pan-European level, being in line with the corresponding storyline descriptions (D7.1)	PU

D6.1	Definition of and requirements for case studies of the European energy transition (R)	Description of 9 case studies performed during the project, as a real-size proof of concept of the project, applied to the main topics of the energy transition. Through the case studies, the model connections were validated, and the modelling assumptions and results evaluated.	PU
D5.2	Definition and implementation of the interface between models in the suite and the Common Database (R)	Report that describes the use of modelling tools and exchange of information among them, and with the Scenario Explorer, that was developed in the context of the Open ENTRANCE project.	PU
D5.3	Definition and implementation of the upgrades to a selected subset of models in the suite to make them "open-source" (R)	Provides an explanation of the necessary steps needed to define an open-source model and report the experiences by the Open ENTRANCE modelling teams for the process of opening the models they have developed and are maintaining.	PU
D4.4	Platform operational for dissemination of modelling results	Same as for D4.1 but open to anyone outside Open ENTRANCE	PU
D2.1	Communication and Dissemination Strategy I-II (R)	Outlines the relevance of communication in achieving the objectives of the Open ENTRANCE project. The communication strategy consists mainly of organising dialogues for co-creation of knowledge for developing a policy-relevant modelling platform, as well as to raise awareness of the importance of taking policy decision on the basis of sound scientific data.	PU
D8.5	Project management plan - final version (R)	Overarching project plan for internal use in the project. Used for detailed planning of the activities and for following up progress of the research and the deliverables.	PU
D1.1	Three workshops for development of the Open Platform	At both the EMP-E 2019 and EMP-E 2020, the Open ENTRANCE consortium organised dedicated sessions to discuss the vision for The Open Platform and related tools. In a third workshop, IIASA presented the Open ENTRANCE modelling platform for the ECEMF project.	PU
D3.2	Quantitative Scenarios for Low Carbon Futures of the European Energy System on Country, region and Local Level.	Updated version of D3.2 with consistent and quality checked data at country level describing consistent scenarios for low-carbon futures for electricity, heating/cooling and transport sector per European country or representative region ®	PU
D5.4	Illustrative case examples for the coordinated use of models (R)	Highlights the main features of the case examples and of the case example process, with a particular focus on the model linking.	PU

D5.1	Analysis framework, functional specification of models, and conceptual assessment of the linkages among them defined in the Case Studies and Pathways (R)	Describes a new methodology developed in Open ENTRANCE that advances from the already existing structured modelling framework to characterizing, scheming and dealing with the linking of energy models to solve particular research questions.	PU
D1.3	Workshop in the European Parliament	Workshop with the theme; Solutions for the European Energy Transition and economic consequences, at the European Parliament in Brussels.	CO
D1.2	Six workshops for scenarios building exercises, case studies and development for transition pathways	Six open workshops hosted in the period 2019 -2023. There were two workshops for scenario building exercises, two workshops for discussion of the case studies and two workshops for development of transition pathways.	PU
D7.2	Macro-economic impacts of low-carbon transition (R)	In this study, the macro-economic and environmental impacts of four decarbonization scenarios and one reference scenario were analysed and compared across two macro-economic models, EXIOMOD and REMES-EU.	PU
D7.3	Policy measures that address barriers and market failures in the low carbon transition (R)	The report discusses the effects potential barriers and incentives can have on the development of low-carbon technologies. These barriers and incentives are analysed from a multidimensional perspective starting from a local and individual scale and reaching the systemic energy and macroeconomic level.	PU
D6.2	Case study results (R)	The analyses result of conducting 8 case studies (initially described in 6.1)	PU
D2.4	Energy modelling conferences	Open ENTRANCE was the main responsible project for the EMP 2020. In addition, there was a final on-line and open conference presenting all the main results.	PU
D2.3	Bi-annual electronic newsletter	Bi-annual newsletter submitted to subscribes about recently published results from Open ENTRANCE	PU
D4.5	Platform innovation recommendations (R)	A report with a list of insights and ideas for future improvements of the open modelling platform. These ideas will be used as starting point for implementation in subsequent research projects. The report and the ideas facilitate an efficient hand-over between development projects	PU

D2.5	Guidelines for policy-science interface (R)	A guideline for a policy science interface based on the experience from Open ENTRANCE.	PU
D6.3	Best practice for performing case studies for the European energy system in transition (R)	Experiences from using the Open Platform for conducting analyses of specific challenges and opportunities related to the energy transition.	PU
D7.4	Open ENTRANCE Synthesis and Recommendations	A synthesis of the analytic results from Open ENTRANCE, mainly the scenarios, the macroeconomic studies and the case studies, and recommendation for further use of the results and for further studies.	PU
D8.2	Exploitation and IPR management strategy - final version (R)	The final strategy from the partners in Open ENTRANCE about who they intend to exploit the results from Open ENTRANCE. The report will describe the intellectual property rights by the end of the project	PU

Table 2-4 Overview of scientific papers (until the end of April 2023)

Title	Authors	Journal or conference	Doi	Open access
PV sharing in Local Communities: Peer-to-Peer Trading under Consideration of the Prosumers' Willingness-to-Pay	Theresia Perger, Lukas Wachter, Andreas Fleishhacker, Hans Auer	Journal paper	https://doi.org/10.1016/j.scs.200.102634	Yes
Development and modelling of different decarbonisation scenarios of the European energy system until 2050 as a contribution to achieving the ambitious 1.5 C climate target – Establishment of open source /data modelling in the European H2020 project Open ENTRANCE	Auer H, Crespo del Granado P, Oei P-Y, Hainsch K, Löffler K, Burandt T, Huppmann D, Graabak I	Journal paper	https://doi.org/10.1007/s00502-020-00832-7	Yes
Estimating marginal likelihoods from the posterior draws through a geometric identity	Reichl J	Journal paper	https://doi.org/10.1515/mcma-2020-2068	Yes
Fair Energy Sharing in Local Communities: Dynamic Participation of Prosumers	Perger T	Conference paper	https://doi.org/10.1109/EEM49802.2020.9221933	Yes
Citizen Participation in Low-Carbon Energy Systems: Energy Communities and Its Impact on the Electricity Demand on Neighborhood and National Level	Zwickl-Bernhard S	Journal paper	https://doi.org/10.3390/en14020305	Yes
pyam: Analysis and visualisation of integrated assessment and macro-energy scenarios	Huppmann D, Gidden M J, Nicholls Z, Hörsch J, Lamboll R, Kishimoto P N, Burandt T, Fricko O, Byers E, Kikstra J, Brinkerink M, Budzinski M, Maczek F, Zwickl-Bernhard S, Welder L, Álvarez Quispe E F, Smith C J	Journal Paper	https://doi.org/10.12688/openreseurope.13633.1	Yes

