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Swiss Policy towards Zero CO_2 Emissions compatible with European Decarbonisation Pathways

POLIZERO

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The authors bear the entire responsibility for the content of this report and for the conclusions drawn therefrom.

Zusammenfassung

Das Projekt POLIZERO bewertet die Auswirkungen der europäischen Energie- und Klimapolitik auf das Schweizer Energiesystem. Ein für die Schweiz relevantes Portfolio von Politikmassnahmen zur Dekarbonisierung wird unter Berücksichtigung der Wechselwirkungen des schweizerischen und des europäischen Systems auf Wirksamkeit und Effizienz evaluiert. Dabei werden für die Schweiz auch erfolgreich umgesetzte Politiken in anderen europäischen Ländern als potenzielle Massnahmen berücksichtigt. Ziel ist die Identifizierung robuster dynamischer adaptiver Politikpfade und deren Implementierungzeiten, um die nationalen Energie- und Klimaziele zu erreichen. Unsicherheiten, die die Umsetzung von Politiken beeinflussen, werden durch eine parametrische langfristige Analyse von Energieszenarien untersucht.

Im ersten Projektjahr wurde eine umfassende Inventar der aktuellen und geplanten Energie- und Klimapolitik in der Schweiz und im europäischen Ausland erstellt. Bei der Bestandsaufnahme handelt es sich um einen detaillierten Katalog und Informationen über die politischen Entscheidungsmerkmale jedes Landes. Darin enthalten sich auch die neuesten wichtigen Energie- und Emissionsstatistiken, welche einen umfassenden Überblick über die Hintergründe der Herausforderungen der Energiewende und deren Bewältigung in den verschiedenen Ländern geben.

Zusammen mit dem Politik-Inventar wurde im Rahmen der Jahrestagung des Gemeinsamen Beirats von POLIZERO ein Stakeholder-Workshop mit Experten aus Wissenschaft und Energiepolitik durchgeführt, um die für die Schweiz relevanten Politiken aus dem Inventar zu priorisieren. In den Diskussionen wurde unter anderem Folgendes hervorgehoben: a) die Notwendigkeit, das Emissionshandelssystem (ETS) fortzuführen und auszubauen, zusammen mit ergänzenden Instrumenten wie CO_2-Abgaben, um eine verbesserte Lastenteilung des Minderungsdrucks der ETS- und Nicht-ETS-Sektoren zu erreichen; b) mit technologieneutralen Ausschreibungen und direkter Förderung für die Übergangszeit zu einem marktbasierten Einsatz erneuerbarer Energien in der Stromversorgung überzugehen; c) die Versorgungssicherheit zu fördern, indem der kombinierte Ausbau erneuerbarer Technologien und Speicher unterstützt wird(und teilweise über Verordnungen durchgesetzt werden); d) Erhöhung der CO_2-Steuern auf Brenn- und Treibstoffe und schließlich der Übergang zu CO_2-Bepreisungssystemen auch für Sektoren, die nicht unter das derzeitige Emissionshandelssystem fallen (z. B. Verkehr); e) Beschleunigung des Ausbaus der Ladeinfrastruktur von Elektrofahrzeugen und von Wasserstoff-Tankstellen; f) Möglichkeit von Subventionsregelungen für den kohlenstoffarmen Infrastrukturausbau in der Industrie (z. B. Bioenergie, Wasserstoff, E-Fuels) und Infrastruktur für den Transport von CO_2; g) Entwicklung rechtlicher und regulatorischer Rahmenbedingungen, um die Verfügbarkeit und den Zugang zu sauberen Kraftstoffen, Bioenergie/Wasserstoff/E-Kraftstoffen, in den Endverbrauchersektoren sicherzustellen.

Das nächste Projektjahr sieht die Entwicklung der Schnittstellen zwischen den bei POLIZERO eingesetzten quantitativen Instrumenten, dem JRC-EU-TIMES-Modell für die Energiesystemmodellierung und dem AIM-Modell für die Exploration dynamischer adaptiver Politikpfade vor. Außerdem wird die quantitative langfristige Energiesystemmodellierung zur Bewertung der Auswirkungen der europäischen Energie- und Klimapolitik auf das Schweizer Energiesystem und die Wirksamkeit der Schweizer Dekarbonisierungspolitik durchgeführt.

Résumé

Le projet POLIZERO évalue l'impact des politiques européennes énergétiques et climatiques européennes sur le système énergétique suisse. Un portefeuille de mesures politiques de décarbonisation pertinent pour la Suisse est évalué en termes d'efficacité et d'efficience, en tenant compte des interactions des systèmes suisse et européen. Ce faisant, les politiques mises en œuvre avec succès dans d'autres pays européens sont prises en considération en tant que mesures potentielles. L'objectif est de générer des voies politiques adaptatives robustes et dynamiques, ainsi

que leur calendrier d'implémentation pour atteindre les objectifs nationaux en matière d'énergie et de climat. Les incertitudes qui influences la mise en œuvre des politiques sont étudiées dans le cadre d'une analyse paramétrique à long terme des scénarios énergétiques.

Au cours de la première année de projet, un inventaire complet des politiques énergétiques et climatiques actuelles et prévues, en Suisse et dans d'autres pays européens, a été réalisé. Cet état des lieux est un catalogue détaillé avec des informations sur les caractéristiques des décisions politiques prises dans chaque pays. Il comprend également les dernières statistiques importante en matière d'énergie et d'émissions, qui offrent une vue d'ensemble complète des défis liés à la transition énergétique et de la manière dont ils sont abordés dans les différents pays.

Parallèlement à l'inventaire des politiques, un atelier des parties prenants a été conduit avec des experts scientifiques et du domaines de la politique énergétique, dans le cadre de la rencontre annuelle du comité consultatif de POLIZERO, afin de classer par ordre de priorité les politiques de l'inventaire qui sont importantes pour la Suisse. Les discussions ont notamment mis en évidence: a) la nécessité de poursuivre et d'élargir le système d'échange de quotas d'émissions (SEQE), ainsi que des instruments complémentaires tels que les taxes sur le carbone pour partager la pression d'atténuation des couvertures SEQE et non SEQE; b) le passage à un déploiement des énergies renouvelables basé sur le marché pour l'approvisionnement en électricité, avec des appels d'offres neutres sur le plan technologique et des subventions directes pendant la période de transition; c) la promotion de la sécurité d'approvisionnement en soutenant (et en imposant dans certains cas par le biais d'ordonnances) des installations combinées de technologies renouvelables et de stockage; d) l'augmentation des taxes sur le CO_2 pour les combustibles et les carburants avec, à terme, la transition vers un système de tarification du carbone, également pour les secteurs qui ne sont pas soumis au SEQE actuellement (p. ex. les transports); e) l'accélération du développement de l'infrastructure de recharge pour les véhicules électriques et de stations-services à hydrogène; f) la possibilité de régimes de subvention pour développer une infrastructure à faible émissions de carbone dans l'industrie (p. ex. bioénergie, hydrogène, e-carburants) et une infrastructure pour le transport du CO2; g) le développement de conditions cadres juridiques et réglementaires pour garantir la disponibilité et l'accès à des carburants propres, bioénergie/hydrogène/e-carburants, dans les secteurs des utilisateurs finaux.

L'année prochaine, le projet prévoit le développement des interfaces entre les instruments quantitatifs utilisés par POLIZERO, le modèle JRC-EU-TIMES pour la modélisation des systèmes énergétique et le modèle AIM pour l'exploration des voies politiques adaptatives dynamiques. Par ailleurs, la modélisation quantitative à long terme des systèmes énergétiques sera réalisée pour évaluer l'impact des politiques énergétiques et climatiques européennes sur le système énergétique suisse et l'efficacité des politiques suisses de décarbonisation.

Summary

POLIZERO aims to assess the impact of European energy and climate policies on the Swiss energy system. A suite of decarbonisation policies relevant for Switzerland, which could also be based on successfully implemented examples in other European countries, is assessed in terms of effectiveness and efficiency by considering the interactions of the Swiss and European systems. The aim is to generate robust dynamic adaptive policy pathways and their implementation timing in meeting the national energy and climate targets. Uncertainties influencing the implementation of policies are explored via parametric energy scenario analysis.

A comprehensive policy inventory of current and planned energy and climate policies in Switzerland and other European countries was constructed during the project's first year. The inventory is a detailed policy catalogue and information about each country's policymaking traits. It also includes the latest key energy and emissions statistics to provide a comprehensive view of the energy transition challenges and how these are tackled in different countries.

Together with the policy inventory, a stakeholder workshop was conducted within the annual meeting of the Common Advisory Board of POLIZERO, with experts from academia and energy policy, to prioritise those policies from the inventory relevant for Switzerland. Among others, the discussions highlighted: a) the need to continue and enforce the Emissions Trading Scheme (ETS) together with complementary instruments such as carbon levies to share the mitigation pressure from ETS and non-ETS coverages; b) to move to a market-based deployment of renewables in electricity supply with technology-neutral tenders and direct subsidies for the transitional period; c) to promote the security of supply by supporting (and enforcing via mandates to some extent) combined installations of renewable technologies and storages; d) to strengthen carbon taxes in heating fuels and eventually move to carbon pricing schemes also for sectors not covered by the current ETS (e.g., transport); e) to accelerate alternative infrastructure in transport with supports on EV charging and H2 fuel stations; f) to consider subsidy schemes for low-carbon infrastructure development in industry (e.g. bioenergy, hydrogen, e-fuels) and CO_2 transport infrastructure; g) to develop legal and regulatory frameworks to ensure availability and access of clean fuels, bioenergy/hydrogen/e-fuels, in the end-use sectors.

The next year of the project foresees the development of the interfaces between the quantitative tools employed at POLIZERO, the JRC-EU-TIMES model for the energy systems modelling and the AIM model for the dynamic adaptive policy pathways exploration. Also, the quantitative long-term energy systems modelling for assessing the impacts of the European energy and climate policies on the Swiss energy system configuration and the effectiveness of the Swiss decarbonisation policies will be performed.

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Abbreviations

AIM	Adaptive PolicymakIng Model
BEV	Battery electric vehicle
CC(U)S	CO_2 capture, utilisation and storage
CCS	CO_2 capture and storage
CHP	Combined Heat and Power
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
COVID-19	Severe Acute Respiratory Syndrome due to the Coronavirus disease in 2019
CPS	Carbon Pricing Score
DSM	Demand Side Management
ESCO	Energy Service Company
ETS	Emissions Trading Scheme
ETSAP	Energy Technology Systems Analysis Program
EU	European Union
EV	Electric vehicle
F-gases	Fluorinated greenhouse gases
GHG	Greenhouse gas
ICAO	International Civil Aviation Organization
IEA	International Energy Agency
JRC	Joint Research Centre of the European Commission
MaaS	Mobility as a Service
NDC	Nationally Determined Contribution
nZEB	nearly Zero Energy Buildings
OECD	Organisation for Economic Co-operation and Development
PV	Photovoltaics
R&D	Research and Development
RES	Renewable Energy Sources
SF6	Sulphur Hexafluoride gas
STEM	Swiss TIMES Energy system Model
TIMES	The Integrated MARKAL-EFOM System
UK	United Kingdom
V2G	Vehicle-to-grid

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1 Introduction

1.1 Background information and current situation

In February 2015, Switzerland was the first country to submit its climate target under the Paris Agreement [1]. It was also among the first countries that met the “midnight survival deadline for the Climate” of the 31st December 2020 for the submission of updated and ambitious Nationally Determined Contributions (NDC) [2]. The significant steps that Switzerland has made in reducing its environmental footprint brought the country among the top-5 countries worldwide in the performance and readiness of its energy system for transition [3].

The challenge of achieving the energy transition in a sustainable and affordable way requires coordinated decarbonisation policies across all sectors of the Swiss energy system. Their design should consider domestic uncertainties, such as resources potentials, demographic and economic developments, and uncertainties from the interdependency of Swiss and European energy grids and markets, such as energy cooperation agreements and access to low-carbon fuels. Moreover, the alignment of the Swiss and European low-carbon infrastructures and policies could contribute to a cost-effective Swiss energy transition and alleviate the security of supply concerns.

Most of the current Swiss energy transition analyses within the European context have focused on electricity imports/exports (e.g. [4-5]), neglecting the trade of other energy carriers and certificates. Policy-oriented analyses on decarbonising the Swiss energy system have dealt with particular sectors, e.g. the power sector ([6-7]) and the transport sector [8], or they have considered the entire energy system at a national only scope (e.g. [9-11]). Studies related to the integration of Swiss and European energy markets [12], the integration of the Swiss energy policy into the European energy policy [13] or the foreign policy spillovers on domestic green innovation [14] are limited on the electricity sector and deal mainly with governance and less with quantification of impacts. In addition, almost all of the Swiss studies dealing with long-term policy planning to meet decarbonisation targets [15], including the Swiss Energy Perspectives studies [16-17], neglect adaptation of specific policy measures determined by what is known in the present and what might be experienced and learned in the future.

The above indicates two important gaps in state-of-the-art research on deep decarbonisation policies in Switzerland. First, the current assessments so far do not include an extensive quantified analysis of the impact of European policies on Swiss policies. Second, when decision-makers face the complex interactions of energy systems that span beyond the national scope, they might benefit from adaptive policy plans that hedge against uncertainties that affect policy implementation and outcomes.

1.2 Purpose of the project

The project “*Swiss Policy towards Zero CO_2 Emissions compatible with European Decarbonisation Pathways*” - short POLIZERO - explores the complex interplay between climate action and cost-effective energy system transformation taking both European and Swiss perspectives. The purpose of POLIZERO is to contribute to the dialogue on how Switzerland can achieve its climate change mitigation targets while interacting at different intensities and levels with the European energy markets, which also face an ambitious transformation as envisioned in the EU Green Deal.

POLIZERO contributes in filling the critical knowledge gap of “*What combination of policies/policy mix is efficient*” and “*when to act*” to avoid carbon lock-ins and the implementation of policies that lead to dead-ends or cannot reach their aims. The project’s modelling framework supports decision-makers in designing adaptive policy pathways that ensure robustness and cost-effective achievement of the climate targets and amplify the need for negative emissions.

1.3 Objectives

POLIZERO has four primary objectives:

1. To analyse a suite of energy sector decarbonisation policies for Switzerland also based on successfully implemented examples in other European countries and innovative policies.
2. To assess the impacts of Swiss and European policies on the European and Swiss energy systems, and consequently, the implications on the implementation of the Swiss policies.
3. To generate robust, dynamic adaptive policy pathways, based on integrated Swiss-European energy systems modelling, in order to describe potential future adaptive actions that handle stringent climate change mitigation policy targets in an agile way.
4. To identify which combination of Swiss policies and policy mixes are efficient, together with the timing of their implementation, under different national and international contextual factors that form the space of uncertainties within the Swiss policies are implemented (e.g. societal, technical, economic, demographic, etc.)

Accordingly, the research questions that POLIZERO aims to answer include, but are not limited to:

- What are Switzerland's efficient policies/policy packages and their timing towards net-zero CO_2 emissions by 2050?
- What are the implications of energy and climate policies of other European countries for the effectiveness of Swiss energy policies?
- Which are the most critical contextual influences and their respective values that could affect policy outcomes, efficiency and effectiveness[1]?
- Which parameters should be monitored to ensure effective policy implementation and which policy alternatives (if any) could be implemented to tackle policy outcome deviations?

Main outcomes from POLIZERO are: a) an inventory of current and to be implemented policies at Swiss and European levels; b) an enhanced modelling framework for policy simulation in Switzerland and Europe; c) a database of selected results; d) an advanced adaptive policy pathways visualisation tool to inform Swiss policy design; e) the final report of the project which includes the analysis of the research results, synthesis on policy evaluation and recommendations.

2 Procedures and methodology

POLIZERO employs stakeholder consultation and a prospective quantitative analysis with a full-scale European energy systems model, complemented with dynamic adaptive policy pathways analysis. Stakeholders' input is used to identify key Swiss policies and contextual factors influencing their efficiency and effectiveness. The quantitative modelling assesses the impacts of these policies on cost-efficient transformation pathways of the Swiss energy system by also accounting for interactions with the European energy policies and system. The explorative analysis of dynamic adaptive pathways, which is informed by the quantitative modelling results and based on stakeholder consultation, identifies alternate Swiss policy pathways and the time of their implementation under national and international contextual uncertainties. POLIZERO consists of four work packages (WP), as shown in Figure 1.

[1] **Efficacy** or success is the accomplishment of a policy target. **Effectiveness** is defined as the deviation of the expected target. We use here the term effectiveness instead of efficacy as it is broader in its definition. **Efficiency** is the outcome achieved in relation to the policy cost. In POLIZERO, the policy cost is calculated as the difference in the energy system cost between a scenario where the policy is implemented and a scenario without the policy.

