

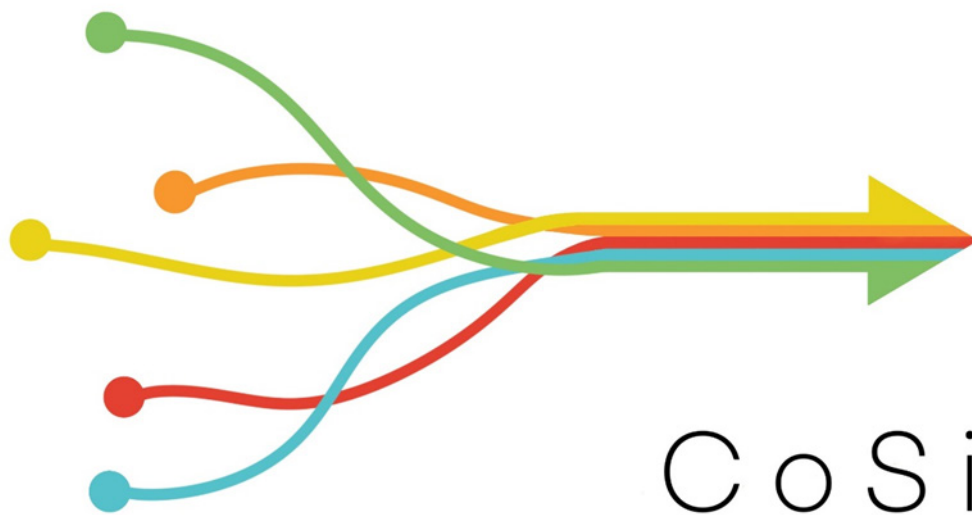


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Executive summary

With the progress of SWEET, the need to coordinate and extend the oftentimes technology-centered model-based research to an interdisciplinary and transdisciplinary research collaboration has arisen. Providing scenario structures and identifying insights from simulation results requires approaches that go beyond technical perspectives. Including political, regulatory, and societal frameworks, as well as actors' decision making and behavior into models, and considering new market designs and business models call for an inter- and transdisciplinary approach, bringing together the expertise of natural sciences/engineering, business/economics, and social science/humanities (SSH).

The ambition of CoSi (Co-Evolution and Coordinated Simulation of the Swiss Energy System and Swiss Society) is to extend the model and simulation-based assessments to account for SSH research and the co-evolution of the energy systems and society to answer how Switzerland can conduct a successful energy transition. CoSi represents a:

- **Platform for exchange:** In order to link the involved disciplines, to develop a common understanding, and to achieve a co-creation process with stakeholders, CoSi will function as a bridge for the different energy research communities as well as between researchers and stakeholders.
- **Test-lab for new approaches:** In order to enhance the usability of models, scenario structures, and simulation insights, CoSi will coordinate model activities in Switzerland to harmonize assumptions, scenarios, and storylines and provide an open documentation of these points.
- **Window into the Swiss future:** In order to provide meaningful pathways of the Swiss future, CoSi will combine the co-creative scenario process and the improved and new model approaches to run a set of CoSi-scenarios that provide a quantification of those integrative storylines. That means CoSi builds upon two interlinked pillars: i) administrative structures and ii) an interdisciplinary setting to build up mutual information, embedded in a transdisciplinary setting with practitioners.

Within the first reporting period (2023 – 07/2024) the administrative structures of CoSi have been clarified and the different research teams and Work Packages started. Due to challenges on the contractual level, this initiation phase took longer than anticipated and many teams only were able to start their work between fall 2023 to January 2024. However, despite the delays, important steps were already taken for modeling activities and research was carried out.

An important element of CoSi is the continuation of the services and activities provided by the SWEET CROSS activity (CooRdination Of Scenarios for SWEET). CROSS is merged with CoSi within an own Work Package, ensuring a smooth transition and continuation of the coordination of ongoing modeling activities across different SWEET consortia. A final scenario comparison with seven participating models was carried out to investigate the role of the Swiss-European market integration as well as the stringency of climate policies. The results form the basis of the planned first CoSi Scenario run in the next years.



Zusammenfassung

Mit dem Fortschritt von SWEET hat sich die Notwendigkeit ergeben, die oft technologiezentrierte modellbasierte Forschung zu koordinieren und auf eine inter- und transdisziplinäre Forschungszusammenarbeit auszuweiten. Die Bereitstellung von Szenariostrukturen und die Identifizierung von Erkenntnissen aus Simulationen erfordert Ansätze, die über technische Perspektiven hinausgehen. Die Einbeziehung politischer, regulatorischer und gesellschaftlicher Rahmenbedingungen sowie der Entscheidungsfindung und des Verhaltens von Akteuren in die Modelle und die Betrachtung neuer Marktdesigns und Geschäftsmodelle erfordern einen inter- und transdisziplinären Ansatz, der die Expertise der Natur-/Ingenieurwissenschaften, der Wirtschaftswissenschaften und der Sozial-/Geisteswissenschaften (SSH) zusammenbringt.