Stable stochastic capacity expansion with variable renewables: Comparing moment matching and stratified scenario generation sampling	Backe S, Ahang M, Tomasgard A	Journal paper	https://doi.org/10.1016/j.apenergy.2021.117538	Yes
Spatial flexibility in redispatch: Supporting low carbon energy systems with Power-to-Gas	Xiong B, Predel J, Crespo del Granado P, Egging-Bratseth R	Journal paper	https://doi.org/10.1016/j.apenergy.2020.116201	Yes
Chances and barriers for Germany's low carbon transition - Quantifying uncertainties in key influential factors	Löffler K, Burandt T, Hainsch K, Oei P, Seehaus F, Wejda F	Journal paper	https://doi.org/10.1016/j.energy.2021.121901	Yes
Social discounting, social costs of carbon, and their use in energy system models	Löffler K	Journal paper	https://doi.org/10.1088/1748-9326/ac228a	Yes
Energy Transition Scenarios: What policies, societal attitudes, and technology developments will realize the EU Green Deal?"	Hainsch K, Löffler K, Burandt T, Auer H, Crespo del Granado P, Pisciella P, Zwickl-Bernhard S	Journal paper	https://doi.org/10.1016/j.energy.2021.122067	Yes
Demystifying natural gas distribution grid decommissioning: An open-source approach to local deep decarbonization of urban neighborhoods	Zwickl-Bernhard S, Auer H	Journal paper	https://doi.org/10.1016/j.energy.2021.121805	Yes
Hydrogen sourcing strategies and cross-sectoral flexibility trade-offs in net-neutral energy scenarios for Europe	Frischmuth F, Härtel P	Journal paper	https://doi.org/10.1016/j.energy.2021.121598	Yes
Dynamic Participation in Local Energy Communities with Peer-to-Peer Trading	Perger T, Auer H	Journal paper	https://doi.org/10.12688/openreseurope.14332.1	Yes



Equitable decarbonization of heat supply in residential multi-apartment rental buildings: Optimal subsidy allocation between the property owner and tenants	Zwickl-Bernhard S, Auer H, Golab A	Journal paper	https://doi.org/10.1016/j.enbuild.2022.112013	Yes
Frigg: Soft-linking energy system and demand response models	Schledorn A, G. Junker R, Guericke D, Madsen H, F. Dominković D	Journal paper	https://www.sciencedirect.com/science/article/pii/S0306261922004640	Yes
Assessing the potential of seasonal thermal storage for local energy systems: Case study for neighbourhoods in Norway	Kauko H, Pinel D, Graabak I, Wolfgang O	Journal paper	https://doi.org/10.1016/j.segy.2022.100075	Yes
Disclosing the heat density of district heating in Austria in 2050 under the remaining European CO2 budget of the 1.5°C climate target	Zwickl-Bernhard S, Huppmann D, Golab A, Auer H	Journal paper	https://doi.org/10.1016/j.segan.2022.100775	Yes
Green hydrogen from hydropower: A non-cooperative modeling approach assessing the profitability gap and future business cases	Zwickl-Bernhard S, Auer H	Journal paper	https://doi.org/10.1016/j.esr.2022.100912	Yes
Impact of Energy Communities on the European Electricity and Heat System Decarbonization Pathway: Comparing local and global flexibility responses	Backe S, Zwickl-Bernhard S, Schwabeneder D, Auer H, Korpås M, Tomsgard A	Journal paper	https://doi.org/10.1016/j.apenergy.2022.119470	Yes
Identification of barriers and investment determinants for hydrogen infrastructure: Development of new business models	Morch A, Crespo del Granado P, Schmidt S	Book	https://doi.org/10.1109/eem54602.2022.9921163	Yes
A research agenda for open energy science: Opportunities and perspectives of the F1000Research Energy Gateway	Huppmann D et al.	Journal paper	https://doi.org/10.12688/f1000research.124267.1	Yes

Table 2-5 Overview of other results from Open ENTRANCE

Name of result	Short description	License	Comment
Data sets for transition pathways	An ensemble of data has a value beyond (a data set) the value of each single data	Creative Commons CC-BY4.0 license	The license is for the scenario ensemble, i.e, all the data from the project accessible in the Scenario Explorer
List of variables and regions used in Open ENTRANCE	Shared lists of variables, regions and units used across the entire project.	Apache License, Version 2.0	https://github.com/OpenENTRANCE/OpenENTRANCE
Python package “nomenclature”	A Python package to work with lists of variables and regions	Apache License, Version 2.0	https://github.com/iamc/nomenclature
Tools for processing of data	Tools for analysis and visualization	Apache License, Version 2.0	https://pyam-iamc.readthedocs.io/en/stable/
Scenario explorer	All the open data from the project are stored and are accessible in the Scenario Explorer	Creative Commons CC-BY4.0 license	https://data.ece.iiasa.ac.at/openentrance/#/login?redirect=%2Fworkspaces
The scripts for linking the models	There is developed scripts for upload of data to and download of data from the Scenario Explorer		https://openenergymodels.net/
Web page for the Open Platform	The web page for The Open Platform will be accessible for several years after the end of the project	Creative Commons CC-BY4.0 license	https://openenergymodels.net/
The Open ENTRANCE web page	The project web page. The page will be accessible for a period after the end of the project	Creative Commons CC-BY4.0 license	https://openentrance.eu/
Tweets and LinkedIn post	Short communication items about results and events	No license	https://www.linkedin.com/company/open-entrance/
Newsletters	Nine newsletters released during the project period	Creative Commons CC-BY4.0 license	https://openentrance.eu/activities/newsletters/

3. Exploitation strategy and plans

The main results that can be explored from Open ENTRANCE are the same results as described related to IPR in Chapter 2. Table 3-1 describes examples of the form exploitation can take [1].