In **WP1**, a repository of energy and climate policy measures in Switzerland and major European countries is established with contextual factors affecting their effectiveness and efficiency. Stakeholder consultation is applied to identify those policy packages and contextual factors that are of relevance for Switzerland.

In **WP2**, the open-source European energy systems model JRC-EU-TIMES [18] that is employed for the model-based quantitative analysis of POLIZERO, is advanced with a more detailed representation of Switzerland based on the well-established Swiss TIMES energy systems model of PSI [19]. Further modelling work envisaged in this work package includes improvements in JRC-EU-TIMES to represent the policies identified in WP1 at higher detail and the establishment of interfaces between JRC-EU-TIMES and AIM [20]; AIM is the framework used to explore dynamic adaptive policy pathways.

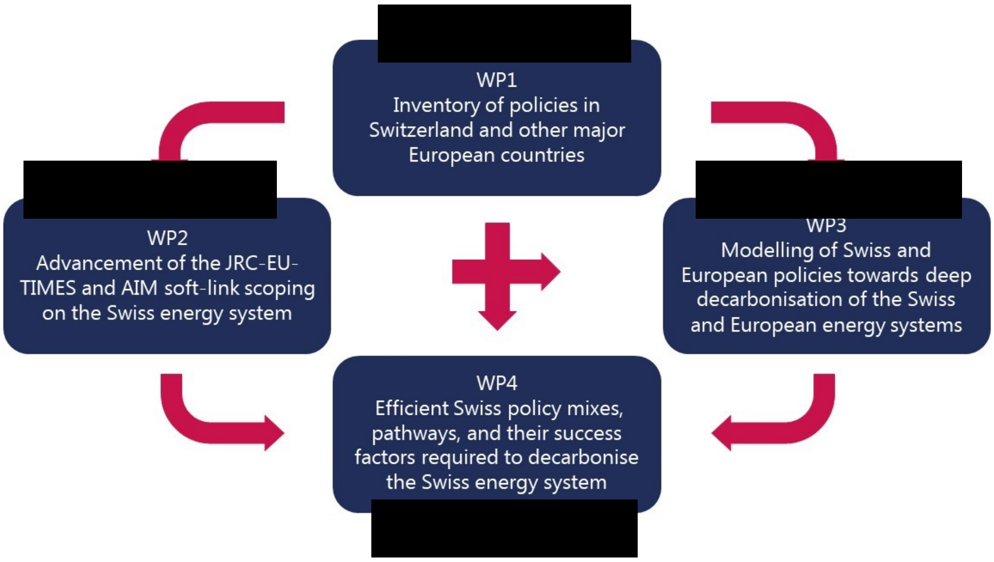

Figure 1: The work packages of POLIZERO and the timing of their implementation

In **WP3**, normative scenarios resembling different EU energy and climate policy goals are quantified with the JRC-EU-TIMES model to identify future configurations of the European energy system. These configurations, together with population, economic growth, technical progress, societal acceptance, resources, energy carriers trade and import prices, etc., form the national and international uncertainty space within which the Swiss policies are assessed by explorative scenario analyses with JRC-EU-TIMES in terms of their efficiency and effectiveness at different policy ambition levels.

In **WP4**, the dataset of WP3 with the Swiss policies' efficiency and effectiveness under different national and international contextual factors is given as input to AIM. AIM performs the dynamic adaptive policy pathways analysis. Alternative pathways are generated from implementing policy packages at different time steps to achieve desired outcomes by also considering criteria such as minimum policy costs or minimum policy changes.

3 Activities and results

After the contract entered into force, the kick-off meeting with the Swiss Federal Office of Energy took place on the 27th of November 2020. The work plan for the first year of the project was concretised. The first meeting with the Common Advisory Board was held on 27th January 2021, and the second on 26th November 2021, together with the first stakeholder meeting of POLIZERO.

Within the first year of the project, WP1 and WP2 started. The work in WP1 focused on establishing a policy inventory with currently implemented or planned decarbonisation policies for Switzerland and several major European countries, and the organisation of stakeholder meetings to identify relevant future policies for Switzerland. The work in WP2 focused on model developments in the JRC-EU-TIMES, such as calibration of the model to the latest statistics of energy balances and emissions for Switzerland and the rest of the European countries, transferring of key STEM features, and development of a flexible open-source result extraction and transformation routine.

3.1 WP1: Inventory of policies in Switzerland and other major European countries

WP1 includes three main tasks, which are briefly described below:

Task 1.1 Plan for stakeholder engagement: It establishes a plan to describe the targeted stakeholder groups involved in prioritising the policies for the quantitative analysis of WP2 and assessing alternate pathways in WP4.

Task 1.2 Literature review on current and to be implemented policies: It creates a policy inventory of current and planned energy and climate policies in Switzerland and major European countries. Appropriate indicators to quantify the policies' achievements and contextual factors affecting policy performance are also included where available.

Task 1.3 Stakeholder needs: This task aims to conduct meetings with the relevant stakeholders of POLIZERO identified in Task 1.1 to prioritise policies included in the policy inventory to identify those relevant to Switzerland and meaningful to the different stakeholders' groups. Contextual factors influencing the identified policies' effectiveness and efficiency are also prioritised. The output from this task is input to the modelling work in WP3 and WP4 in the second year of POLIZERO.

3.1.1 Task 1.1 - Plan for stakeholder engagement

The plan aims to attract stakeholders' interest in the project and elicit their needs in terms of policy evaluation. Stakeholder involvement occurs in two stages:

a) in the prioritisation of policies and contextual factors relevant for Switzerland; and
b) in the development and assessment of dynamic adaptive policy pathways.

POLIZERO follows a participatory modelling approach as stakeholder input in co-creating and co-designing Swiss decarbonisation policies, policy packages, and policy pathways are essential for their assessment in WP3 and WP4. Consequently, the relevance, validity and robustness of the scientific processes in the project and obtained results are improved via the involvement of stakeholders.

The engagement of stakeholders and the interaction with them is based on transparency, representativeness, pertinence and balance. Transparency and representativeness relate to stakeholder selection and guarantee the inclusion of opposing views. Pertinence ensures that the stakeholder input would lead to outcomes useful to the end-users of POLIZERO, mainly the energy, transport and environment national and cantonal agencies; by acknowledging that results could be relevant for other groups of stakeholders too. Balance concerns a fair engagement process in which conflicting interests of stakeholders are taken into account and resolved to the extent possible.

However, the engagement plan also considers the time and resources required for stakeholder involvement, which can be a barrier to extensive stakeholder participation. Thus, the plan carefully sets the timeline of engaging stakeholders to save resources and maximise benefits to the project. In addition, the plan avoids developing unrealistically high expectations of stakeholders' participation in the project outcomes. It also avoids unclear and lengthy involvement processes so that stakeholders do not disengage from participation. However, it should be acknowledged that getting the right stakeholders to the table is challenging, and some stakeholders may be prevented from freely participating and giving their inputs to the project due to institutional considerations.

In POLIZERO, the stakeholders involved have trusted relationships with the project partners that were established through a series of past and current interactions. Their role in the project and the timeline of their engagement is clarified early in their involvement to maximise the benefits of the participatory modelling processes. They are involved in two work packages. First, in WP1 to identify and prioritise decarbonisation policies relevant for Switzerland. Second, in WP4 to aid the exploration of the dynamic adaptive policy pathways.

Stakeholder groups are defined in the literature across four major categories. Stakeholders with high influence and high interest in the project, stakeholders with high influence but low interest, stakeholders with low influence and high interest, and stakeholders with low influence and low interest. In each stakeholder group we take care that different opinions and mindsets related to ambitious and innovative energy and climate policies are included in a balanced way, without over-representing specific opinions. Given the limited resources in POLIZERO, an inclusive stakeholder engagement across all the four major categories is out of the scope of the project. In this regard, the following subgroups have been identified to be relevant for stakeholder involvement in POLIZERO:

1. **Federal Administration related to Environment, Transport and Energy**: the most important group of stakeholders in POLIZERO is the group of energy and climate agencies, as they have an active interest in project outcomes. It is the stakeholder group to engage, consult and implement its inputs to the largest extent. The members of the Common Advisory Board of POLIZERO from the Swiss Federal Office of Energy (SFOE), the Federal Office for the Environment (FOEN), and the Federal Office for Spatial Development (ARE) constitute this group. The foreseen consultation method used is formal workshops. At least one workshop for WP1 and one for WP4 is envisaged.
2. **Academia**: the second group are the researchers from projects sharing the Common Advisory Board with POLIZERO, as they are also interested in identifying and assessing Swiss decarbonisation policies, and from the international community (e.g., the IEA-ETSAP). Although they will not be involved as frequently as the previous stakeholder group, their input is relevant to POLIZERO and will be integrated to the extent possible. The engagement method will be formal workshops, bilateral exchanges, academic conferences and fora. At least one workshop in WP1 is envisaged, but no workshop for WP4 as the aim of WP4 is closer related to the first group of stakeholders. Consultation and interaction with the researchers from the projects sharing the Common Advisory Board with POLIZERO can be also established during the meetings of the Common Advisory Board.
3. **Cantonal Administration related to Energy, Transport, Environment, Infrastructure, and Spatial Planning:** the third group of stakeholders, the group of Cantonal offices and departments for energy, transport, environment, infrastructure and spatial planning, has a strong influence in energy and climate policy in Switzerland, as Cantons implement ambitious climate change mitigation targets and face similar challenges as on the national level. Depending on their interest, this group of stakeholders could have a consultation role in the project, and its inputs will be considered. The engagement is foreseen via a workshop with participatory activities to facilitate group discussions. We seek one workshop with Cantons for WP1 to get their views and prioritisation of relevant decarbonisation policies for Switzerland. Depending on their interest in the project, one workshop with Cantons in WP4 could also be envisaged.
4. **Thematic focus groups:** the fourth group of stakeholders is quite large and heterogeneous. It includes energy providers, associations of consumers, companies and industries, national

and international think-tanks, youth organisations, as well as NGOs with a focus on environmental issues – and those against. These stakeholders are mainly concerned with energy and climate policies directly related to their activities and interests. Given that POLIZERO follows a systemic approach to assessing policies across sectors and it targets mostly national and cantonal energy, transport and climate agencies as its end-users, the interest of these stakeholders in the project might be somewhat lower than in the other stakeholder groups. However, they could have a consultation role in the project, and their inputs, when provided, would be considered. We will seek to organise a workshop with this group of stakeholders to identify and prioritise relevant policies for Switzerland for WP1, structured around focused meetings (parallel sessions) on specific topics relevant to the participants' expertise. To minimise POLIZERO resources, a possibility is to organise a combined workshop of Cantons and thematic focus groups, depending on the interest of these two groups of stakeholders and levels of participation. A maximum of 10 people would be invited to participate in each thematic meeting via participatory activities to facilitate discussions. No workshop for WP4 is foreseen with this group of stakeholders.

A database is created for all stakeholders that declare interest in participating in the stakeholder events of POLIZERO. The database aims to facilitate the most effective forms of stakeholder engagement and organise the stakeholders' information. Key variables included in the database are: the group to which the stakeholder belongs, main activity, interest in the project, dates of engagement, and contact information.

In addition to the stakeholder description, the database also includes a stakeholder engagement activity timetable. For each stakeholder, the engagement purpose (consulting, sharing, listening or collaborating) is registered together with the type of the engagement activity (e.g., workshop or focus groups) and the outlining dates and locations where the activity took place. Also, for monitoring and reporting purposes, the database contains the results from the most significant interactions with stakeholders, such as engagement activity summary, issues raised, and follow-up actions agreed.

It is worthy to note that prior to contacting stakeholders an analysis of their responses in key consultation rounds related to revisions of the Energy Law and CO_2 Act is conducted, combining qualitative methods and advanced Natural Language Processing algorithms. This analysis helps identifying key topics that are important for stakeholders in the adoption of energy and climate policies, and it could facilitate stakeholder communication. Main findings, primarily from the consultation of the amendment of the Energy Act are already reported in section 3.1.3, while during the second year of the project these findings will be complemented with the analysis of the total revision of the CO_2 Act, the consultation of which was published towards the end of the current reporting period.

An example of a POLIZERO session for stakeholders related to the activities of WP1, i.e. the identification and prioritisation of Swiss energy and climate policies, is presented in Appendix 10.1.

3.1.2 Task 1.2 – Literature review on current and to be implemented policies

This task aims to establish a comprehensive inventory of policies implemented and planned in Switzerland and major European countries. The main sources of the inventory were open policy databases, such as the IEA Policy database[2], the Climate Policy database[3], IEA country policy brief reports[4], the RES Legal database[5], energy and climate strategies, laws and acts, transposition of the EU directives to national legislation, relevant research projects and literature, and media releases.

[2] https://www.iea.org/policies

[3] https://climatepolicydatabase.org

[4] https://www.iea.org/countries

[5] http://www.res-legal.eu

Substantial effort was made to consolidate the collected policies from the different sources to remove duplicates or incomplete policies, and also eliminate ambiguities. In addition, an effort was made to decompose large policy packages into individual key policies. The inventory produced at POLIZERO constitutes a comprehensive, solid and open-source database containing the description of policies, implementation periods and status, sectors and technologies to which the policy is relevant and, whenever possible, policies' budgets and impacts. The inventory also provides a timeline of the different policies, including start and end dates as well as which policies substitute others and by when.

The selection of the countries included in the inventory was based on criteria such as CO_2 emissions per capita in 2019, change in CO_2 emissions from 2005 to 2019 in buildings and transport sectors, electrification of demand in 2019, the energy transition index published by the World Economic Forum [3], and the number of policies implemented in the post-2020 period identified in the aforementioned open-source databases.

For the identification of the contextual factors influencing the effectiveness and efficiency of energy and climate policies, relevant project reports[6], academic papers, national reports and technical studies were used as sources. The contextual factors were grouped by sector of relevance.

The European countries included in the inventory are: Switzerland, Germany, France, Italy, Austria, Spain, Portugal, Greece, the United Kingdom (UK), Ireland, Denmark, Norway, Sweden and Finland. As shown in Figure 2, a detailed catalogue of policies implemented in the past, currently active and planned to be implemented is included for each country. In addition, key energy statistics and a short analysis of the policymaking traits give a quick overview of the decision process background and the challenges that the country faces in implementing the energy transition. Whenever possible, for each policy, its budget and impact were included as well. An extract of the POLIZERO policy inventory database file, which is in Excel format to increase its usability, is given in Figure 3.

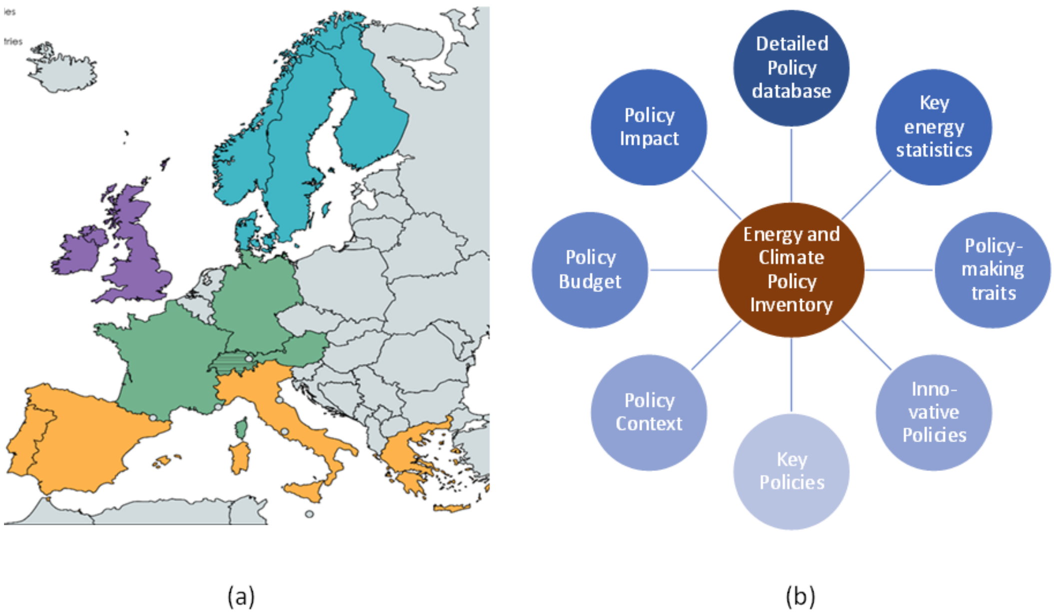

Figure 2: (a) Countries included in the inventory and (b) contents of the inventory per country

[6] for example https://ibroad-project.eu

ID	Policy	Policy type	Description	Start	End (	Status	Part of	Replaces	Sector	Technologies	Jurisdic	Budget	Impact	Source
FR37	Decree of 24 of April 2016 on	Targets	Decree of 24 April 201	2016	2023	In force	FR44	FR60	Energy sector	Renewable technol	National		15 GW (2018);	https://www.legifran
FR38	EV Infrastructure Charging Pro	Economic instr	In 2016, the ADVENIR	2016		In force			Transport	Charging infrastruc	National	100 MEUR (202	58700 charging	http://advenir.mobi/
FR39	Low Emissions Zone (Crit'Air)	Regulation	In France, the scheme	2016		In force	FR44		Transport	Vehicles	National			https://www.iea.org/
FR40	Support scheme for electricity	Economic instr	The Energy Transition	2016		In force	FR44	FR86	Energy sector	Renewable technol	National			https://www.iea.org/
FR41	Building code - EV charging	Regulation	Residential: New Buildi	2015		In force			Industry, Servic	Charging infrastruc	National			https://www.iea.org/
FR42	Demonstration Fund "Vehicle	Capacity Buildi	The main objectives pu	2015	2017	Ended		FR46	Transport		National	1.2 BEUR		https://appelsaprojet

Figure 3: An example of the energy and climate policy inventory for France

A subset of policies identified by the authors as key ones is also included for each country, based on their budget (or cost-efficiency), impact or policy effectiveness (where available) and also by considering the implementation timeframe (i.e., how long the policy is implemented), and policy type (i.e., economic instrument, regulation, target, etc.). Some measures that belong to specific policy types do not require large budgets to be implemented, e.g., a regulation policy. In the POLIZERO inventory we have included regulations also as key policies as they are important for the national energy and climate legislation. In addition, a subset of policies identified by the authors as innovative are highlighted for each country, based on their frequency of appearance in policy inventory (e.g., a low frequency could imply in some cases innovative elements) and on their status in relationship with the country of implementation (e.g., planned policies in countries that are ranked high in energy transition indices [3]). It should be noted that the main challenge in this task is the lack of information about policy impact. In some cases, where it was clear that a policy was successful or unsuccessful, the policy impact was considered as a prioritisation criterion for key or innovative policies.

Figure 4 shows an example of the additional information contained per country, beyond the list of implemented and planned policies, and related to background information regarding the policymaking traits, key energy statistics to provide a better overview of the energy transition challenges that the country faces, and the identification (subjective to the authors) of key policies and innovative policies.

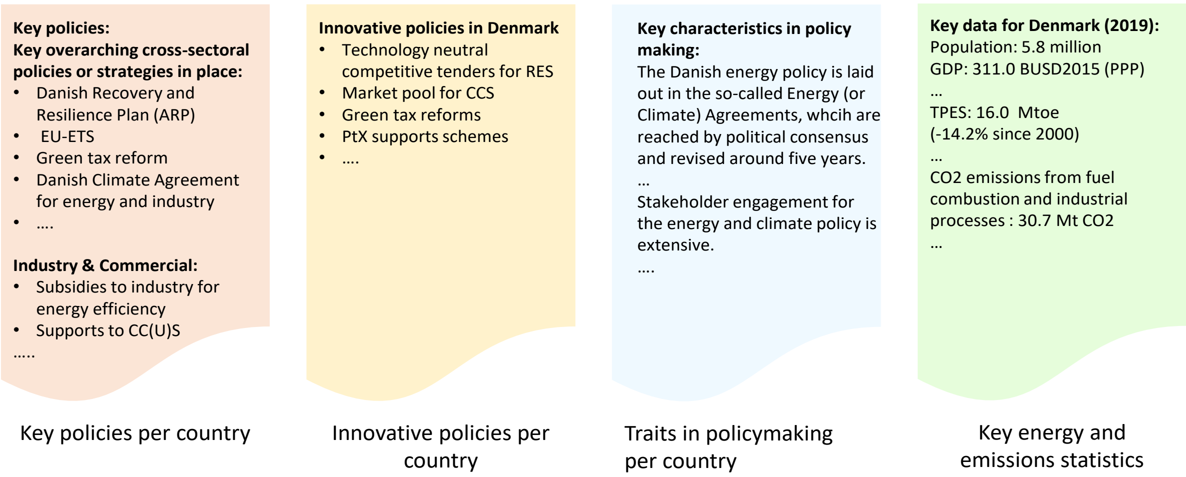

Figure 4: Additional information contained in the inventory beyond the policy list, per country (Denmark is shown here as an example)

Policy-making traits in (some of) the assessed countries

While the policy-making traits are not explicitly considered in our analysis[7], they provide useful background information regarding the implementation context of the listed policies for each country.

[7] However, different levels of social acceptance will be accounted for as an exogenous assumption (i.e. policy contextual factor) in the scenario modelling of WP3 and based on the outcomes of the stakeholder workshop

Thus, the stakeholders can qualitatively consider such traits when selecting examples of successfully implemented policies in other European countries as relevant for Switzerland.

The policy-making process varies, depending on each country's socio-political and historical context. Some examples are presented below, and more insights are provided in the policy inventory database in the policymaking characteristics section included for each country.

In Germany, the federal government is responsible for establishing legislation on energy policy, while the federal states contribute to the shaping of the energy policy and take part in federal legislation. The guiding principle is that government interventions are minimised and used only if a market mechanism does not exist or does not work well.

In Austria, the sole competence for energy policy is at the federal level. At the provincial level, the governments of the nine provinces retain competence for permitting infrastructure, land-use and zoning, building codes, etc. The split of legislative competence for the energy sector between the two levels of government often leads to duplications of instruments and delays in permitting processes for investment processes.

The British Isles also follow a decentralised approach to energy and climate policy-making. The UK has a mixed approach with the so-called devolved administrations. At the same time, the Irish county and city councils play a key role in meeting Ireland's energy targets, particularly for climate change and energy efficiency. Similarly, this approach can sometimes prove to be an obstacle in the policymaking process. It is worthy to note that the UK has been a front-runner in the energy transition by emphasising innovative technologies and policies in the context of the national 5-year carbon budgets.

The Nordic countries' energy and climate policymaking targets mainly the transport and industry sector. The Nordic countries provide a great example of a unified and collaborative approach to the energy transition. Their co-operation and shared goals are well established. Historically, emphasis has been placed on innovative technologies and policies that can facilitate the energy transition.

The Danish energy policy is laid out in the so-called Energy (and Climate) Agreements, which are reached by political consensus and revised every five years. Stakeholder engagement for the energy and climate policy is extensive, and consensus between political parties is necessary and based on dialogue. The policy-making process recognises the important role of local and regional authorities, and strong international cooperation is pursued.

Finland's energy and climate policy is largely based on voluntary efficiency agreements with industry and the transposition of the EU directives. The energy policy is driven by an efficient lean government and a commercially strong and export-oriented energy industry that mainly invests in innovative biofuel production from residues. Clean energy technology innovation is considered a critical success factor for reaching long-term decarbonisation goals. The government emphasises climate change mitigation, having ambitious goals of achieving carbon neutrality by 2035.

The energy policy in Sweden rests with the government, supported by several national authorities and active local authorities. The energy policy has for decades aimed to establish a sustainable energy system. The Swedish CO_2 tax was introduced in 1991 as one of the first in Europe. Currently, the Swedish carbon tax is one of the highest worldwide. The country can undoubtedly be considered a front runner in a transition towards a zero-emission welfare state and hosts several innovative decarbonisation projects, e.g. related to advanced biofuels or hydrogen-based steel production.

Norway's climate policy relies on international carbon credits because of the few domestic options for GHG emissions mitigation. The government accepts that achieving Norway's climate targets domestically would increase the mitigation cost per ton avoided. Priority is to secure carbon credits early, as their supply is expected to decline if global climate change mitigation efforts are pursued.

Among the Southern European countries, only Spain follows a fairly decentralised approach with the government holding basic competencies on energy and the 17 autonomous communities having legal capabilities related to power plant authorisation of less than 50 MW, distribution networks of electricity and gas. The rest of the Southern European countries follow a more traditional approach to policymaking, with singular political entities that oversee the establishment and implementation of policies. However, this does not always guarantee that there would be overlapping measures imposed by these entities that increase complexity and create an uncertain environment for stakeholders.

The evolving energy and climate policy landscape towards decarbonisation

A brief analysis of the major policies implemented in the assessed countries for key sectors of the energy system is given below. More details and a deeper analysis of the presented policies (and additional policies not discussed in this section) are provided in the policy inventory database, which accompanies the report (see Appendix 10.2 for a download link). The contents of the policy inventory database could facilitate a systematic assessment of the policies and provide the basis for the stakeholder workshop on prioritising them, while acknowledging the challenge in collecting information from open databases and grey literature on the effectiveness of the policies.

In the **energy supply sector**, renewable support policies are constantly adjusting in relation to technology costs to mitigate investment risk and distortion of the markets. There is a clear trend towards deploying renewable electricity supply on free market-competition terms. Many countries phase out feed-in tariff schemes and feed-in premium schemes and enter into a transitional period with direct subsidies (for small units) and technology-neutral tenders (for larger installations). To relieve pressure on the grid because of the integration of high shares of renewable energy, grid connection schemes are implemented (e.g., in Denmark) in which producers bear more of the costs of integrated renewable energy into the grid to ensure that renewable plants are located where the grid can best handle them.

Net-metering schemes enabling self-consumption are also implemented in several countries, as credit for free energy (e.g., in Italy), remuneration (e.g., in the UK), deduction in electricity bills (e.g., in Greece), or exemption of surcharges and taxes (e.g., in Denmark and Sweden).

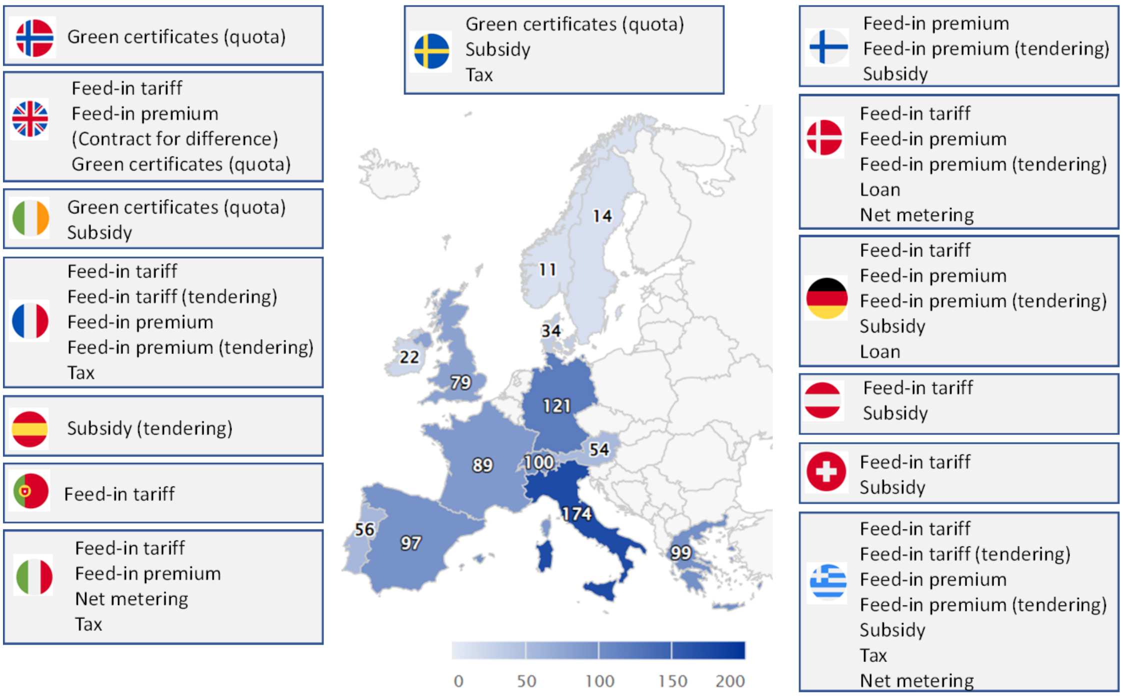

Figure 5: Major support policies for renewable electricity and the weighted average level of support in EUR/MWh in 2019

Figure 5 presents an overview of the major policies to support renewable electricity in the assessed countries for 2018/9. In addition, it shows the weighted average level of support per MWh of electricity generated from supported installations, using the energy supported through each policy instrument as the weighting factor when multiple policy schemes are in place. The figure is based on data from [22] and own calculations. The Nordic countries show lower levels of support because they target wind, while the central and south European countries also place emphasis on solar power. Hence, PV still has the highest weighted average support level. In addition, the level of support correlates with the wholesale electricity price. A higher average wholesale electricity price results in lower support levels with systems with feed-in tariffs or variable premiums. Fluctuating full load hours can also result in lower or higher overall support payments, as can a fluctuating pace of development. Finally, the longer the support times, the lower the annual average support levels are. However, this does not necessarily imply a lower total support volume over the full support period.

The large share of weather-dependent energy supply in future energy systems makes secure and reliable energy supply a major concern in many assessed countries. Among the measures implemented towards this direction are making supervision of abuse of dominant market positions more transparent, guaranteeing free price formation on the electricity market, anchoring further development of the electricity market in the European context, opening ancillary services market to new providers, evaluating minimum generation, introducing capacity reserve markets, etc. Legislation for demand management is also put in place, including rules for the aggregation of flexible electricity consumers, the introduction of smart metering, reduction of costs of grid expansion via peak shaving schemes, revising grid charges to allow for greater demand-side flexibility, enabling and ensuring participation of consumers in energy markets, promoting local energy communities and markets, addressing responsibilities between energy suppliers, grid operators and consumers regarding their role in securing energy supply, and facilitating the exchange of and access to data on an equal and non-discriminatory basis.

As heating and cooling supply lag behind in the deployment of renewable energy compared to the electricity supply, support schemes in the form of subsidies, tax exemptions and feed-in tariffs for the production of biogases/e-gases and their injection into the gas grid are implemented in many countries. Guarantee of origin systems related to the green gas and hydrogen supply are already designed (e.g., in Portugal), while revisions of the regulation for injecting hydrogen and other “green gases” to the gas grid are in progress (e.g., in Portugal). District heating and cooling networks receive subsidies for developing renewable-based (and waste heat-based) heating and cooling (e.g., in Germany, Denmark and the UK) to promote switching to low-carbon sources. Incentives are also given to consumers to switch to district heating when it is technically possible, either directly via subsidies (e.g., in Sweden) and tax exemptions (e.g., in Italy) or indirectly via heating levies and CO_2 taxes (e.g., in Germany).

Energy storage, electric, thermal and hydrogen, has an increased role in future energy systems with high shares of renewable energy. To this end, promotion schemes for storage installations are implemented in many countries, not only in the form of soft loans (e.g., in Germany) or subsidies (e.g., in Austria) to battery storage connected to PV/Wind systems, but also in the form of tenders (e.g., in Germany) and direct subsidies for large-scale storage installations to stabilise electricity grids (e.g., in France and Spain). These schemes are accompanied by necessary legislation and regulatory frameworks to ensure enough storage capacity in the energy system, which complements (to some extent) price signals from the energy markets (e.g., in Spain). Besides the economic and regulatory schemes, pilot projects to demonstrate the integration of large storage in grids have been implemented, or are being implemented, across Europe (e.g., in the UK).

New energy carriers and pathways, like hydrogen and Power-to-X, have long investment cycles and require strong policy signals to make them part of the national energy systems. Many European countries have already started to implement schemes promoting the penetration of hydrogen as an energy carrier, for example, via tax exemptions for hydrogen and synthetic e-fuels (e.g., in Austria, Portugal and Spain), exemption of grid charges for Power-to-X facilities (e.g., in Denmark), and direct subsidies (also through tenders) to help reduce production costs for green hydrogen (e.g., in Denmark). Given the increased future role of hydrogen in low-carbon energy systems, many countries also proceed to international agreements to secure imports (or exports) of low-carbon hydrogen (e.g., Portugal and Norway). Together with national strategies and hydrogen roadmaps, the legal framework setting the foundations of a hydrogen production industry by providing legal security and clarity to investors and manufacturers and by establishing a typology for officially distinguishing green hydrogen and carbonaceous hydrogen is being established in major European countries (e.g., in France).

The development of CO_2 capture, utilisation and storage (CC(U)S), which is essential to achieve the net-zero emissions targets, requires legal and regulatory frameworks to be in place (e.g., like in Norway, the UK and Denmark), also for domestic CO_2 storage (e.g., like in Portugal). To this end, Norway is a pioneer as it has already established an authority for CC(U)S to regulate the development, storage and transportation of CO_2. Roadmaps and strategies for CC(U)S development and setting targets for 2030 are conducted in several countries already (e.g., in Denmark, the UK and Norway). However, these need also to be accompanied by pilot and demonstration programmes, which showcase the feasibility of CCS for electricity and hydrogen production (e.g., like the ones implemented in Norway and the UK) as well as for industry, with a strengthening of national carbon sinks and securing access to international CO_2 storage sites (e.g., as Spain and Norway do). Supports for pilot CC(U)S projects is given in the form of direct subsidies (e.g., in Norway) or via the establishment of technology-neutral, market-based pools to promote CCS-related technologies (e.g., like in Denmark) regarding their use in electricity and hydrogen production and the development of CO_2 transport national and cross-border infrastructures.