Table 3-1 Examples of the form exploitation can take

Examples of the form exploitation can take [1]	Description [1]	Assessment of relevance for Open ENTRANCE
Further internal research	These research activities take place outside the Open ENTRANCE project, and are relevant for research organisations and research intensive companies.	Very relevant
Collaborative research	This is Open ENTRANCE results used as background for future collaborative research projects. Relevant for research organisations and research intensive companies.	Very relevant
Internal product development	Results used in developing, creating and marketing a product/process. Relevant for companies	Relevant for some partners
Service creation	Results used in creating and providing a service. Relevant for companies delivering consultancy.	Relevant for some partners
Licensing	Results exploited by other organisations through out-licensing. Relevant for all participants, but care should be take to comply with H2020 rules	Less relevant since most of the results from Open ENTRANCE can be reused openly by anyone.
Assignment	Results exploited by other companies by transfer of ownership	Less relevant since most of the results from Open ENTRANCE open and can be reused by anyone.
Joint venture	Results used as background for a joint venture	Possible
Spin-off	A separate company established in order to bring the results from the project to the market. Relevant for all participants, but care should be take to comply with H2020 rules	Possible

Standardisation activities	Results used either to develop new standard activities, or to contribute to on-going standardisation work. Relevant for all participants, but care should be taken to comply with H2020 rules. Especially relevant for standardisation of energy system data.	Relevant
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All of the exploitation measures in **Feil! Fant ikke referanse kilden.** are dependent of which licence is chosen by the owner of a result.

3.1 Target groups for results from Open ENTRANCE

The main target groups for the results from Open ENTRANCE are:

1. European and national energy and climate policy makers and other decision-makers.
2. Other modelling groups/researchers and users of local, national and pan-European models for analyses of the transition of the energy system to a low-carbon future.

Some main examples of stakeholders are:

The European Commission

The European Commission is the EU's politically independent executive branch. It is alone responsible for drawing up proposals for new European legislation, and it implements the decisions of the European Parliament and the Council of the EU [7].

The European Parliament

The European Parliament is one of the legislative bodies of the European Union and one of its seven institutions. Together with the Council of the European Union, it adopts and decides European legislation, based on proposals developed by the European Commission. The Parliament is composed of 705 members [8].

National and local authorities

National authorities shall be understood as governments, city councils etc.

ENTSO-E, ENTSOG, TSOs

ENTSO-E is the European association for the cooperation of transmission system operators (TSOs) for electricity. ENTSO-E represents 39 (March 2023) electricity transmission system operators from 35 countries across Europe, thus extending beyond EU borders.

ENTSG is the European Network of Transmission System Operators for Gas. The role of ENTSOG is to facilitate and enhance cooperation between national gas transmission system operators (TSOs)

across Europe, to ensure the development of a pan-European transmission system in line with European Union energy and climate goals [9].

ACER and regulators

ACER is EU's Agency for the Cooperation of Energy Regulators. The agency has a very important role in integration of the electricity and the gas systems in EU.

Non-governmental organisations (NGO)

While there is no fixed or formal definition for what NGOs are, they are generally defined as non-profit entities that are independent of governmental influence—although they may receive government funding [10].

Energy companies in Europe

In this context energy companies are companies producing electricity, heat and/or gas.

Research organisations, universities

Research organisations and universities including the Joint Research Centre (JRC). The JRC provides independent, evidence-based science and knowledge, supporting EU's policy making [11].

3.2 New collaboration opportunities among the Open ENTRANCE partners

This report is published in the last months of the Open ENTRANCE project, in April 2023. The results from the project are already further used in several projects or used as a cornerstone in new proposals, see Table 3-2. Several of the projects or proposals are developed in collaboration among the partners, e.g, Man0EUvRE or Open Mod4Africa.

When this report is written, Man0EUvRE is a Clean Energy Transition Partnership proposal. Man0EUvRE will improve energy system modelling across Europe and provide open research-based answers with ambitions to:

1. Develop robust pathways for the European energy system that meet climate targets towards net-zero GHG emissions and consider current policies
2. Increase coordination between European modelling groups and – efforts.
3. Provide feedback and advice to the National Energy and Climate Plans (NECPs) of the individual EU countries.
4. Improve the toolbox for conducting energy transition studies at European and national level, which can support NECP generation, evaluation and future updates.

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5. Publish consistent energy system modelling datasets and scenario projections at European and national level.
 6. Strengthen coordination between national energy plans and EU-wide transition goals.

In April 2023, the HEU proposal OpenMod4Africa was invited to Grant Agreement preparation. The project will use The Open Platform from Open ENTRANCE to develop a similar platform adapted to the features and possibilities of the African energy system and society. African scientists and students will be trained in using The Open Platform and will bring with them their expertise to the African energy community. By applying The Open Platform on local, domestic and cross-country level in Africa, they will contribute to develop the energy systems in 25 African countries in a sustainable direction and such that it supports as many African people as possible. The Open ENTRANCE partners TU Berlin, Comillas, EDF, IIASA and SINTEF are partners in OpenMod4Africa.

Table 3-2 Use of results from Open ENTRANCE beyond the project

No	Project	Type of project	Link	Status project	Project period	Open ENTRANCE partner(s) involved	Reuse from Open ENTRANCE
1	ECEMF	H2020	www.ecemf.eu	Ongoing	2021-2025	IIASA and Comillas	Data format and nomenclature
2	Plan4res	H2020	www.plan4res.eu	Completed	2017-2021	EDF	Scenarios
3	SUPEERA	H2020	www.supeera.eu	Ongoing		SINTEF	Scenarios and GENeSYS-MOD
4	EDF further use of The Open Platform	Internal EDF	no link	Planned		EDF	Scenarios, GENeSYS-MOD, The Open Platform
5	TRANSFORMAR (GA no.101036683)	H2020		Ongoing	2021 -	NTNU	Scenarios
6	NTRANS	FME a)	www.ntnu.no/ntrans	Ongoing	2019-2027	NTNU/SINTEF	Scenarios, linked tools: REMES, EMPIRE and GENeSYS-MOD
7	Nordic Energy Outlook	Nordic Energy Research	www.sintef.no/en/projects/2021/nordic-energy-outlooks/	Ongoing	2021-2023	SINTEF	Scenarios and GENeSYS-MOD
8	Ocean Grid	Grønn Plattform NFR b)		Ongoing		SINTEF	Scenarios and GENeSYS-MOD
9	HydroConnect	KSP NFR c)	www.sintef.no/en/projects/2021/hydroconnect/	Ongoing	2021-2024	SINTEF/Fraunhofer	Data format and nomenclature
10	HydrogenPathways	NFR		Ongoing		SINTEF/NTNU	GENeSYS-MOD, REMES, EMPIRE, linked models

11	CleanExport	KSP NFR	www.sintef.no/en/projects/2020/cleanexport/	Ongoing	2020-2024	SINTEF/NTNU	GENeSYS-MOD
12	Data Cellar	Horizon Europe	www.datacellarproject.eu	Ongoing	2022-2025	EDF	nomenclature, scenarios, other data from data platform (inputs and results of case studies)
13	OpenMod4Africa	HEU proposal		Proposal accepted for GAP		SINTEF, EDF, Comillas, TU Berlin IIASA	The Open Platform
14	ManOEUVRE	CETP d) proposal		Proposal submitted		SINTEF TU Berlin, EDF, NTNU, Khas	GENeSYS-MOD, scenario data
15	InterPlay	FME proposal		Proposal development		SINTEF, NTNU, TU Berlin	GENeSYS-MOD; EMPIRE, scenario data
16	iDesignRES	HEU proposal		Proposal accepted for GAP		NTNU, SINTEF, IIASA, TU Berlin, TU Wien, EDF	GENeSYS-MOD, The Open Platform

a) FME - Centre for environmental friendly energy research

b) NFR - Norwegian Research Council

c) KSP - Knowledge Building Research project

d) CETP- Clean Energy Transition Partnership

3.3 Exploitation activities and plans per Open ENTRANCE partner

This chapter describes the plan each partner has for exploiting the results from the project.

Exploitation plan - SINTEF Energy Research

The exploitation plan of the Open ENTRANCE comprises the following dimensions, to which SINTEF Energy Research is committed: (i) research, (ii) teaching/education, (iii) service to the community, policy/decision making and society.

i) Further research:

Exploitation of The Open Platform in a domestic centre for long term energy planning.

SINTEF Energy Research aims to develop a centre for long term domestic energy planning. The centre will be built upon the Open ENTRANCE Platform. The Platform will be extended with more models, and new functionality will be included in the models, e.g. impact on biodiversity and local environment by expanding energy infrastructures. The models will be open available for use by others.

Further develop the Open ENTRANCE scenario results for Norway and the Nordic region.

The Open ENTRANCE scenarios for decarbonisation of the energy system will be further developed by SINTEF Energy Research to improve spatial and temporal granularity and in that way give more insight into possibilities and impacts of decarbonisation of the Nordic energy system. This work has already been started by two master students at NTNU (Norwegian University of Science and Technology) and will be continued in further student work and new projects.

Use the Open ENTRANCE results as context for more specific studies in domestic decision making. The Open ENTRANCE can be used as context in more specific analyses at Norwegian and Nordic level. An example is the national research project "HydroConnect". This project investigates the use of Norwegian hydropower for increased balancing purposes in the future European power system. HydroConnect uses the Open ENTRANCE scenarios to quantify the development of the European energy and power system, and the research questions in HydroConnect are studied within this context. There will be several different studies in the next years, related to for example production and use of hydrogen or large-scale wind power production in the North-Sea, where results and insights from Open ENTRANCE will be highly relevant and can help to put local or domestic results into a wider European context. The results from these projects are used in domestic decision making related to de-carbonisation of the energy system.

ii) Teaching/education

SINTEF Energy Research has a close collaboration with NTNU about Master and PhD thesis. The results from Open ENTRANCE will be further developed in both master and PhD work.

iii) Service to the Community, Policy/Decision Making and Society

Exploitation of Open ENTRANCE results in European research organisations.

SINTEF Energy Research has close cooperation with the European Research Alliance (EERA), among other related to the SUPEERA project coordinated by EERA. EERA has already disseminated some results for Open ENTRANCE. SINTEF will use its close cooperation with EERA to reach out to the

European research community, such that the Open ENTRANCE results can be exploited by a large number of research partners, also by research organizations outside the consortium.

The coordinator for Open ENTRANCE, Ingeborg Graabak, is a member of the Joint program (JP) "Energy System Integration" in EERA. She plans to present the Open ENTRANCE results to the other members of the JP, again such that the Open ENTRANCE results can be exploited by as many research organisations as possible. The Open ENTRANCE project has also been presented in the social science group JP e3s.

Exploitation plan – TU Wien

The exploitation plan of the Open ENTRANCE insights, outcomes and products comprises the following three dimensions, to which the TU-Wien as a university is committed: (i) applied research, (ii) teaching/education, (iii) service to the community, policy/decision making and society.

(i) Applied Research (national, European, global)

In applied research (i.e. mainly upcoming research proposal and projects) on national, European and global level the use and tailor-made application and further development of the Open Platform from Open ENTRANCE and corresponding open models like GENeSYS-MOD, FRESH:COM and GUSTO are planned. E.g., this comprises the following (no claims are made for the completeness of the list): Contribution to national (competitive) calls for proposal in the national climate and energy research program shaping "Climate neutrality Austria 2040". Use of the Open ENTRANCE outcomes (in future project proposals and scientific papers) to better understand specific real-world implications of the modelling results, e.g. for

shaping sustainable business models to produce hydrogen beyond periods with RES excess generation (e.g. based on (run-of-river) hydropower).

considering partial decommissioning of the gas distribution grid in Austria (and better integrate sector coupling of remaining energy domains) due to limited availability of competitively produced "green" gas.

trying to better understand the role of CO₂ prices governing the decarbonisation of the Austrian energy system and, subsequently, the creation of new "green" jobs (incl. macro-economic analyses on national level together with other experts in the field).

Contribution to trans-national (competitive) calls for proposal and corresponding programs of the European Research Alliance (EERA), envisaging a carbon neutral society by 2050.