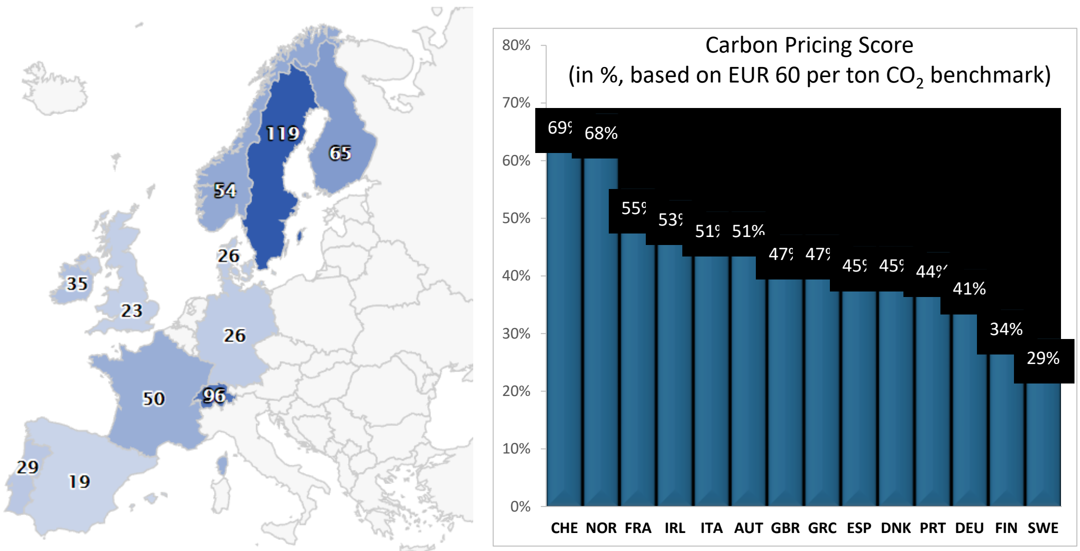

Figure 6: Left: Carbon taxes in the assessed countries for heating fuels, outside ETS, as of 2021, in CHF/tCO_2; Right: the carbon pricing score at the benchmark value of 60 EUR/t as measured in the OECD Effective Carbon Rates study [23]

The establishment of carbon markets is moving higher in the policy agenda and goes beyond the current emissions trading scheme (ETS). The forthcoming effort sharing regulation in the EU imposes binding annual GHG emissions targets for 2021-2030 for the non-ETS sectors in the EU-member states. Germany pioneers, for example, as it implements ETS also for buildings and transport; and other countries are planning to do so, as well, within this decade. While carbon taxes in the non-ETS sectors are already implemented in many countries (see Figure 6 on the left), energy taxes reformations based on a life-cycle approach, by accounting not only for direct emissions from fuel combustion but also for emissions during the production and transportation, are being planned (e.g. in

Finland for motor fuels). Figure 6 also shows the carbon pricing score (CPS) which measures the extent to which countries have attained the goal of pricing all energy related carbon emissions at the benchmark of 60 EUR/tCO_2, which is a mid-range benchmark of carbon costs in 2020 and can be considered as a low-end benchmark for carbon costs in 2030, as this is assessed by OECD [23].

In **industry**, a major challenge is that decarbonisation projects currently lack positive business cases. To this end, frameworks encouraging markets for low-carbon high-price products are discussed in the policy agenda, such as introducing carbon tax border adjustments that could also protect the competitiveness of the European industry. Industry has achieved so far significant efficiency gains via the implementation of a range of programmes like grants for applying best available technologies and energy efficiency management systems, tax exemptions or credits, loans for installing energy efficiency measures, and obligatory energy audits (which in some countries are subsidised to reduce the cost for companies). Efficiency standards on cross-sectoral technologies (e.g., like the ones implemented in Germany), competitive tenders to reduce electricity consumption (e.g., in Germany and Switzerland), incentives to reduce consumption during the peak hours (e.g., via exemptions related to the grid and renewable energy surcharges) and waste heat recovery grants (e.g., in Germany) are commonly adopted efficiency promoting measures for the sector.

Grants to promote electrification have been successful so far (e.g., in France and Portugal) to shift away from fossil-based industrial production. At the same time, the promotion of renewable energy is moving higher in the policy agenda, either directly via grants for renewable heating equipment, tax exemptions on investments in renewable technologies and tenders for deploying renewable heat (e.g., in Germany), or indirectly by removing tax exemptions on fossil-based CHP plants (e.g., in Ireland) and increasing the carbon tax of fossil fuels (see also Figure 6).

Eco-industrial development to secure industrial growth and environmental protection is supported through funding mechanisms (grants, R&D support or subsidies) for circular economy business models for reuse and recycling of key materials and industrial by products, material efficiency, retrofitting of equipment or waste recovery (e.g., in Ireland, Finland, Norway and Spain). Other policies on this topic include funding to promote innovative industry clusters and efficient industrial networks between companies for implementing efficiency and climate change mitigation measures via grants for energy infrastructure and low-carbon technologies (e.g., in Germany).

Together with industrial symbiosis, also digitalisation becomes a priority for the sector. Tax exemptions and financial incentives in the form of direct subsidies and loans for promoting the digital and technological transformation of production processes, smart energy management and measurement solutions are in place in several countries (e.g., in Italy, Germany, and the UK).

The CO_2 levy in many countries is a major instrument for achieving statutory CO_2 emissions targets for sectors not covered by the emissions trading scheme. However, companies may be exempted from it via voluntary agreements to reduce CO_2 emissions and energy consumption. Preferential financial treatment is given to the industries formally committed to them, for example, via exemptions on carbon levies or other tax credits (e.g., in Switzerland, Spain, Germany, the UK and France).

Such voluntary agreements are also relevant for reducing F-gases and SF6 gases (e.g., in Switzerland). Particularly for F-gases, many of the assessed countries implement quota systems on their use or taxes differentiated according to the global warming potential of the substance (e.g., in Spain and Denmark).

However, the transition to a low-carbon industry cannot be achieved without coordinated policies with the energy supply sector to secure infrastructure development and access to clean fuels. Funds for the development of hydrogen production and distribution infrastructure and also supports to hydrogen-based industrial production (e.g., in Sweden and France) are also implemented for major industries. The development of new infrastructure also requires setting legal foundations, which are currently processed in countries like France and Sweden.

In the **buildings sector,** policies and programmes to promote general energy efficiency have been in place since the 1980s. They have been progressively reinforced to meet stringent climate change mitigation commitments. The first cohesive legal act at the EU level was the Energy Performance of Buildings Directive (EPBD, 2002/91/EC) introduced in 2002 and imposed minimum energy efficiency requirements. Energy Performance Certificates were also introduced within this directive, together with inspections of boilers and air-conditioning systems. The concept of “nearly zero-energy buildings” (nZEB), also included in the recent update of the Directive, requires that new private buildings comply with the nationally defined nZEB standards by January 2021. Finland is one of the countries that have already transposed this requirement into the national building codes.

To improve efficiency, especially in buildings in the services and commercial sectors, mandatory energy audits are enforced in all the EU member states, which transposed the Energy Efficiency Directive (EED, 2012/27/EU) as part of the European Energy and Climate Package. Additional policies have been implemented in the assessed countries to provide incentives to facilitate investments in energy efficiency in existing buildings. These incentives range from low- or zero-interest loans (e.g., in Germany and France) to subsidies (grants, tax deduction, white certificates) for upgrading and inefficient equipment (e.g., in Italy, Austria, France and Spain). Recent schemes also support markets for energy services based on heat pumps (e.g., in Denmark), in which companies install and run heat pumps in houses and consumer pays for the delivered heat, and which imitates district heating in urban areas.

Given the low rate of new building constructions in Europe, it is essential to focus on existing buildings by triggering retrofits and including energy efficiency measures in routine building maintenance works. Targeted consumer information through enhanced energy performance certificates and financial support through tailored instruments are provided in many countries. For example, voluntary agreements for public buildings to increase energy efficiency (e.g., in Denmark and Switzerland), financing of serial renovations that aim at industrial prefabrication of facade and roof elements and a standardised installation of a heating system that allows a building to be quickly renovated via pre-configured renovation packages (e.g., in Germany), tax regulations on renovations, subsidies and soft loans are among them.

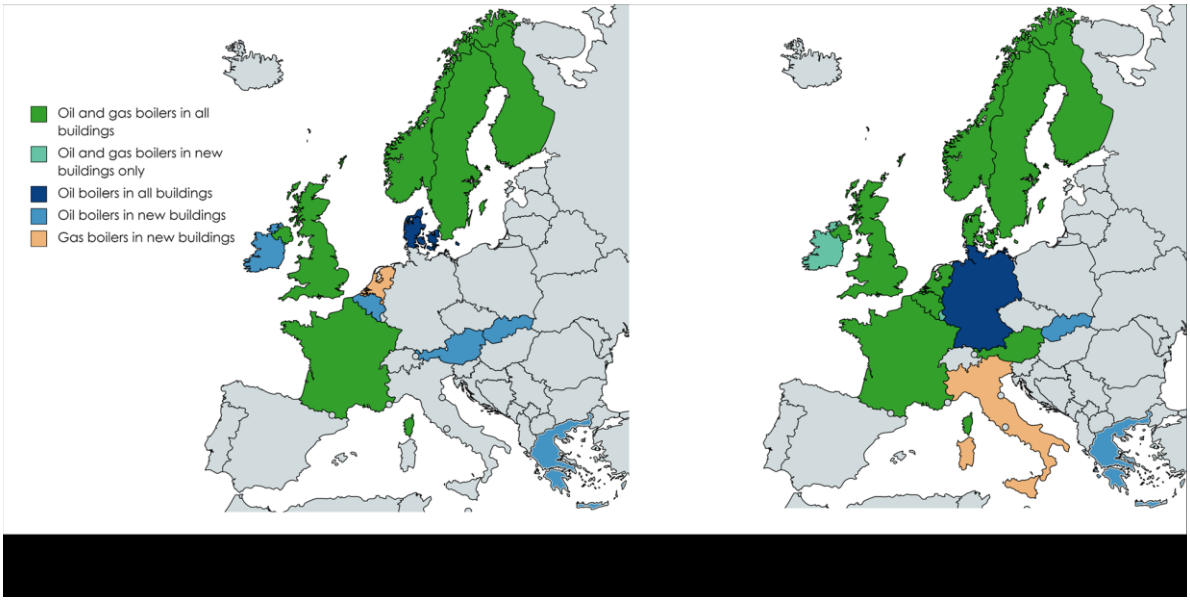

Figure 7: Types of fossil-fuel based boilers banned and their timing, based on National Energy and Climate Plans of the countries included in the policy inventory

Besides efficiency, reducing the carbon intensity of heat supply in buildings is promoted. Several measures are implemented, including, but not limited to, the establishment of climate protection urban areas in which newly constructed buildings must be equipped with renewable energy or district heating (e.g. in Austria), carbon taxes and heating fuel taxes, tax regulations for clean technologies (e.g. in Italy), phase-outs of fossil-fuelled boilers in new buildings (e.g. in Nordic countries, Austria, Germany and France), fixed payments for each kWh generated from renewable heat in buildings (e.g. in the UK), and biofuel obligation quotas in space heating (e.g. in Finland). Figure 7 presents the timing of fossil fuel boiler bans in the assessed countries based on the National Energy and Climate Plans [21].

The energy behaviour of individuals and increased awareness of new technologies are two additional targets of national decarbonisation policies in the buildings sector. Such policies implement programmes to inform on types and sources of energy, costs and environmental impacts and encourage individual responsibility and change in everyday behaviour (e.g., like the ones implemented in Italy and Ireland). Funding for consultation on energy efficiency is provided in many countries (e.g., in Germany), together with the labelling of boilers and appliances (Eco-design Directive 2009/125/EC). Introducing voluntary programmes for replacing electrical appliances in households and offices (e.g., in Germany), setting procurement criteria for low-carbon and efficient technologies (e.g., in Finland), implementing demonstration programmes of houses fuelled with alternative energy carriers such as hydrogen (e.g., in the UK) and showcasing zero-emissions buildings (e.g., in Austria) are also included to the set of policies targeting consumer behaviour and awareness.

Beyond active solutions, smart metering systems have an important role in reducing energy consumption because they can control supplied services, inform occupants about their behaviour and encourage energy conservation measures. Rollout programmes based on loans and subsidies are implemented in many countries, while installation and operation regulations and obligations are also established (e.g., in the UK, Austria and Italy).

Barriers related to split incentives are tackled through schemes that promote energy service companies (ESCOs) financing (e.g., in Spain) and sharing of costs and benefits of efficient and low-carbon equipment between ESCOs, tenants and landlords (e.g. in Italy and Spain). New electricity acts, in which solar PV plants are supported through the tenant electricity surcharge if electricity is supplied and consumed within the building, are implemented in many countries to alleviate decision making complexities in multi-family buildings (e.g., in Germany). Other barriers related to capital access and cost of capital are also tackled via soft loans that support renovation and efficiency measures in social housing schemes (e.g., in the UK) and via supports to retrofits in low-income households (e.g., in France, the UK, Sweden and Ireland).

In **transport,** a wide range of measures are available to reduce CO_2 emissions, but the sector needs additional policy instruments to meet the longer-term climate agreements. The largest potential comes from technological options to improve the energy efficiency of vehicles. The second-largest potential comes from renewable fuels and zero-carbon energy carriers for the different transport modes. And, the third potential comes from measures to change mobility behaviour to improve the efficiency of the transport system itself.

Regarding energy efficiency in the mobility sector, car labelling, vehicle scrapping incentives and strengthening of efficiency and emissions standards of vehicles are among the key policies implemented in several countries. The challenge in implementing efficiency and emissions standards for vehicles is the need for swift policy action since the new legislation takes time to be adopted and applies only to new vehicles. This means roughly ten years for the full effects to kick in, depending on the vehicle lifetime. An indirect measure also to increase efficiency is lowering the speed limits on highways (e.g., in Austria and France).

Because climate targets can only be met if light-duty vehicles become nearly zero-emission, purchase subsidies have been instrumental so far in accelerating EV deployment. However, as the funds available for subsidies are being exhausted in many countries, broader portfolio options are needed. These include, among others, registration and ownership benefits, corporate tax benefits, other tax benefits (e.g., import and luxury tax exemptions), value-added tax reductions and other benefits such as free parking, access to bus lanes, and reduced tolls for roads (see Figure 8). Besides the direct support for alternative vehicles, CO_2-based vehicle registration and circulation taxes are imposed from some countries (e.g., Ireland, the UK, Denmark, and Norway) to shift consumers in buying low-carbon vehicles. Similarly, CO_2 reduction measures for electricity input to (road) transport strengthen the principle of "user pays".