Contribution to fitting calls for proposals in the Horizon Europe program and further extension and promotion of the Open Platform.

Making Open ENTRANCE work visible also outside Europe in the academic and research community (and intensifying existing scientific cooperation (incl. PhD exchange) in the field of decarbonisation of the energy systems: e.g. sharing modelling experience and initiating future joint work with MIT (U.S.); contribution to their events in the climate/energy field (e.g. MIT Applied Energy Symposium, <http://applied-energy.org/mitab2021/index>).

Contribution to establish open access science and publication, i.e. submission of scientific papers presenting Open ENTRANCE work at the Open Research Europe (ORE) platform of the European Commission.

others

(ii) Teaching/Education

TU-Wien commits itself to “research driven teaching” on several scales and levels. This contributes to fast sharing and dissemination of the latest research results and methods among students and scholars. Exemplarily the following exploitation measures of Open ENTRANCE are implemented:

- Teaching of Open ENTRANCE research results, tools and methods in different courses, notably the specific course “Open-Source Energy System Modeling”.
- Open platform and Tools (mainly GENeSYS-MOD, FRESH:COM, GUSTO) to be further developed based on tailor-made research questions and modelling exercises in Bachelor-, Master and PhD theses, addressing national or European research questions.
- Teaching of Open ENTRANCE research results, tools and methods in several different postgraduate and international courses and programs at TU-Wien (MSc Studies at: the “Continuing Education Centre, in “Renewable Energy in Central and Eastern Europe”, Erasmus, Marie Skłodowska Curie, International Summer/Winter Schools, etc.).

(iii) Service to the Community, Policy/Decision Making and Society

The Open Platform as well as several Open ENTRANCE results, tools and methods are exploited at different fitting occasions/events within the scientific community and towards policy/decision makers. E.g.

- Keynote and plenary session contributions at international energy/climate conferences (e.g. organised by MIT, IAEE, EMP-E Conf., etc.) or webinars/workshops (e.g. IAEE, IEA, NTNU Energy Transition Conf., etc.).
- Follow-up scientific journal publications (peer-reviewed) and/or special issues like those of the EMP-E conferences presenting further development and application of the Open ENTRANCE Open Platform and tools.
- Policy advice to national authorities, policy/decision makers and stakeholders for efficient decarbonisation of the energy system, based on corresponding Open ENTRANCE tailor-made technology choices.
- Bringing Open ENTRANCE insights, results, methods and policy recommendations to national expert committees and bodies dealing with energy, climate and energy security related topics in Austria.
- Reporting in the public media and in interviews (e.g. TV, online media, etc.) about the Open ENTRANCE insights, results, methods and policy recommendations.

Exploitation plan – Comillas

Exploitation by policy and decision makers

Comillas will present the Open ENTRANCE quantitative results for the scenarios explored and the Open Platform features and capabilities to relevant Spanish stakeholders, including national authorities, institutions and industry players in the energy and electricity sectors. The objective of this is to convince these entities to consider the Open Platform and the project quantitative results in their future analyses.

- The Ministries of Energy and Environmental Issues could use the results computed and the Open Platform in the development of the Spanish NECP.
- The Ministries of Energy and Environmental Issues could compare the results they compute in their analyses with those produced by Open ENTRANCE.
- Companies in the energy and electricity sectors could use the data and tools available in the Open Platform in their analyses.

Exploitation by the research community

- Comillas can use the results produced in Open ENTRANCE for scenario analyses and pathway as input for setting the context for analyses focused on the Spanish system or the European one. Aspects like the fuel and CO₂ prices, the level of demand, or other general ones could be extracted from the scenario data sets produced within Open ENTRANCE.
- The overall Spanish research community, and Comillas in particular, can use the Open Platform to conduct relevant analyses.
- The overall Spanish research community, and Comillas in particular, could take the Open Platform and further develop it in future national/European projects.
- Comillas is already making use of the model openTEPES, developed in Open ENTRANCE, within several projects and will further on develop and use it:
 - As a further step in the process of opening the model openTEPES, it has been uploaded as a python module, ready to be installed. See the installation web page <https://pypi.org/project/openTEPES/> and the documentation web page <https://opentepes.readthedocs.io/en/latest/>
 - Besides, the openTEPES is being used in several other projects to represent the Spanish electric system and analyse specifically the storage dimensioning and storage use/needs for future years. See the brief project descriptions below:
 - Analysis of the expansion and operation of the Spanish electricity system for a 2030–2050-time horizon, developed for Iberdrola, aims at evaluating the potential and role that each generation, storage and consumption technology can play in the future mix of the Spanish electricity system.
 - Assessment of the storage needs for the Spanish electric system in a horizon 2020-2050 with large share of renewables, developed for the Instituto para la Diversificación y Ahorro de la Energía (IDAE), aims at assessing, from a technical and economic point of view, the daily, weekly

and seasonal storage needs for the Spanish electricity system in the 2020-2050 horizon.

- MODESC – Platform of innovative models for speeding the energy transition towards a decarbonized economy, developed for the Ministry of Science and Innovation, aims at developing a global platform that integrates innovative energy simulation and impact assessment models that accelerate the decarbonization of the electricity system including the electrification of the energy demand.
- Improving energy system modelling tools and capacity, a project developed for the European Commission, aims at improving the description of the Spanish energy system in model TIMES-SINERGIA, improving the technologies considered, developing a higher time resolution, detailing modelling of the power sector, e.g. the inclusion of transmission constraints.
- Furthermore, the openTEPES is also to be used in an ongoing European project also oriented to expand the modelling capacities of the scientific community. This is the project ‘European Climate and Energy Modelling Forum’ (ECEMF), developed for the European Commission, which is aimed at providing the knowledge to inform the development of future energy and climate policies at national and European levels. The ECEMF’s programme of events and novel IT-based communications channel will enable researchers to identify and co-develop models for the most pressing policy-relevant research questions together with a range of stakeholders to meet ambitious European energy and climate policy goals, in particular the European Green Deal and the transformation to a climate-neutral society.

Last but not least, openTEPES is to be used in another European project that has recently started, ‘Delivering the next generation of IAMs for net-zero, sustainable, development’. This project is focused on the further development of Integrated Assessment Models and the development of links between IAM - and sectoral models providing further detail on specific sectors. Within the project, proper linkages are to be built between openTEPES and several IAMs for the latter to be able to provide further insights into the functioning of the electricity sector when used in combination with openTEPES.

Exploitation plan – EDF

Internal Use

- Use of The Open Platform from Open ENTRANCE for performing internal studies. The Open ENTRANCE Platform is a very relevant suite of models for analysing the energy transition in Europe. EDF is performing energy transition analyses for the benefit of its strategy departments, and also for internal research. The use of the Platform will make those studies easier and will allow comparisons with external studies. In particular, the easy access to a

complete, relevant, public and validated through the Open ENTRANCE case studies database of European scenario, as well as the ability of using alternative models for conducting those studies will make them more robust and credible.

- Use of the Open ENTRANCE Platform for validation of internal (non-public) tools. The Open ENTRANCE platform can also be used for connecting no-open models and thus easily validating them, as all necessary data as well as a benchmark database are available.
- Use of the Open ENTRANCE platform for training activities. The platform, together with Open ENTRANCE main results, models and scenarios is a very good material for internal training (for interns, PhD students, young engineers) getting more familiar with - and understand the scope of energy system modelling, and the energy transition. Every year, EDF R&D is welcoming more than 15 students and around 20 new engineers who require training on these specific topics.

External Use:

- Exploitation of The Open Platform for consultancy purposes. EDF R&D, but also some other EDF departments, are regularly involved in consultancy actions towards other companies, in Europe and outside Europe, in the area of energy system modelling and scenario analyses. The open platform in Open ENTRANCE can be used to perform analyses on different energy systems, using a wide variety of models, based on the validated and public Open ENTRANCE scenarios.
- Exploitation of the open platform for commercial exploitation of EDF models. The functionalities of the platform, in particular the database, easy connection of models and pre/postprocessing analyses could be further included in a 'product', together with one or more EDF models, making them more attractive.
- Use the Open ENTRANCE scenarios for benchmarking of external studies, as well as internal studies for publication purposes. It is today very difficult to benchmark studies as there exist few available datasets which are fully complete. The scenarios in Open ENTRANCE will be used to this end.

Exploitation for research purposes

- Exploitation of Open ENTRANCE for new research activities. The Open ENTRANCE project is a very good basis for further research projects in Horizon Europe. Further research projects may for example extend The Open Platform with more open models, improve functionality in existing models and improve the linkages between models. Existing datasets available through the platform can be improved and extended, and used to conduct further analyses of the energy transition in Europe, conduct comparative studies, etc. EDF aims at exploiting The Open Platform for further research activities at European level. In particular, the Open ENTRANCE platform is a very good basis for building GAIX use cases about long-term energy systems.

Exploitation plan – NTNU

NTNU aims to connect the knowledge and results of Open ENTRANCE to trigger further research and innovation activities in the field of energy transition analyses. Moreover, Open ENTRANCE will be featured in the NTNU energy transition initiative that reach out policy makers, industry and interested stakeholders. The exploitation plan for NTNU is as follows:

European Energy Transition analyses awareness for National strategies and relevant stakeholders

- Through NTNU various energy research initiatives, the Open ENTRANCE project outcomes will be expose to the following exploitation activities: I) participation in workshops and the yearly Energy Transition conference in Trondheim which gathers around 700 attendees, ii) dissemination of results on large-scale research centres in Norway (e.g. FME NTRANS, FME MOZEES, FME ZEN, and others), and iii) trans-disciplinary collaboration in drafting white - or position papers. In all these activities, there is a diverse group of stakeholders, from industry, NGOs, local governments, and others that follow latest insights and innovative solutions related to the energy transition.
- NTNU has strong involvement in multiple sub-programs of the European Energy Research Alliance (EERA). There NTNU will exploit Open ENTRANCE developments and outcomes stimulating the creation of new projects and making aware the EERA community about open data and models available at the platform of Open ENTRANCE.
- National projects and related initiatives. Open ENTRANCE results will be used in National projects that rely on knowledge and latest results of European energy transition analyses. NTNU participation in these projects (funded by the Norwegian Research Council) will provide awareness and alignment of national strategies with EU decarbonization targets and related policies.

Capacity building and education

- NTNU has 3 master's degree programs that relate to Open ENTRANCE scope. NTNU aims to have at least 10 master thesis that uses or are in collaboration with Open ENTRANCE project. Moreover, NTNU aims to educate at least 5 PhD students that applies some of the work of Open ENTRANCE in their research.
- Open models. Thanks to Open ENTRANCE, NTNU is making the EMPIRE model and REMES model open source. Both models will be supported beyond the duration of the project.

Research exploitation

- Collaboration with other EU projects: NTNU will ensure that there is a strong cross-collaboration with other EU projects that can help replicability and knowledge transfer. This mainly in terms of the following actions: sharing data and models, writing joint publications, organizing and coordinating joint events (e.g., webinars), showcasing results on other projects websites or events, and others. In April 2023, the plan is to have further synergies and collaboration with the following ongoing projects: BEYOND and Syn.ikia (focus on, buildings, energy communities and end-use flexibility), and ECHOES/SMARTTEES projects (focus on social innovation led by NTNU).

- NTNU aims to publish around 8-to-10 academic publications with open-access.

Exploitation plan – IIASA

IIASA will use the components and modules that form the open platform in a range of ongoing research projects as well as in proposals being developed. Most importantly, the Scenario Explorer is a central tool for data management, scenario compilation and model linkage in the Horizon 2020 project *European Climate and Energy Modelling Forum (ECEMF)* coordinated by KTH. Synergies with Open ENTRANCE are also being used in the projects *NAVIGATE* coordinated by the Potsdam Institute (PIK) and *ENGAGE* coordinated by IIASA.

The pyam package, which was extended and improved thanks to the feedback and contributions from Open ENTRANCE consortium partners over the course of the project, will be used in numerous future projects for scenario analysis, model validation and data visualization.

The integration of the GAINS model as a module for scenario post-processing in the IIASA Scenario Explorer will be used in projects by IIASA supporting national policymaking in relation to air quality improvements. Several other projects are relevant for exploiting results from Open ENTRANCE in particular with East Asian partners.