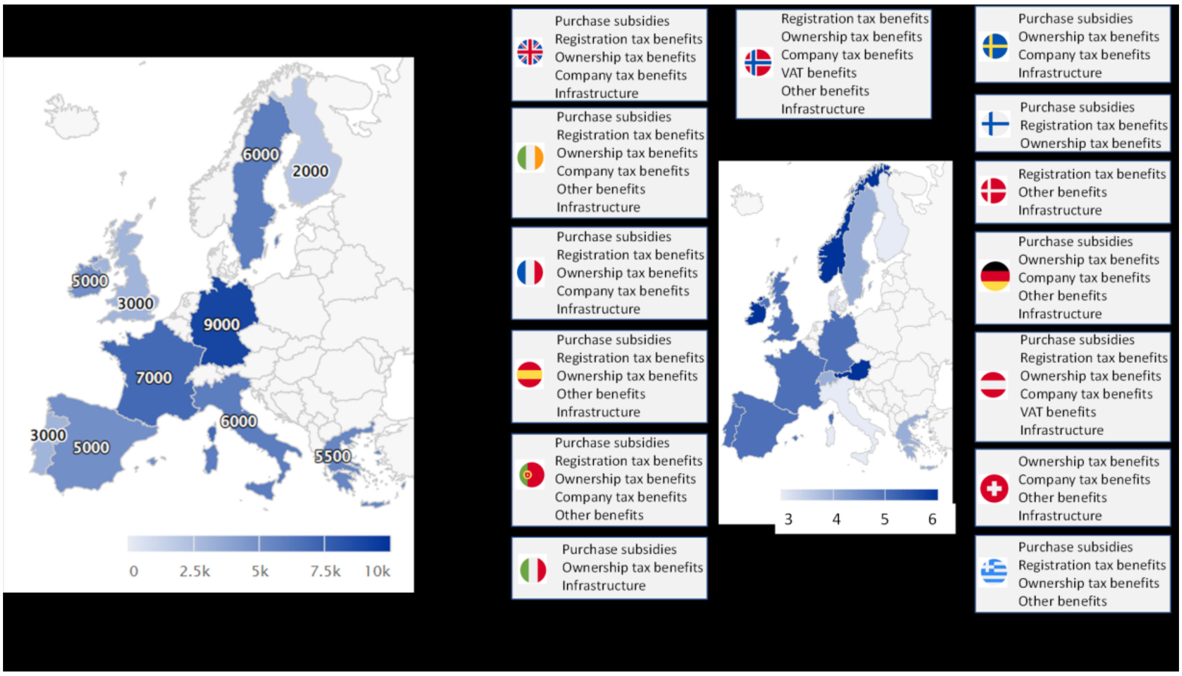

Figure 8: Overview of direct incentives for battery electric (BEV) cars in the assessed countries and overview of the policy instruments

Mandates for low- or zero-carbon vehicles are also being implemented in the assessed countries. Except for Norway, which decided for prohibiting fossil-based cars sales by 2025, most of the countries ban new fossil-based vehicles by 2030 (Denmark, Sweden, Germany, Greece and the UK) or by 2040 at the latest (Austria, Ireland, France, Spain, Finland, and - to be announced - Italy and Portugal). As a first step, many countries already create low emissions zones in urban and rural areas, in which polluting vehicles are excluded from accessing them.

Other measures for accelerating the penetration of low-carbon vehicles are public procurements of a certain percentage of electric, hybrid or hydrogen cars (e.g., in Italy, Sweden, and France), bonus-malus schemes that implement the "polluter pays" approach with eco-bonus for low-carbon vehicles and eco-taxes for carbon-intensive ones (e.g., in France, Germany and Sweden), and fleet exchange programmes for non-profit organisations that subsidise electric mobility in social services (e.g., in Germany).

In public passenger road transport, subsidies for purchasing low-carbon vehicles are available in many countries, while in other countries, like France or Portugal, subsidies are also available to decarbonise the taxi fleet and the fleet of the car rental companies.

To increase the uptake of low-carbon freight transport, taxation of heavy trucks to use highways is one of the most common measures, which can be of the form of one-time taxation related to the vehicle's performance or on a per km basis. In addition, emissions reduction targets for freight transport are also imposed in some countries via the implementation of voluntary agreements with corporates (e.g., in Germany). Direct subsidies for purchasing electric and hydrogen trucks are also implemented in several countries (e.g., in Germany, the UK and France) together with incentive schemes for van and truck scrapping when converting to a zero-emission van or truck (e.g., in Norway). Finally, the newest

EU Directive 2019/1242/EU introduces and tightens in the long-term emissions standards for new lorries and imposes penalties for excess emissions.

In accelerating the use of renewable fuels and new energy carriers like electricity, e-fuels and hydrogen, many assessed countries already implement policies promoting their use or setting minimum blending requirements (biofuel quotas). Direct tax exemptions of biofuels, green e-fuels and hydrogen are implemented in almost all national legislations assessed. Besides tax exemptions in the consumption, many countries also provide duty reduction to producers and importers of biofuels if these meet specified sustainability criteria. Explicit carbon taxes are also used in some countries (e.g., in Denmark and Sweden). Indirect incentives for the penetration of low-carbon fuels are reforms of motor fuel taxes towards life-cycle approaches that account for the direct CO_2 emissions and CO_2 emissions during the production and transportation of the fuels (e.g., in Finland). In Switzerland, there is also a CO_2 compensation duty for importers of fossil motor fuels to indirectly enable more low-carbon fuels in transport. Finally, the biofuel quotas can be set on fuel consumption or avoided emissions (e.g., Germany).

Aviation is a global sector regulated at a global level in ICAO and CORSIA. Still, the policy framework in the assessed countries recognises, to some extent, the weakness of both the current global market-based measures for aviation and the CO_2 standards for aircraft. To this end, additional measures at national jurisdiction are also taken in some countries. These measures range from constructing hydrogen fuel stations and charging stations for hydrogen-fuelled and electric airplanes (e.g., in Norway) to minimum biofuel obligations in aviation kerosene (e.g., in Sweden) and reduction or elimination of tax subsidies for paraffinic diesel (e.g., in Finland). Some countries also implement a carbon tax scheme on aviation (e.g., Portugal). At the same time, it is also considered in many EU-member states to keep a share of aviation emissions in the ETS.

To influence consumer and companies behaviours towards eco-friendly choices in mobility, several measures are implemented related to private, public and freight transport. In private passenger transport, several information campaigns encourage the use of electric cars (e.g., in the UK, Austria, and Germany). Eco-driving programmes are also implemented to increase awareness of the benefits of environmentally-friendly driving (e.g., in Spain).

To shift demand from private transport to non-motorised and public transport, a suite of policies is currently in place in the assessed countries. For example, funds to develop walking and cycling infrastructure are becoming increasingly available. Mobility pricing of the km travelled, possibly differentiated by time of day, date and mode, is another instrument aiming to shift private transport demand to public passenger transport, and which is under consideration in many countries. The reduction of fares for (also night) rail passenger transport and the increase in the taxes included in aviation fares are also measures aiming at less-carbon intensive passenger mobility (e.g., in Germany). Smart mobility and mobility as a service (MaaS) combines multiple transportation modes and mobility services such as public transport, car-sharing, taxis and bike-sharing under competitive pricing schemes compared to the use of the private car for passenger mobility (e.g., in Finland). Voluntary agreements with financial incentives are also implemented for companies to encourage the adoption of MaaS schemes in employees' travel to reduce GHG emissions and road traffic (e.g., in France).

E-carbo trikes is a measure targeting freight transport and subsidises the km driven by e-bikes for delivering goods. Incentives for freight rail transport via reduction of fares and further development of rail infrastructure aim at reducing the demand in the hard-to-decarbonise freight road transport (e.g., in Sweden).

Finally, it is worth noting that carbon-pricing for transport has already been introduced in Germany, where the price is paid not by the emitter but by the producer or importer of the fossil fuel. In the post-2020 effort sharing directive, which is being prepared, binding annual GHG emissions targets for the period 2021-2030 are imposed for sectors outside the ETS system's scope, mainly for buildings and transport.

Contextual factors affecting policy implementation and outcome

Literature identifies several contextual factors that affect the policies' implementation and outcomes. A subset of these factors, which can be represented in the quantitative modelling frameworks of POLIZERO and are relevant for the project's analysis, are to be used as inputs in the parametric scenario analysis of WP3 to explore the uncertainty space within which the Swiss decarbonisation policies are implemented. Below, the factors that can be represented in the JRC-EU-TIMES model, either explicitly or indirectly as side-constraints influencing the uptake of low-carbon options, are listed. Because the parametric scenario analysis modifies model parameters, only the contextual factors exogenous to the model are considered in this section. For example, fuel or electricity prices that are endogenous to the model cannot be part of the parametric scenario analysis. The contextual factors represented in the JRC-EU-TIMES model in WP3 are the ones also considered in the AIM model in WP4. The policy inventory database of POLIZERO includes a broader list of contextual factors and the relevant literature sources than the ones discussed below, also beyond the scope of the JRC-EU-TIMES.

Contextual factors that transcend sectoral boundaries are the economic and population growth, the availability of domestic renewable resources, the climate change impacts on energy supply resources and demands, conditions and the implementation and participation to the European Emission Trading Schemes. Additional contextual factors belonging to this category are the levels of societal acceptance and awareness of new technologies, the level of integration of Switzerland into the European (and global) energy markets for carbon-free fuels (biofuels, e-fuels, hydrogen and electricity), and the import prices of resources and energy carriers.

In the energy sector, the main contextual factors are the import prices and availability for energy carriers and fuels that are imported from outside Europe which in the model are implemented as exogenous price assumptions (e.g., for uranium, oil, natural gas, LNG, e-fuels and biofuels, electricity, etc.), the investment and operating cost of energy supply technologies, including storage, infrastructure and CC(U)S, the domestic CO_2 storage potential, the energy security of supply levels (reflected through reserve margins, import dependency and reserve operating markets), and the lead-in time for the development of new infrastructures (e.g., electricity grid upgrades or hydrogen distribution).

When it comes to the end-use sectors, straightforward contextual factors like fuel prices are excluded a priori from the analysis as they are model results. Thus, in industry, contextual factors that can be assessed in the parametric analysis with the JRC-EU-TIMES are the investment and operating costs of new efficient and low-carbon industrial processes and technologies, the level of industrial production, and the development of circular economy schemes (as these lie outside the scope of the JRC-EU-TIMES model and affect the exogenously given to the model energy service demands).

In the buildings sector, the cost of renovation, the cost of heat pumps and efficient appliances, the cost of decentralised energy technologies and storage, the evolution of the building stock (demolition and construction rates), the technical specifications and requirements for the buildings (e.g., buildings envelope, heating systems etc.), the level of adoption of energy and emission performance standards, the household disposable income and access to capital, and the level of comfort in heating and cooling of consumers are some of the factors that can be analysed with a parametric scenario analysis with the JRC-EU-TIMES model.

In transport, contextual factors relevant to the modelling frameworks of POLIZERO are the purchase and operating costs of alternative low-carbon vehicles, the lead-in times in the development of alternative transport infrastructure, the renewal rate of vehicle stock, and modal shifts induced by changing consumer behaviour and influence the energy service demands for mobility.

3.1.3 Task 1.3 – Stakeholder needs

The purpose of Task 1.3 is to conduct stakeholder-informed sessions for identifying policies relevant to Switzerland and prioritising them together with the contextual factors influencing their effectiveness and efficiency. The output from this task would be input to the modelling tasks of WP3 and WP4.

A physical stakeholder meeting with two stakeholder groups, representatives from the Federal Administration and Academia, was organised within the current reporting period. The meeting was held together with the annual meeting with the Common Advisory Board on the 26th of November, 2021, thus its duration was rather limited for enabling extensive and exhaustive discussions on different policies. The main reason for not organising additional workshops with the rest of the stakeholders relevant to POLIZERO was that most of them already have published their positions on the latest revisions of the Swiss energy and climate laws and regulations for the post-2020 period within a short time frame from the starting date of POLIZERO. Given also the restrictions in physical meetings imposed by the Federal Office of Public Health due to the COVID-19 pandemic, it was deemed appropriate (and after consultation with the Swiss Federal Office of Energy) to postpone further potential direct engagement of other stakeholders for 2022 (for WP1/WP3) and 2023 (for WP4) – depending on the development of the COVID-19 pandemic and imposed restrictions in meetings.

To partially compensate for the lack of direct stakeholder consultation, we developed an alternative approach based on qualitative and quantitative (via Natural Language Processing algorithms) analysis of the stakeholders' published position papers related to the "Revision of the Energy Law (support measures from 2023)"[8] that took place in 2020 with 208 stakeholder position papers, and the "Partial revision of the CO_2 Act on reducing CO_2 emissions in view of the coupling of the EU and Swiss emissions trading systems"[9] that took place in 2019 and resulted in 163 position papers. It was not possible to include within the current report period a similar level of analysis for the "Total revision of the CO_2 Act for the reduction of the GHG emissions"[10], as the 121 stakeholder positions relevant to this revision were only recently published. Still, based on qualitative analysis, we present in the current report some key insights regarding their positions on the total revision of the CO_2 Act for completeness. A more comprehensive analysis of the position papers of the stakeholders participated in the total revision of the CO_2 Act will be performed in the second year of the project. Insights from this analysis will be given in the next annual report of POLIZERO.

While the meeting held on the 26th of November 2021 does not substitute for an extensive stakeholder workshop, interesting insights, policies and instruments were discussed. The main findings from the meeting and the analysis of the stakeholders' published positions during the consultation of the revision of the Energy Act (and to some extent of the CO_2 Act) are summarised below.

Findings from the stakeholder meeting on the 26th of November 2021

The stakeholders who participated in the meeting were experts from the Common Advisory Board of POLIZERO from the Swiss Federal Office of Energy, the Swiss Federal Office for Environment and the Swiss Federal Office for Spatial Development, together with the research teams from EPFL, ETHZ, University of Geneva, and HESO that lead projects sharing the same advisory board with POLIZERO.

The stakeholder meeting was structured around thematic tables, following the general structure of the stakeholders' workshops for POLIZERO, which is presented in Appendix 10.1: energy supply, industry, transport and buildings. Each thematic table had on average 5 participants, and the

[8] https://fedlex.data.admin.ch/filestore/fedlex.data.admin.ch/eli/dl/proj/6020/14/cons_1/doc_1/de/pdf-a/fedlex-data-admin-ch-eli-dl-proj-6020-14-cons_1-doc_1-de-pdf-a.pdf

[9] https://fedlex.data.admin.ch/filestore/fedlex.data.admin.ch/eli/dl/proj/6019/17/cons_1/doc_1/de/pdf-a/fedlex-data-admin-ch-eli-dl-proj-6019-17-cons_1-doc_1-de-pdf-a.pdf

[10] https://fedlex.data.admin.ch/filestore/fedlex.data.admin.ch/eli/dl/proj/2021/59/cons_1/doc_1/de/pdf-a/fedlex-data-admin-ch-eli-dl-proj-2021-59-cons_1-doc_1-de-pdf-a.pdf

discussions aimed at identifying relevant sectoral decarbonisation policies for Switzerland. The moderators of the tables were members of the POLIZERO research team.

To facilitate the discussions with the stakeholders, the policies of the inventory were aggregated under policy themes that served as thematic groups. A cross-country categorisation was conducted, and the comparison between them led to creating a policy typology as presented in the policy inventory, the link to which is given in Appendix 10.2 of the report.

Two overarching questions guided the discussions in each table:

1) Assuming Swiss policymakers need to prioritise and schedule the policies to achieve the energy and climate targets. How do you see the prioritisation and timing of the selected/presented policies accounting for criteria such as effectiveness, feasibility, efficiency and acceptance and the time for their implementation (e.g. 2025, 2030 or later)? How does the prioritisation/scheduling depend on the EU climate and energy policy, e.g., ETS or energy market framework agreements?

2) Reflecting on the shortlisted policies – are there additional essential policies a Swiss policymaker should consider in this sector, and if yes - why?

In **buildings**, stakeholders highlighted the importance of fuel taxes, reflecting carbon taxes or carbon prices, as a major instrument available to decarbonise the sector. The implementation of this policy could be realised in different ways. On the one hand, some experts argued that this policy could be implemented in the context of an Emission Trading System (ETS) (e.g., the EU ETS), targeting the sellers of heating fuels and producing revenues that could later be used as subsidies for building sector energy projects (e.g., new nZEBs, building renovations, etc.). On the other hand, others commented that the continuation of the currently in force CO_2 levy, as a means of taxing fossil fuels for heating and subsidising investments for energy-efficient renovations or renewable energy through public programmes, for instance, the current Buildings Programme, could also facilitate the decarbonisation of the sector.

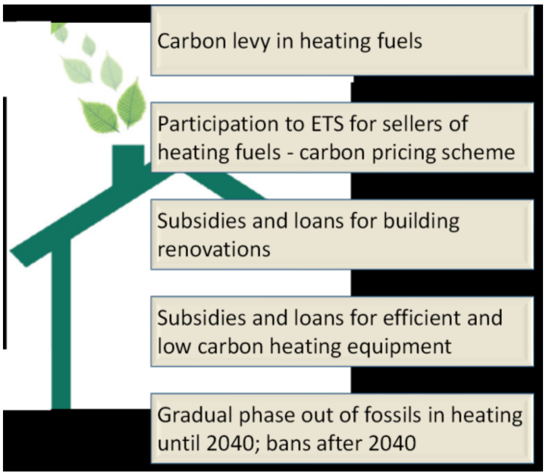

Figure 9: Subset of policies identified by stakeholders in buildings

To this end, subsidies, specifically those targeting near-zero-emission buildings (nZEBs) and building renovations, are considered instrumental by the stakeholders. Experts mentioned that subsidies for new nZEBs could be a solution for triggering innovation in the sector, potentially accelerating its decarbonisation until 2030. Furthermore, stakeholders noted that subsidies for building renovations could also be prioritised with an implementation timeframe spanning until 2050. However, they highlighted that fine-tuning of subsidies in terms of focusing on specific low-carbon technologies and reaching the “right” beneficiaries would be needed.