Exploitation plan – TNO

Internal exploitation

- The Open Platform from Open ENTRANCE will be used for performing internal studies. Quantified trajectories of the Open ENTRANCE scenarios can be used as input for these studies that uses the same underlying assumptions. The Open ENTRANCE trajectories can serve as input for TNO models.
- Within the Open ENTRANCE project, there have been many discussions on how (e.g. the format) to share data between the different partners and how to use the output of one model as input for another model. The insights from these discussions will also be used for model communication in future research projects and TNO internal projects.

Research Exploitation

- TNO aims to publish at least two open access papers from the work performed in Open ENTRANCE.
- Macro-economic model EXIOMOD remains publically available via Github. This allows other research institutes to gain knowledge on the model and help to further improve and expand the model for future impact assessments.
- TNO aims to use the data produced by the Open ENTRANCE models, and published on the open platform, for impact assessment studies for the national government.

Exploitation plan – EUF (and TU Berlin)

Europa-Universität Flensburg (EUF) plans to use the knowledge, results, and insights generated within the Open ENTRANCE project to strengthen its academic efforts across multiple areas. Therefore, the exploitation plan of EUF encompasses both internal research applications and education, but also public services in the form of political and societal outreach.

Exploitation of Open ENTRANCE assets for research purposes

- The open platform, as well as the enhancements and data sets for the open-source Global Energy System Model (GENeSYS-MOD) will be used within other research projects at EUF and will improve the future work with the model.
- Model linkages between GENeSYS-MOD and the macro-economic model REMES that have been conducted within Open ENTRANCE will be deeply beneficial for future analyses for both national and European, but also global model applications, combining the technical detail of an energy system model with macro-economic information and influential factors.
- Contribution to open science by making both model, data, and publications openly available, therefore enabling reproducibility and strengthening the validity and transparency of model results.

Education and teaching

- The open-source energy system model GENeSYS-MOD will be used in various courses and seminars at EUF. A major goal of these courses is usually the generation of first in-depth experience in research for students, offering very closely tied topics to current research projects such as Open ENTRANCE.

Outreach and academic, policy, and societal exploitation

- Dissemination of results at international conferences, aimed both at academia, but also at political decision makers, give the opportunity for a direct exchange of insights and knowledge, thus enabling fruitful discussions.
- Scientific journal publications, as well as science communication through social media (Twitter, LinkedIn, ResearchGate, etc.).
- Exploitation of insights generated within the Open ENTRANCE project at national and international modelling events, such as the openmod initiative or the International Energy Workshop (IEW).
- Reaching out to national policy- and decision makers and stakeholders for an efficient knowledge transfer of the Open ENTRANCE results. Partaking in advisory panels and expert workshops of governmental entities, promoting the current research positions and science-based results.

Exploitation Plan – EI-JKU

The knowledge gained in our participation in Open ENTRANCE is diverse and merits dissemination to the (i) public, (ii) policy makers, and the (iii) research community. Our work in the project, Case Study 1, demonstrates the contributions EU households can have on the formation of the Energy Union by allowing grid system operators to control the non-essential electrical devices in their household (Demand Load Control - DLC). The exploitation plan is outlined for the three stakeholders' groups below:

1. Research community

- The “open” aspect in Open ENTRANCE allows the scientific contributions of the project to be continued long after the finalization of the project. Specifically, the GitHub repository shows the assumptions Case Study 1 made (i.e., Python code used to generate the raw data and system model assumptions), thus, facilitating the ease of the research community to exploit, adapt, and apply the data, methods, or results to similar studies.

2. Policy Makers

- The Open ENTRANCE deliverable and the platform that hosts the raw data, models, and results of Case Study 1 will allow pan-European, national, and regional policy makers to reference specific results when advocating for policies that target DLC programs or their energy systems.

3. Internal exploitation

- EI-JKU will enable replication and knowledge transfer from the Open ENTRANCE project by exploiting synergies with other research initiatives. This primarily entails exchanging data and models as well as presenting Open ENTRANCE outcomes at other projects' events. For instance, results of Case Study 1 will be used within the context of the IEA UsersTCP SLA 2.0 project (EI-JKU leads one of the subtasks).
- Methods and results developed in Open ENTRANCE will be used and further developed in future and ongoing research proposals. *MultiFutures*, the Horizon Europe proposal currently developed (coordinated by EI-JKU), is one example of this. The project, if funded, will build on the work done in Open ENTRANCE by modelling alternative scenarios.

Exploitation plan – DIW Berlin

The knowledge gained by participating in the Open ENTRANCE projects is diverse and merits dissemination to (i) the public, (ii) policy makers, and (iii) the research community. It also includes many different aspects and multiple sectors related to the European energy transition.

More concretely, DIW Berlin already has the following plans for further exploitation of the work in Open ENTRANCE:

- Use the Open ENTRANCE pathways' indicators (e.g., share of renewables in future years until 2050) to analyse the appropriateness of current energy policies in European countries to reach a 1.5°C / 2°C warming target. More concretely, the Open ENTRANCE pathways'

indicators obtained from GENeSYS-MOD give country-level detail in 5-year steps. In a first step, the French part of the Open Energy Tracker at DIW Berlin (<https://openenergytracker.org/>) will compare the energy policy targets of the French government with the GENeSYS-MOD results of the four central Open ENTRANCE pathways.

- DIW Berlin will continue to work with the networks established in the Open ENTRANCE project, including in new project proposals and grants.
- DIW Berlin will continue to work in the model comparison group EFECT of which the core group comes from the Open ENTRANCE project (e.g., participants from NTNU, TU Wien, DIW Berlin, EDF, EUF, EI-JKU, TU Berlin, IIASA, DTU, KHAS and SINTEF).
- DIW Berlin will continue the work on the gas market development, in particular with respect to green gases such as hydrogen. DIW Berlin cooperates with TU Berlin and EUF on this question. In particular, the development of a hydrogen grid and of hydrogen storage infrastructure (topics of Case Study 8) will continue to be a research interest at DIW Berlin.