The second policy group brought into the discussion was funding (e.g., loans) for building renovations. Stakeholders argued that loans might have a smaller impact than subsidies since this policy measure targets only a small part of the building sector’s beneficiaries, i.e., mostly those who have access to capital and financial creditworthiness (e.g., large investors). Regarding the implementation timeframe for funding, experts argued that this option could be implemented until 2050.

Finally, the conversation also revolved around banning fossil fuels in heating at a national scale, as some cantons already implement such bans (e.g., Basel Stadt, Zürich, Glarus, Neuchâtel, etc.). Stakeholders doubted the acceptance of this regulation until 2030. Instead, they argued that to be able to enforce such a policy measure, a stepwise process will be needed. In this regard, experts referred to replacing existing fossil-fuelled heating with more efficient equipment as an intermediate acceptable policy option, e.g., until 2030. Next, fossil-fuelled technologies could be replaced by renewable heating, heat pumps, etc., until 2040. After 2040, when the market is transitioned at a certain degree into low-carbon technologies, fossil fuels in heating could be ultimately banned.

In **industry**, stakeholders stressed the continuation and strengthening of the emissions trading scheme in the context of the coupling of the Swiss and European ETS and the carbon tax on fossil fuels with exemptions under the condition of climate change mitigation voluntary agreements. Important for industry is certainty on future policy ambitions. In this regard, a floor price for the trade of certificates on the emission trading system was discussed and regarded as a useful measure to enable near-term investments with long amortisation times. Alternatively, to an ETS floor price, subsidies (related to operating or capital expenditures) were suggested to provide investment security for new energy applications in industry.

Complementary policies would be desirable to steer better and accelerate investments in clean technology and large-scale infrastructure. It was suggested to consider subsidy schemes for hydrogen, CO_2 and district heat infrastructures as they represent critical infrastructures for decarbonising industry. Clearly, this needs holistic, integrated planning, preferable on a federal level complemented with cantonal expertise. In several European countries, integrated networks are successfully promoted as well as decarbonisation strategies for entire industry clusters or regional cooperative industry networks.

Bioenergy and alternative fuels have a role to play, especially for high-temperature applications. Promoting these technologies in industry might be an option (e.g., through subsidies on the energy carriers). However, the willingness to pay for these energy carriers might be very high in other demand sectors, such as mobility. Hence, it was discussed that a possible regulation on these energy carriers in demand sectors other than industry might be effective to prevent carbon-lock-ins and limited availability of bioenergy and alternative fuels in industry in the future. An example would be to forbid (or limit) the deployment of biomass boilers for residential heating as solid biomass is expected to be particularly valuable for industrial heat production.

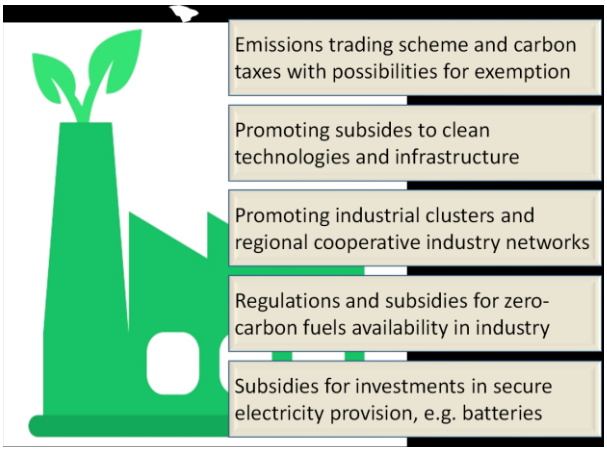

Figure10: Subset of policies identified by stakeholders in industry

In several industrial branches, increased electrification and electricity-based heat production (e.g. through high-temperature heat pumps) are expected to become a cost-effective decarbonisation option. However, a reliable electricity supply is regarded as a critical element in moving towards higher electrification levels for industrial production. This means that measures to ensure secure electricity provision need to be implemented as well, and for which incentives might be required that industry is willing to invest. Subsidies for investment in decentralised battery storages is one example.

In **mobility**, the discussions were focused on private cars and freight transportation. Mainly economic and regulatory instruments were deliberated on. Economic instruments referred to tax exemptions for low-carbon vehicles, purchase and scrapping subsidies, and higher carbon tax for motor and aviation fuels. Taxation of aviation fares was also a policy discussed with the stakeholders. In the regulatory category of policy measures, a ban of internal combustion engine (ICE) vehicles, urban low-emission zones, stricter vehicle emission standards and charging station requirements were considered. Additionally, the round table also added policies for freight transport, such as the addition of CO_2 factor into the existing heavy vehicle charges' calculations («Leistungsabhängige Schwerverkehrsabgabe»).

The voting of the top three prioritized policies within personal transport resulted in an overwhelming majority in favour of carbon and/or fuel taxation as the dominant policy goal in the mid to long term. Regulatory measurements were also the most prioritized. The arguments for these prioritizations mainly source from necessity and impact. A ban of internal combustion engine (ICE) vehicles was prioritised and could serve as a warning signal to give time for the population to transit. The transition can be further facilitated and accelerated by implementing carbon taxes, promoting e-mobility infrastructure, along with scrapping schemes of vehicles with low environmental performance.

Additionally, taxation of aviation (fuel or passenger) was well received by the participants in the discussions. Creating low/zero-emission zones (either no car or clean car) was considered an effective policy to promote low emission mobility as the convenience to drive the vehicle to one's household without being restricted to its emissions would be a powerful behaviour to push household vehicles to become cleaner vehicles. Nevertheless, it was acknowledged that political feasibility and public acceptability were identified as major uncertainty in implementing these measures.

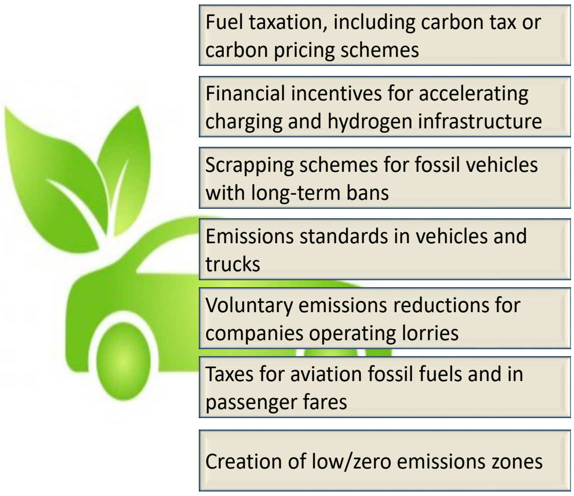

Figure11: Subset of policies identified by stakeholders in mobility

Similar to personal mobility, CO_2 tax stood as a good policy option for freight transportation because industry tends to react to cost-based instruments better than the general public. Introducing and eventually tightening the emission standards for trucks was well received. A corporate voluntary emission reduction was proposed as a potential policy. For example, large supermarket chains can shift to clean delivery transportation. The existing road pricing policy for heavy vehicles, including distance-related heavy vehicle fee (LSVA) and the related lump-sum heavy vehicle charge for foreign vehicles (PSVA), was acknowledged as the most effective policy.

In the **energy supply** sector(s), the discussions were focused on thematic areas related to electricity supply, energy storage, hydrogen production, supply of green and zero-carbon gases, as well as CO_2 capture, utilisation and storage infrastructure. The emissions trading scheme was perceived as an overarching policy for the sector that should be continued and strengthened further to maintain a low-carbon electricity system (and a low-carbon hydrogen system if domestic hydrogen production materialises). Moreover, as a large part of the energy industry in Switzerland is currently under a carbon levy or has bilateral agreements to reduce emissions[11] (e.g., the 30 major waste incineration plants), these measures need to effectively complement the emissions trading scheme to avoid jeopardising the competitiveness of the Swiss industry.

[11] The CO_2 levy in 2020 is 120 CHF/tCO2, while the bilateral agreements with managers of the waste treatment installations are to be extended also for the period 2021-2030 according to the Federal Office for the Environment

The security of supply was a major concern in the discussions, distinguishing between seasonal and intraday, short-term and long-term. Switzerland also has a regulatory framework in which the primary responsibility for the supply lies within the energy industry, grid operators ensure grid security, and the Federal government and Cantons have a subsidiary role. However, the stakeholders raised the issue that long-term security of supply would need framework agreements with the EU.

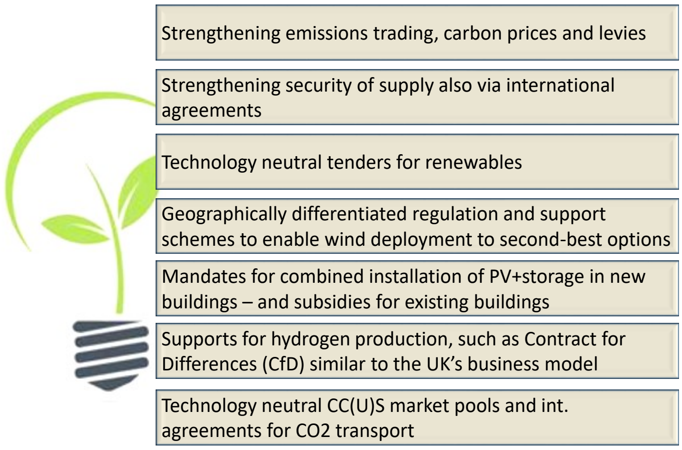

Figure12: Subset of policies identified by stakeholders in energy supply

In electricity supply, stakeholders suggested the continuation of the direct subsidies to renewable energy and introducing competitive technology-neutral tenders for a transitional period towards a market-based deployment of renewable electricity. To mitigate issues related to seasonal imbalances, stakeholders proposed revision of regulations and support schemes that could make the installation of wind turbines attractive in areas with higher social acceptance for wind but perhaps with lower potential. These "second-best" options in terms of wind speeds would imply a geographical differentiation of the support schemes to wind power and the associated grid connection costs. Still, policies that also support "second-best" locations could accelerate wind deployment and close the electricity gap in winter in the long term.

In energy storage, stakeholders proposed equal treatment of pump storage and other storage concerning grid charges. To secure intra-day balancing, combined solar PV and battery installations could be mandated for new buildings. Direct subsidies to storage could serve as an intermediate option, but stakeholders also note that when correct price signals are received, storage would be deployed in any case.

In hydrogen production, stakeholders avoided recommending direct subsidies to technologies or other targeted support measures benefiting particular options (e.g., removing grid charges for electrolysis). In contrast, they opted for contract for differences (like in the UK, where the instrument was inspired from the renewable electricity sector and in which the eligible technologies are divided into "pots" with the government confirming the economic support and the amount of the generated hydrogen production in each pot (i.e., for each pot there is a "pot budget" and a "pot capacity cap"[12]).

Related to support for green gas production or production of e-fuels, stakeholders were rather sceptical due to Switzerland's limited domestic production potential. The price signals from increasing CO_2 taxes and prices should provide incentives for their long-term development. Thus, stakeholders recommended continuing the current direct and indirect support schemes for green gases as planned and reassessing them in the long-term depending on the CO_2 price development.

Finally, regarding CO_2 capture, utilisation and storage, all stakeholders shared the same view that market pools should be established for demonstrating and developing CO_2 capture (e.g., in waste incineration plans). At the same time, international agreements for accessing CO_2 storage sites abroad should be fostered too.

[12] See also https://www.cms-lawnow.com/ealerts/2021/10/uk-hydrogen-business-model-comparison-against-key-terms-of-the-generic-cfd

Findings from the analysis of the stakeholders' position papers

By combining qualitative analysis and machine learning algorithms for Natural Language Processing, like Topic Modelling, insights were gained on the drivers that influence stakeholder opinions, and underlying hidden topical patterns were mined.

Related to "Revision of the Energy Law (support measures from 2023)", the analyses revealed some overarching focuses for the majority of the stakeholders. The highest concern is the security of supply. The frequent occurrence of keywords such as auctions and sliding market-premium indicates a discussion of market-competitive support mechanisms for renewable energy. Additionally, regulation on self-consumption was dominant in the discourse and energy supply costs remain one of the fundamental considerations for policy acceptance. These overarching findings from the position papers are largely consistent with the discussions and priorities set by the stakeholders who participated in the physical meeting of POLIZERO, organised on the 26th of November.

Using the topics identified in Figure 13, a second-level clustering of topics was performed. It was found that types of stakeholders such as waste incineration and wastewater plants, stakeholders from the wood industry, farmers' associations and stakeholders with interest in wind technology are highly aligned among themselves, and their positions are coherent among each other. Wastewater and waste incineration plants need planning security and a subsidy regime that takes into consideration the fees they pay for the waste. They advocate for the inclusion of heat energy into the support scheme. Wood-relevant stakeholders also note on the inclusion of renewable heat and feed-in-tariff.

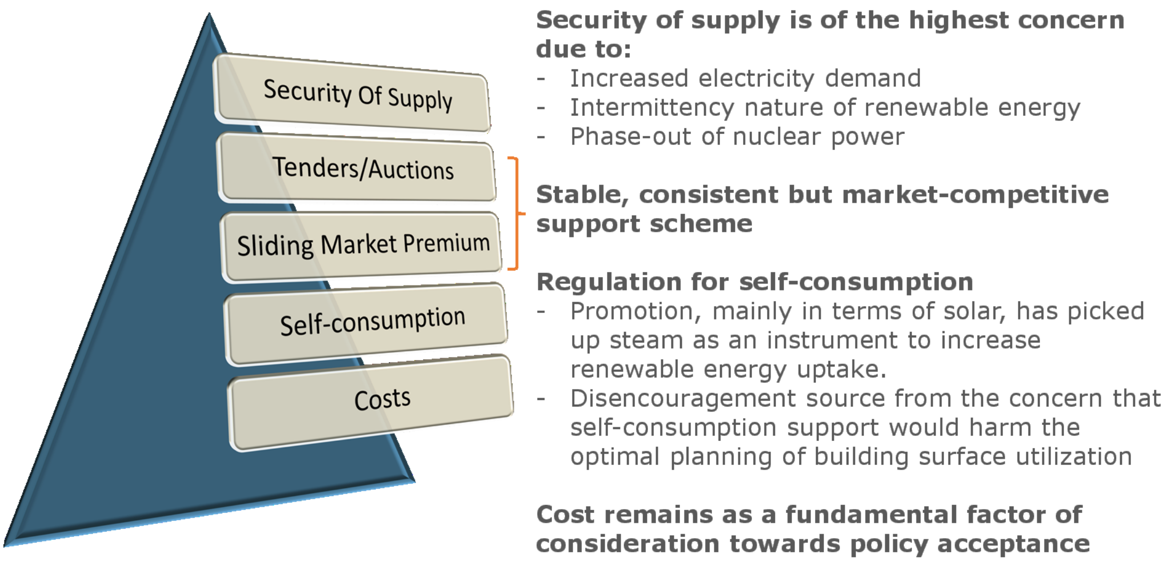

Figure 13: Top-five topics in 208 stakeholder position papers related to the revision of the support measures to renewables for 2023

The cement industry is clustered within the same subgroup as the wood industry, and this indicates their grip on biomass as their primary tool for industry emission reduction. This finding correlates well with the discussions at the meeting of the 26th of November, where concerns regarding the availability of bioenergy for industry were expressed.

The farmers' association not only notes on the inclusion of heat but also the additional costs, operational costs and self-consumption for rural buildings. Wind-relevant stakeholders largely deem themselves as a source of local, national and domestic basic energy supply, which requires investment security to alleviate concerns of obtaining construction permits and which would welcome the role of the cantons as enablers in the licensing procedures.

Types of stakeholders that are relatively clustered together but have niche fractioning and differences are solar-based stakeholders and large energy utility and production companies. The division among solar-based stakeholders lays on the different target areas for solar technology expansion. One group focuses more on promoting it in the building sector with incentives and self-consumption, while the other focuses on the electricity market models involving factors such as network surcharges, redelivery tariffs, market price, electricity price, and investment security. The energy utility and production companies can be characterised into two major groups: let's call them the "Alpiq-led coalition" and the "Axpo-led coalition". The "Alpiq-led coalition" centres around aspects of the electricity market, such as the electricity supply law, winter production, auctioning, consumers and investment incentives. At the same time, the "Axpo-led coalition" also talks about storage and sector coupling. Nevertheless, both acknowledge the role of large-scale hydropower plants as a critical resource for Switzerland to achieve its decarbonisation target and ensure the security of supply.

The final category of stakeholders is classified as scattered, which implies that they are not coherent or aligned based on which energy technology they are associated with or which type of stakeholder they are (Figure 14). They are observed to be sprinkled in all the different subgroups. In this case, they are political parties, cantons and communes. With further complementary qualitative research support, it could be concluded that for cantons and communes, the maintenance of large-scale hydropower in terms of renewal licensing and subsidies is important; they call for further exploitation of solar energy potential on top of auctioning of large-scale solar installations, and they concern for supporting instruments targeting winter energy production. Regarding political parties, there is an overall concern on planning security and risk cushioning for energy technology investments. There is also a relatively clear divide between the liberal and left-wing parties. Liberal parties intend to expand auctions to further technologies (wind, biomass, etc.), while left-wing parties notion to emphasise energy efficiency and sufficiency along with urban spatial regulations.

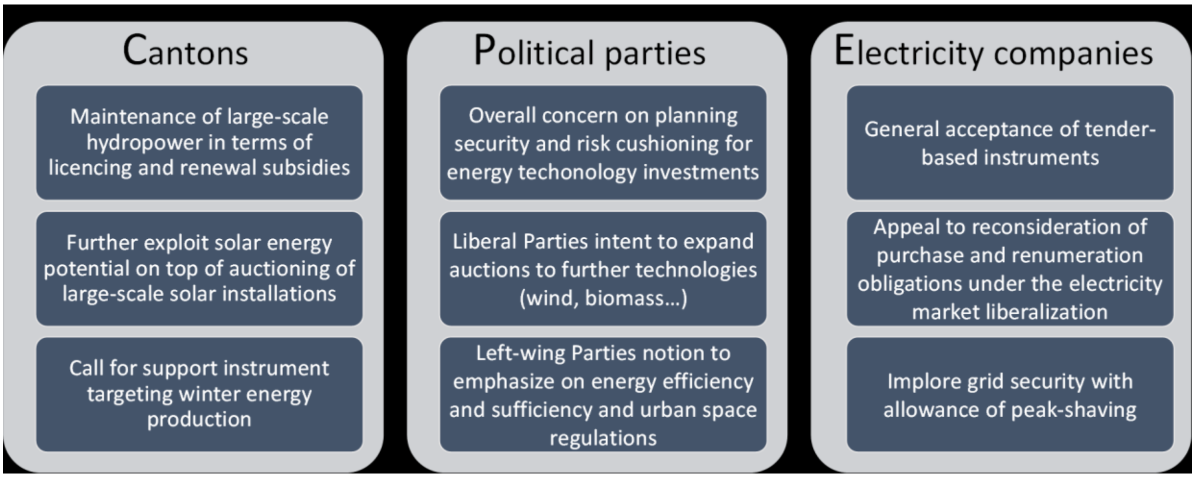

Figure 14: Topics with high frequency in the position papers of different types of stakeholders

Looking at the views of stakeholders per sector, the following can be summarised:

In **energy supply**, sliding feed-in premiums are positively seen, while subsidies shall distinguish between large- and small-scale installations. Also, stakeholders welcome the possibility of plant operators receiving and utilising certificates for emissions reduction. Still, they also express concerns that the increase of emission compensation rates for non-ETS installations should not be disproportionate. Increasing the CO_2 tax is seen as purposeful by stakeholders. However, CHP plants and waste plants should receive a reimbursement of the CO_2 tax together with thermal fossil power plants operating above a number of hours per year for security of supply – mainly in winter. The majority of stakeholders are positive in counting CO_2 storage domestic and abroad (including biological sinks - agriculture, soil and forests) as emission compensation projects, but there is a disagreement regarding the permanence, as this ranges from 15 to 30 and even 500 years for different stakeholders. Concerns about reversibility risks may prevent biological sinks from certification as compensation projects abroad. However, for the wood and forestry industry, there are concerns related to the overage of the Swiss forests and the emissions saving benefits of wood in construction rather than for CO_2 sink. According to several stakeholders, the types of sinks based on concrete debris, mineral waste or slag/ash should also be treated symmetrically with wood-based sinks. Nevertheless, many position papers call for support and research on CO_2 sinks, including biological sinks. At the same time, Cantons should be involved in certifying geological sinks as geological CO_2 storage needs to be coordinated with other subsurface uses. To this end, updated regulations for land registers to account for CO_2 sinks are also seen as necessary.

In **industry,** there is a reluctance in accepting the continuation of grid surcharges. At the same time, there is support for technology-neutral tenders to prevent distortion of free markets induced via taxes, bans and subsidies. CC(U)S should be eligible as an emissions reduction option and should be deducted from direct CO_2 emissions in the monitoring report without adjusting the free allocation of emission rights. Stakeholders propose a regulatory framework to be in place to ensure that emissions generated from biomass and captured in ETS should count as negative in the emission rights too. Exemption from the CO_2 tax through reduction commitments for companies in services and commercial sectors that do not participate in ETS is seen as an efficient instrument for reducing climate targets. Many stakeholders representing SMEs interests also welcome the possibility of forming emissions pools for collectively defined targets and reduction measures to lower mitigation costs. Moreover, policymakers should ensure that the new regulations to facilitate the decarbonisation of industry should not induce an additional bureaucratic burden on SMEs.

In **buildings,** prioritisation to secure heat supply in winter and support for sector-coupling schemes, together with the utilisation of solar panels for self-consumption. The banning of fossil fuels in heating is a controversial issue. Some stakeholders propose immediate bans, while others suggest postponement to the post-2030 period to avoid accentuating near-term negative economic impacts for consumers. Green gases, e-gases and hydrogen supports for heating are particularly welcome from stakeholders interested in the gas business. Accounting for grey emissions, e.g., during the building construction, is also seen positively by some stakeholders regarding taxation measures. Further, stakeholders support schemes of certificates of origin to increase awareness and promote renewable heating.

In **mobility,** instruments should be uncomplicated and with the least administrative effort. Plug-in hybrids and biogas-powered light commercial vehicles should be counted as emission-free. Incentives to clean vehicles should not exclude other zero-carbon options based on hydrogen and e-fuels. Increasing CO_2 emissions compensation rates in transport fuels is a quite controversial issue, with many stakeholders supporting the measure, others expressing concerns that the level of compensation should be feasible for fuel importers to avoid excessive fines with negative economic impacts and rising fuel prices, and others proposing that unused compensation certificates be transferable to other periods. Voluntary emission reduction measures for companies operating lorries receive support from many stakeholders. In aviation, double counting and conflicts between the emissions reduction managed at the global level via CORSIA and ICAO and the share of emissions under ETS should be avoided. However, increasing taxes on flight tickets is acceptable in many of the papers analysed. Finally, in freight transport, the tightening of the emissions standards for trucks is welcomed by many of the stakeholders.

Finally, regarding the **financing of the decarbonisation policies** via technology dedicated funds and climate funds, stakeholders' views are generally positive, provided that clear funding criteria are set, and there is no overlap with similar measures already in place, such as the ones undertaken by Cantons. Other stakeholders note the need to consider geographical and demographic criteria in establishing and accessing these funds, particularly related to mountainous and rural regions.

3.2 WP2: Advancements of the JRC-EU-TIMES and AIM soft-link

The work in WP2 for the first years aims to enhance Switzerland's representation in the JRC-EU-TIMES modelling framework by integrating the technology databases from the Swiss TIMES energy systems model (STEM).

3.2.1 Task 2.1 – Transferring the STEM database to JRC-EU-TIMES

Both the STEM and JRC-EU-TIMES are based on the well-established TIMES energy systems modelling framework of the IEA-ETSAP. They share the same mathematical paradigm as bottom-up partial equilibrium models representing the energy system of the underlying countries. They also share the same database structures for input and output data. Thus, integrating features and data from one model to the other is technically a quite straightforward process.

The major differences between the two models, concerning the representation of the Swiss energy system, are the higher intra-annual resolution and more advanced representation of the electricity sector in STEM compared to the JRC-EU-TIMES model (see Table 1). STEM identifies 288 typical operating hours in a year (timeslices) compared to only 12 in the JRC-EU-TIMES. The higher number of timeslices is crucial for implementing the advanced features of STEM, such as the topology of the Swiss electricity transmission grid, the identification of several voltage levels, the markets for operating reserves (ancillary services markets) and a computationally efficient unit commitment algorithm, in order the value-added gained in the analysis to compensate for the increased complexity and solution times. Thus, the 12 timeslices of the intra-annual resolution of the JRC-EU-TIMES are not sufficient and need to be increased in order to justify the transferring of STEM advanced mechanisms to it.

Table 1: Summary of the key features in STEM and JRC-EU-TIMES and actions are taken or to be taken in JRC-EU-TIMES

Feature	STEM	JRC-EU-TIMES	Action (to be) taken in JRC-EU-TIMES
Time periods	8	9	No action
Timeslices	288	12	Increase number of timeslices
Primary supply	5-step supply curves	3-step supply curves	Introduce additional supply curve steps for CH
Electricity supply	Grid topology	Single node	Introduce transmission grid topology for CH
Electricity supply	Unit commitment	No Unit Commitment	Introduce unit commitment
Electricity supply	Ancillary services	No Ancillary services	Introduce ancillary services markets
Hydrogen supply	All P2X options	All P2X options	No action
Bioenergy supply	All Swiss options	All Swiss options	No action
District heating	All Swiss options	All Swiss options	No action
Energy storage	Centralised/decentralised	Elementary options	Introduce additional storage technologies
V2G, DSM	Endogenous	Endogenous	Introduce advanced V2G and DSM from STEM
Industry	1 - 6 sectors (flexible)	7 sectors	No action
Services	1 sector, 6 end uses	6 sectors, 24 end uses	No action
Residential	4 sectors, 12 end uses	4 sectors, 15 end uses	No action
Transport	10 modes	18 modes	Introduce STEM detail in buses

An exploration is undertaken in Task 2.1 to identify “a sweet spot” between the number of timeslices in the JRC-EU-TIMES and the requirements in computational resources, which would enable the introduction of the advanced features of STEM related to the representation of the electricity sector. The TIMES modelling framework also allows the different modelled regions to have a different number of timeslices. This means that if the complexity of the JRC-EU-TIMES dramatically increases with the increase of timeslices, Switzerland and its neighbouring countries may have a larger number of timeslices, while the rest of the countries have fewer timeslices. Such an exploration process regarding the number of timeslices in the modelled countries in the JRC-EU-TIMES requires significant time, in order to test the model under different scenarios to identify the trade-offs. However, it is worth the effort because increasing the number of timeslices in the JRC-EU-TIMES model would more accurately capture the challenges and costs of the Swiss (and European) energy transition when integrating high shares of renewable energy. Thus, it directly impacts the outcome of the modelling analysis of WP3 and WP4.

Once the number of timeslices is determined, transferring the advanced features of STEM to the JRC-EU-TIMES would be a quite straightforward task. It should be noted that the enhanced JRC-EU-TIMES will be made available as open-source after the POLIZERO project finishes.

3.2.2 Task 2.2 – Calibrating the enhanced JRC-EU-TIMES

The JRC-EU-TIMES model is calibrated to reproduce the 2016 energy balances and GHG emissions statistics for Switzerland and European countries. To achieve this, several input databases are used. Table 2 lists the most important of these input databases. A pseudo-calibration is in place for 2020 in the latest model version available from JRC. However, only recently (August 2021) IEA and EUROSTAT have published the latest 2019/2020 statistics for energy balances and GHG emissions, which deviate to some extent from the ones used in the pseudo-calibration and now need to be reflected in the JRC-EU-TIMES.

Table 2: Major input databases used in the JRC-EU-TIMES

Input data category	Major database(s) used
Macro-economic (GDP, Gross value added, Industrial production)	EUROSTAT national accounts (link) EUROSTAT industrial production (link) Federal Statistical Office national economy statistics (link)
Demographic (population, households, urbanisation)	EUROSTAT population and demography (link) Federal Statistical Office population statistics (link)
Energy (balances, prices, trade, infrastructure)	EUROSTAT energy statistics (link) ENTSO-E (link) ENTSO-G (link) Federal Office of Energy (link) Swissgrid grid data (link) Swissgas (link) and other Swiss gas grid operators
Power plants (capacities, production)	JRC IDEES database (link) Federal Office of Energy (link)
Mobility sector (vehicles, mileage, pkm, tkm)	JRC IDEES database (link) EUROSTAT mobility statistics (link) Federal Statistical Office mobility and transport (link)
Buildings sector (building stock, appliances, floor area)	EU building stock observatory (link) JRC IDEES database (link) Federal Statistical Office construction and housing (link) Federal Office of Energy statistics on final consumption (link)
Industry and Services sectors (energy service demands and consumption by use)	JRC IDEES database (link) Federal Office of Energy statistics on final consumption (link)
Renewable and resource potentials	JRC ENSPRESSO database (link) BGR Energy Resources database (link) ETRI database (link) SCCER JASM database (link)
Technology costs and characterisation	ENTRANZE for building sector (link) SET Plan for power sector (link) SCCER JASM database (link) IEA-ETSAP Techs database (link)
Fuel prices by country and imported prices to the European market	OECD/IEA Energy Prices and Taxes (link) BP Statistical Review of World Energy (link) IEA ETP (link)
Other databases	JRC Heat Roadmap Project (link) IINAS Biomass project (link) ETRI,GEOELEC (link)

To reduce complexity, the calibration of the model to the latest statistics is performed independently from the exploration in the number of timeslices in Task 2.1. Also, the interfaces between the databases of STEM and the JRC-EU-TIMES model established in Task 2.1 are not enabled during the calibration to reduce the overall task complexity. The STEM features identified in Task 2.1 will be introduced to the JRC-EU-TIMES model once its re-calibration has been completed.

The task is still in progress because a number of constraint violations were detected during the wide-ranging test runs of the model. By performing extensive sanity checks to the open-source version available from JRC and contrasting to the latest published statistics (and projections of the European energy system), several constraints were corrected or re-designed to resolve these issues. This also includes removing or updating outdated constraints that are not consistent with recent policy developments in the EU (e.g., implementation of coal phase-out in several countries). Also, some power generation capacity constraints, such as those reflecting potentials or deployment rates of new technologies, were inconsistent with recent developments in several European countries, e.g., related to renewable electricity uptake, and needed to be re-designed and updated.

It is envisaged that these sanity checks and model updates performed within Task 2.2 would further enhance the quality of the JRC-EU-TIMES modelling framework and benefit the entire IEA-ETSAP community. Some of the updates in the model's constraints were already communicated and transferred to other users of the JRC-EU-TIMES model within IEA-ETSAP. The updated model version from POLIZERO will be available as open-source to the energy modelling community.

3.2.3 Task 2.3 – Testing the enhanced JRC-EU-TIMES via scenario analysis

A result extraction procedure is being developed for easier and comparable scenario result analysis. The Python programming language in a bundle with Excel has been chosen as a flexible and powerful solution. In this pair of tools, Excel spreadsheet files are used as a model dictionary and as a user interface to set up the required model results form (template). This form is filled using a Python script that acts as an extractor of results. This result extraction routine is currently in a testing phase to explore and solve possible errors in performing transformations and aggregations of the raw modelling results as per the user's requirements specified in the Excel form. Once the routine is ready, it could also be applied to export results instead of Excel to the web with slight modifications, as Python has built-in libraries for supporting such functionality. Figure 15 provides an overview of the links between the main components of the newly developed result extraction and visualisation procedure for the JRC-EU-TIMES model.

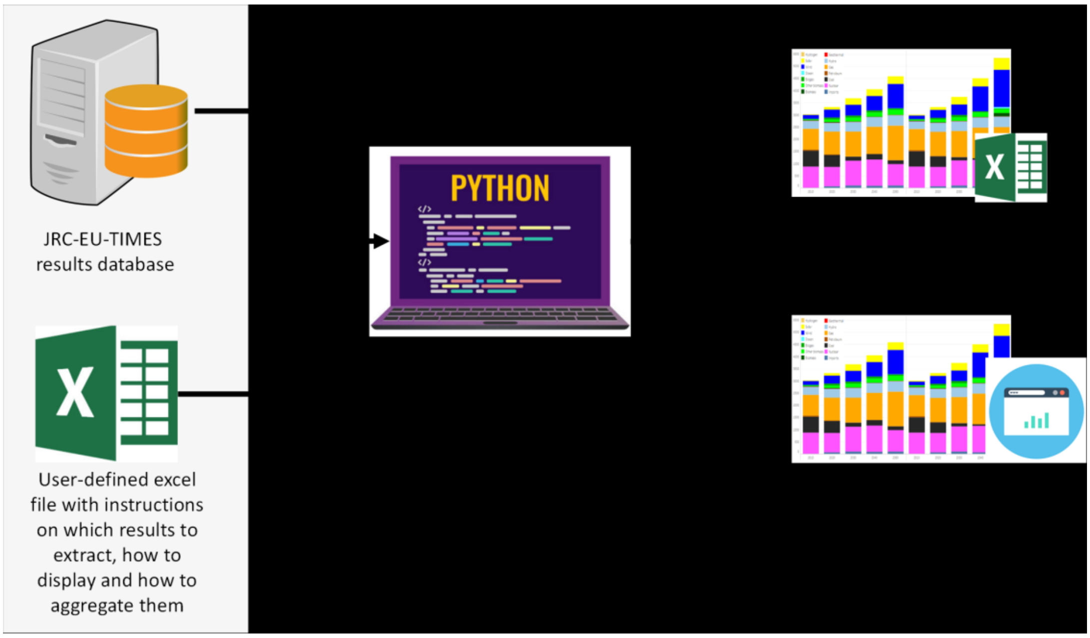

Figure 15: The automated new result routine for the JRC-EU-TIMES for user-customised result views and interfaces to Excel and Web

Because the design and functionality of the result routine can accommodate different structures of the JRC-EU-TIMES model flexibly, we aim to provide the routine as open-source to the whole community of the users of the model by the end of the POLIZERO project.