Exploitation plan – DTU

The knowledge gained by DTU in participating in the Open ENTRANCE project centers around case study 7 for which we further developed and applied a novel mathematical modelling framework. Hence, we plan to further exploit both methodological results in the form of the Frigg modelling framework and the analytical results of the case study.

Research

- Frigg is planned to be further developed and applied in additional research projects. This includes the Innovation Fund Denmark project MissionGreenFuels and the EU-co-funded project Elexia.

Teaching

- Based on methodological results from the Open ENTRANCE project, multiple student projects testing different modelling methods to approach similar problems have been supervised.
- In future teaching, we aim to extend these student projects.

Dissemination

- Further application of the Frigg modelling framework will be disseminated in scientific conferences and journals.

Exploitation plan – Fraunhofer IEE

As an applied research organisation, Fraunhofer IEE will exploit the Open ENTRANCE results at different levels and in various domains. The Open ENTRANCE results for Fraunhofer IEE can be summarised as follows:

- Connection of the proprietary modelling and optimisation framework SCOPE Scenario Development (SCOPE SD) to Open Platform of Open ENTRANCE
 - Possibility to quickly adopt new global or European storylines and quantified scenarios as input for the capacity expansion planning problems of SCOPE SD
 - Possibility to easily publish and communicate the SCOPE SD results in the public domain
 - Possibility to better collaborate with other modelling groups across Europe
- New insights and policy recommendations from Case Study 4 on cross-sectoral flexibility and the impacts of modelling flexibility sources at different spatial resolutions by combining the proprietary SCOPE SD (Fraunhofer IEE) and the open plan4EU (EDF) models.

Exploitation by policy and decision makers

- Exploitation of the Open Platform and insights of Case Study 4 for decision making support in German companies, NGOs, and by public authorities, primarily the Federal Ministry of Economic Affairs and Climate Action (BMWK), Federal Ministry of the Environment (BMU), and the Federal Environment Agency (Umweltbundesamt) in Germany.
- Use the Open ENTRANCE results as context for more specific studies for domestic decision-making support. The Open ENTRANCE results allow for improved recommendations in contracted research projects focussing on increasingly local (e.g. distribution grid level) but also global system levels and interactions (e.g. global markets for fuel imports). For instance, this concerns the DevKopSys2 project on robust national transition pathways in Germany considering uncertainty in European and global energy supply scenarios, the HydroConnect project with SINTEF Energy Research on the role of Norwegian hydropower (flexibility) in net-neutral Europe, and a project with a German TSO on long-term uncertainties and regional impacts on electricity transport volumes in net-neutral scenario settings for Germany.

Exploitation by the research community

- Exploitation of Open ENTRANCE for new research activities at national, European, and global levels. The Open ENTRANCE project and its consortium provide a sound basis for developing new research proposals and projects for suitable national and Horizon Europe calls. These could address the integration of Fraunhofer IEE's new open EMPRISE framework into the Open Platform to investigate energy system transformations with high cross-sectoral integration under strategic and operational uncertainties. By using the Open Platform, additional project opportunities may come from improving the functionality of existing tools (SCOPE SD model) and linking them with other tools and datasets.

- Exploitation of Open ENTRANCE results in European research organisations. Fraunhofer IEE is a member of the European Energy Research Alliance EERA and plans to disseminate the results in suitable workshops and conferences in the Joint Program Wind. Moreover, within the Fraunhofer-Gesellschaft, Open ENTRANCE results and tools are to be shared in the [Fraunhofer Cluster of Excellence for Integrated Energy Systems \(CINES\)](#), which addresses the central technical and economic challenges of the next phase of the global energy transition.
- Further develop the Open ENTRANCE scenario results for Germany and Europe. Based on the existing databases for structural and time-series information for sector-integrated energy systems towards net-neutral Europe, comparisons and validations will be carried out to improve both Fraunhofer IEE's data sets and the available data on the Open Platform. Any relevant improvements regarding the European and German regional data will be reported back to the Open Platform.
- Follow-up scientific journal publications (peer-reviewed) and/or special issues such as those of the EMP-E conferences presenting further development and application of the Open ENTRANCE Open Platform and open tools.
- Two publications in peer-reviewed journals are planned. The first paper resulting from the EMP-E 2020 conference has been published in Energy. To disseminate the Case Study 4 results, a second publication is planned in collaboration with EDF.

Exploitation in teaching and education activities

- Fraunhofer IEE contributes with its latest research to student and scholar programs at various organisations. The latest Open ENTRANCE results and methods will be disseminated in a Master-level course at the University of Kassel and a postgraduate level (PhD) course at NTNU.
- Based on the research activities preparing Case Study 4, a Master Thesis has been completed in collaboration with the University of Koblenz Landau.

Exploitation plan – KHAS

The knowledge gained by KHAS in participating in the Open ENTRANCE project centers around case study 8, for which we further developed GENeSYS-MOD -Turkey and applied a gas storage framework in which clean hydrogen is generated and blended with natural gas. Hence, we plan to exploit further the methodological and analytical results of this case study.

Research

- GENeSYS-MOD is planned to be further developed and applied in additional research projects. This includes the recently submitted Clean Energy Technology Partnership proposal ManuOEUVRE. KHAS will continue to work in the networks established in the Open ENTRANCE project, participating in new project proposals and grants.

- KHAS will further develop the Open ENTRANCE scenarios to improve spatial and temporal granularity, giving more insight into the possibilities and impacts of decarbonization of the Turkish energy system.

Teaching

- Open ENTRANCE research results, tools, and methods are taught in different courses, notably in the specific graduate-level course “Energy Modeling, Simulation, and Optimization”. Multiple student projects in this course are testing GENeSYS-MOD to approach similar problems. We aim to extend these student projects.

Dissemination

- Further application of the production and storage of hydrogen framework will be disseminated in scientific conferences and journals. Follow-up scientific journal publications (peer-reviewed) and/or special issues (i.e. EMP-E conference) will present further development and application of the Open ENTRANCE Open Platform and open tools.
- Policy advice will be given to national authorities, policy/decision makers, and stakeholders for efficient energy system decarbonization. We will bring Open ENTRANCE insights, results, methods, and policy recommendations to national expert committees and bodies dealing with energy, climate, and energy security-related topics in Turkey.

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