The overall workflow of the JRC-EU-TIMES model run is presented in Figure 16. The input databases with statistics, technology costs, energy service demands, energy and climate policies and other scenario assumptions (see Table 2 for some key input databases used in the model) are loaded into the VEDA 2.0 software[13]. VEDA 2.0 accepts input from a variety of Excel files with different (flexible) structures that are tailored to work efficiently with data-intensive models. It is a powerful yet user-friendly set of tools geared to facilitate the creation, maintenance, browsing, and modification of the large databases required by complex mathematical and economic models. It constitutes the main interface between the user and the JRC-EU-TIMES model. It offers scenario handling and also handles the model executions. Once a scenario has been solved, its results are loaded back to VEDA 2.0 for visualisation. In POLIZERO, we also load the results to the new routine that has been specifically designed to enhance flexibility without going through the VEDA 2.0 software for their visualisation.

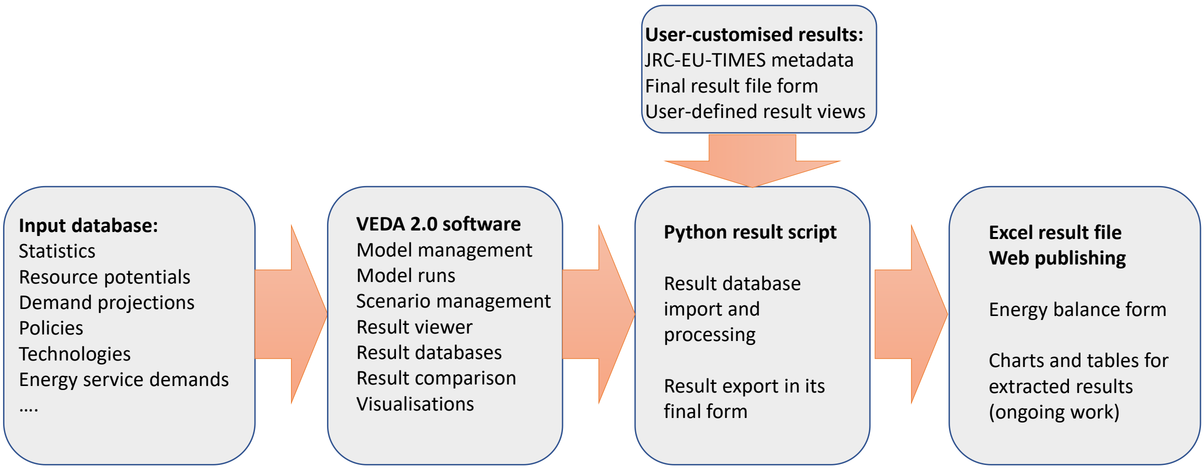

Figure 16: Workflow with the JRC-EU-TIMES

In collaboration with GAMS GmbH, and within a project funded by the IEA-ETSAP, PSI also develops an open-source interface for TIMES-based models with similar functionality as VEDA 2.0. Once the software is completed and stabilised, JRC-EU-TIMES can also be transferred to this interface to enhance the open-source character of the overall modelling framework[14].

4 Evaluation of results to date

The project started on 1st November 2020, and the kick-off meeting occurred on the 27th of November 2020. Both work packages WP1 and WP2, started as planned.

In WP1, Task 1.1 derived a stakeholder engagement plan, describing major stakeholder groups relevant to POLIZERO and possible ways to engage them. Task 1.2 delivered more than 2000 energy and climate policies for Switzerland and 13 major European countries, including performance indicators and contextual factors, where available. The deliverable “D1.2 Repository of co-identified policies and contextual factors for Switzerland and the EU” was made publicly available on the

[13] https://iea-etsap.org/index.php/etsap-tools/data-handling-shells/veda

[14] https://www.gams.com/blog/2020/07/an-open-source-times/miro-app-introducing-miro-1.1.0/ and https://miro.gams.com (click on the TIMES MIRO App picture)

project's website (www.polizero.ch). In Task 1.3, one physical meeting with two stakeholder groups of POLIZERO was organised on the 26th of November 2021, for which we reported the outcomes in section 3.1.3 of this report (Task 1.3). The invitation sent to stakeholders, the event timeline and its structure is described in Appendix 10.1. The reasons for conducting only one workshop were the restrictions in physical meetings due to the COVID-19 pandemic and the fact that the major Swiss stakeholders expressed positions regarding revisions of the Energy and CO_2 Laws for the post-2020 period shortly before or after the project started. In consultation with the Swiss Federal Office of Energy, it was concluded to postpone larger physical stakeholder workshops in 2022 (for WP1) – depending on the development of the COVID-19 pandemic. Nevertheless, stakeholders' perspectives are derived using an alternative approach based on the analysis of their position papers on recently proposed energy policies in Switzerland.

In WP2, tasks T2.1 – T2.3 related to the improvements of the European energy systems models JRC-EU-TIMES started as planned. To avoid delays due to the late start of the PhD student of POLIZERO from PSI, we involved scientific personnel for six months without implications on the overall funding provided by SFOE.

Overall, the project fulfilled the milestones and deliverables for the first year, except for the stakeholder meetings planned in Task 1.3 for the reasons mentioned above.

5 Next steps

During the second year of POLIZERO, we plan to organise 1-2 stakeholder workshops with further stakeholder groups identified in the stakeholder engagement plan and fulfil the deliverables of Task 1.3. The analysis of the stakeholder positions of the total revision of the CO_2 Act will also be made. Work will start in Task 2.4 for developing the interfaces between the AIM and the JRC-EU-TIMES model and in Task 2.5, which foresees an advancement of AIM.

The second year of the project includes the core modelling work of WP3 on the Swiss and European policies towards deep decarbonisation of the Swiss and European energy systems. WP3 lies at the project's critical path. It delivers the necessary datasets for WP4 that starts in the final year of the project and relates to the dynamic adaptive policy pathways exploration. The definition of policies, policy packages and long-term scenarios to be assessed in WP3 is also planned for the second year of the project, shortly after the stakeholder workshop(s).

6 National and international cooperation

With PSI and UPRC as partners, the project team represents international cooperation. In addition, both research teams are involved in different national and international activities based on other ongoing research projects related to deep decarbonisation pathways for Switzerland and European countries.

The policy inventory of POLIZERO was published on the project's website and made available to other Swiss researchers and national experts. Further cooperation at the Swiss level is during meetings with the Common Advisory board, as members of the other research teams constitute a stakeholder group for POLIZERO.

Moreover, POLIZERO is planned to give input to two additional projects of PSI involving Swiss and international partners. The long-term energy system scenarios for Europe and Switzerland assessed in POLIZERO will provide boundary conditions to the "Synfuel" project, a partnership between PSI and EMPA regarding the role of low-carbon synthetic fuels in Europe and aviation. They will also be used in the “SWEET SURE” project to define the European boundary conditions to the Swiss decarbonisation pathways assessed in the project.

Moreover, PSI is involved in the IEA-ETSAP energy modelling community. The concept of the POLIZERO project and insights from its policy inventory were presented in the semi-annual winter workshop at Oslo in Norway on November 30th 2021. The POLIZERO inventory is also available to all IEA-ETSAP members through the POLIZERO website. We hope it will attract further interest to the project and possible collaborations with international teams.

The policy inventory may also be utilised in the context of the on-going H2020 research projects of UPRC, e.g., “Sustainable Energy Transitions Laboratory (SENTINEL)[15]”, “Energy Citizens for Inclusive Decarbonization (ENCLUDE)[16]”, etc., related to modelling energy transition scenarios for decarbonisation in different European contexts and scales. If necessary, further development of the policy inventory by the respective consortia may take place to fulfil the needs of relevant project activities.

7 Communication

Although POLIZERO is not a flagship project, within 2021, the following communication activities were undertaken:

- Creation and operation of a dedicated website with the project description and objectives, information about the modelling tools used, and updates regarding publicly available deliverables (www.polizero.ch)
- Announcement of POLIZERO in social media: So far, the following have been achieved: (i) 6286 post views and 122 likes via LinkedIn & Twitter accounts, (ii) 134 users and 205 page views of the POLIZERO website (but the website has been online only for a short time so far).
- The meeting with the Common Advisory Board on the 26th of November 2021 and the stakeholder workshop that was held in parallel
- POLIZERO and its policy inventory were announced in the ETSAP semi-annual winter meeting on 29-30th November 2021.

8 Publications

No publications were made in the context of POLIZERO.

The policy inventory has been released as open access according to the Creative Common License Option CC BY (https://creativecommons.org/licenses/by/4.0/).

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10 Appendix

10.1 Format of a POLIZERO session with stakeholders in WP1

As stated in the main part of the report, within the current reporting period, there was only one meeting with *representatives from the Swiss Federal Offices of Energy, Transport and Environment* and *academia* on the 26th of November 2021. In this section, we present the general structure of this meeting which applies with some modifications to other meetings with stakeholders.

Invitation to stakeholders

The stakeholder invitation includes brief information about POLIZERO with a link to POLIZERO website, the objectives of the stakeholder session, and an agenda. The logos of POLIZERO, the partners and the Swiss Federal Office for Energy are visible in the invitation. In the box below, a sample of the invitation text informing the stakeholders about the project and the objectives of the stakeholder session is given.

> *POLIZERO is a research project funded by SFOE and aims at evaluating efficient policies and policy packages for Switzerland and their possible implementation timing towards net-zero CO_2 emissions in 2050. POLIZERO also brings the European policy dimension into the design of effective Swiss policies because of the influences between European and Swiss mitigation measures and energy transition pathways. Like Switzerland, also the EU aims at Net-Zero emissions in 2050.*
>
> *The project has two main parts. The first part deals with constructing a "policy inventory" of existing and planned energy and climate policies of selected European countries, including Switzerland. A handful set of important policies and innovative instruments for reaching the Net-Zero 2050 target is derived from the inventory.*
>
> *The POLIZERO team wants to understand the relevance, importance, feasibility, and*

barriers in implementing this set of policies in Switzerland. Close cooperation with stakeholders allows prioritization of these policies along with the criteria mentioned above and in view of meeting the Swiss pledges under the Paris Agreement.

The focus of the workshop is to discuss and prioritise the policies in order to help the POLIZERO team develop realistic and feasible pathways from both technical and societal perspectives. The outcome of today's workshop will be used in the rigid modelling framework of POLIZERO to come up with alternate policy pathways that are also robust and account for uncertainties related to Swiss and European policy, economic, technical and societal context within the pathways are implemented.

Stakeholder event timetable

An indicative agenda of a two-hour session with stakeholders is as follows:

Time	Topic	Presenter tentative
10 min	Introduction to POLIZERO and objectives of this session	*Evangelos Panos (PSI)*
15 min	POLIZERO policy inventory	*Nikos Kleanthis (UPRC)*
15 min	Analysis of stakeholder views obtained so far	*Meixi Zhang (PSI)*
20 min	*Break – moving to discussion tables*	
40 min	World-Café conversations	*Moderated by POLIZERO:*
	Industry	*Tom Kober*
	Buildings	*Nikos Kleanthis*
	Mobility	*Meixi Zhang*
	Energy transformation sector	*Evangelos Panos*
10 min	*Break – moving to the plenary session*	
10 min	Feedback & conclusions from the World Café	*POLIZERO team*

"Running" the event

The event starts with a brief presentation about the project and presents its objectives. It also sets the purpose of this session and demonstrates the links of the expected outcomes to POLIZERO activities. The role of stakeholders in this session is clarified to avoid unrealistically high expectations that could risk their disengagement.

The event continues with the presentation of selected policies from the policy inventory of POLIZERO, which have been identified as relevant, feasible, important or innovative for Switzerland by the research teams and other stakeholder meetings. Experiences in implementing or designing these policies in other European countries and lessons learned are also discussed and highlighted. The purpose of this presentation is to familiarise stakeholders with the energy and climate policy developments in other European countries, provide insights about their impact in achieving energy efficiency and climate targets, and highlight barriers or challenges in their implementation and how these have been tackled outside Switzerland. In addition to the policies from the inventory, the presentation also discusses policies identified or suggested by stakeholder groups in other meetings.

The presentation on stakeholder views that follows next, the POLIZERO team presents an analysis on the views and positions of other stakeholder groups, not present in the current session, regarding the acceptance, feasibility, importance and relevance of a key set of energy and climate policies for Switzerland, together with challenges in their implementation. The purpose of this presentation is to provide participants with a broader view of how the policies that are going to be discussed in the current session have been perceived so far or what additional innovative policies were suggested by other stakeholders.

The World Café session lies at the heart of the event and is the core work with stakeholders. It is structured around thematic tables with 5 to 10 participants. Usually, the thematic tables refer to different sectors of the energy system, but this would depend on the composition of the stakeholders. In each table, a member of the POLIZERO team presents a handful set of key or innovative energy and climate policies identified during the presentation of the policy inventory and are relevant to the topic of the table. A first brainstorming on the relevance of these policies to the topic (or sector) of the table would lead to a consensus among the participants, who are asked to complement this set also with additional policies. The discussion in the table would aim to classify these policies among key dimensions:

- Effectiveness: outcomes of the policies
- Efficiency: outcomes to inputs of the policy (e.g. impact per cost)
- Institutional feasibility: political factors affect support of policy
- Acceptance: equity in the distribution of policy impacts

An example of the targeted outcomes of the discussion is given in the picture below. In this theoretical example, from the list of the relevant sectoral policies presented by the POLIZERO team and identified by the participants in the table, only a few were considered relevant for Switzerland. The participants then classified these across the four dimensions: effectiveness, efficiency, institutional feasibility, and acceptance.

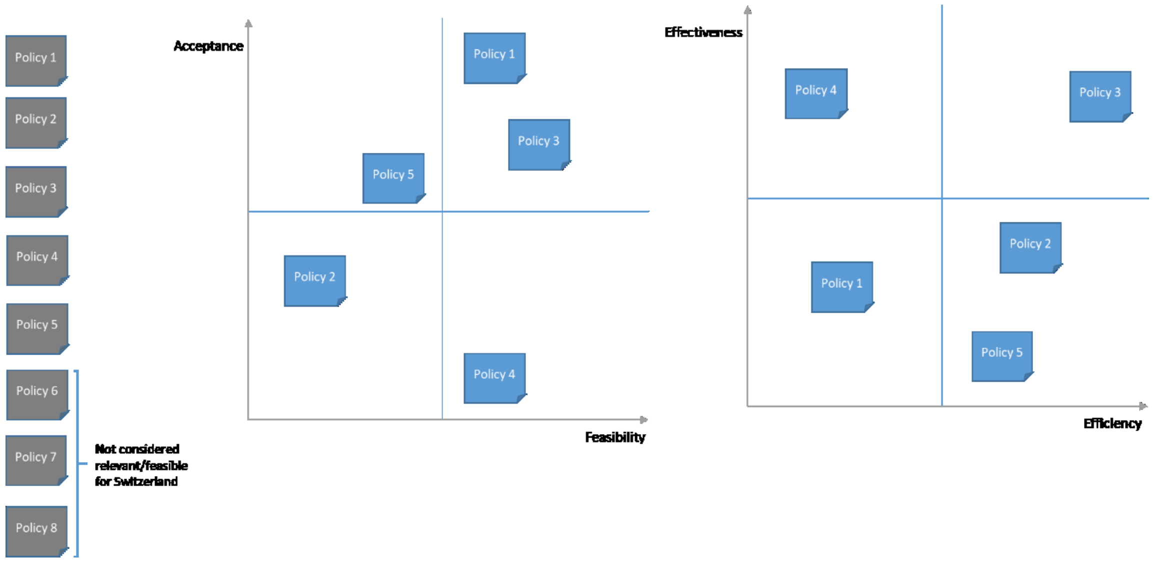

Figure 17: The whiteboard after discussing a table for a particular sector of the energy system.

From the outcome of the discussions, the (i) opportunities, (ii) challenges and (iii) barriers in the implementation of policies that are identified as most relevant by the participants can be used to further prioritise policies in the context of POLIZERO.

10.2 Inventory of policies in Switzerland and other major European countries

The policy inventory can be downloaded as an Excel file from https://polizero.ch/energy-and-climate-policy-inventory