Das Ziel von CoSi (Co-Evolution und Koordinierte Simulation des Schweizerischen Energiesystems und der Schweizerischen Gesellschaft) ist es, die modell- und simulationsbasierten Abschätzungen um SSH-Forschung im Rahmen einer Co-Evolution der Energiesysteme und der Gesellschaft zu erweitern, um zu beantworten, wie die Schweiz eine erfolgreiche Energiewende durchführen kann. CoSi steht für:

- **Plattform für den Austausch:** Um die beteiligten Disziplinen zu vernetzen, ein gemeinsames Verständnis zu entwickeln und einen gemeinsamen Gestaltungsprozess mit den Akteuren zu erreichen, wird CoSi als Brücke zwischen den verschiedenen Energieforschungsgemeinschaften sowie zwischen Forschern und Akteuren fungieren.
- **Testlabor für neue Ansätze:** Um die Nutzbarkeit von Modellen, Szenariostrukturen und Simulationserkenntnissen zu verbessern, wird CoSi die Modellierungsaktivitäten in der Schweiz koordinieren, um Annahmen, Szenarien und Storylines zu harmonisieren und eine offene Dokumentation dazu bereitzustellen.
- **Fenster in die Schweizer Zukunft:** Um aussagekräftige Wege in die Schweizer Zukunft aufzuzeigen, wird CoSi den co-kreativen Szenarioprozess und die verbesserten und neuen Modellierungsansätze kombinieren, um eine Reihe von CoSi-Szenarien zu erstellen, die eine Quantifizierung dieser integrativen Storylines ermöglichen. Das bedeutet, dass CoSi auf zwei miteinander verknüpften Säulen aufbaut: i) Administrative Strukturen und ii) ein interdisziplinäres Umfeld, um einen gegenseitigen Informationsaustausch aufzubauen, eingebettet in ein transdisziplinäres Umfeld mit Praktikern.

Im ersten Berichtszeitraum (2023 - 07/2024) wurden die formalen Strukturen von CoSi definiert sowie die verschiedenen Forschungsteams und Arbeitspakete gestartet. Aufgrund von vertraglichen Herausforderungen dauerte diese Initiierungsphase länger als erwartet, und viele Teams konnten ihre Arbeit erst zwischen Herbst 2023 und Januar 2024 aufnehmen. Trotz der Verzögerungen wurden jedoch bereits wichtige Schritte für Modellierungsaktivitäten und Forschungsarbeiten unternommen.

Ein wichtiges Element von CoSi ist die Fortführung der SWEET CROSS-Aktivität (CooRdination Of Scenarios for SWEET). CROSS wird mit CoSi in einem eigenen Arbeitspaket zusammengeführt, um einen reibungslosen Übergang und die Fortsetzung der Koordinierung der laufenden Modellierungsaktivitäten zwischen den verschiedenen SWEET-Konsortien zu gewährleisten. Ein abschliessender Szenarienvergleich mit sieben teilnehmenden Modellen wurde durchgeführt, um die Rolle von Marktintegration und Klimapolitik zu untersuchen. Die Ergebnisse bilden die Grundlage für den geplanten ersten CoSi-Szenariolauf in den nächsten Jahren.



Résumé

Avec l'avancement de SWEET, il est apparu un besoin de coordonner et d'élargir la recherche basée sur des modèles, souvent centrée sur la technologie, à une collaboration interdisciplinaire et transdisciplinaire. Fournir des structures de scénario et identifier des idées à partir des résultats de simulation nécessite des approches qui vont au-delà des perspectives techniques. L'inclusion des cadres politiques, réglementaires et sociétaux, ainsi que la prise de décision et le comportement des acteurs dans les modèles, et l'examen de nouvelles conceptions du marché et de nouveaux modèles d'entreprise nécessitent une approche transdisciplinaire, réunissant l'expertise des sciences naturelles et de l'ingénierie, de l'économie et business, ainsi que des sciences sociales et humaines (SSH).

L'ambition de CoSi (Co-Evolution and Coordinated Simulation of the Swiss Energy System and Swiss Society) est d'étendre les évaluations basées sur des modèles et des simulations pour prendre en compte la recherche en sciences humaines et la coévolution des systèmes énergétiques et de la société afin de répondre comment la Suisse peut mener à bien une transition énergétique réussie. CoSi représente :

- **Un plate-forme d'échange:** Afin de relier les disciplines concernées, de développer une compréhension commune et de mettre en place un processus de co-crédation avec les parties prenantes, CoSi servira de pont entre les différentes communautés de recherche sur l'énergie ainsi qu'entre les chercheurs et les parties prenantes.
- **Un laboratoire d'essai pour les nouvelles approches:** Afin d'améliorer l'utilisation des modèles, des structures de scénarios et des résultats des simulations, CoSi coordonnera les activités de modélisation en Suisse afin d'harmoniser les hypothèses, les scénarios et les récits et de fournir une documentation ouverte sur ces points.
- **Une fenêtre sur l'avenir de la Suisse:** Afin de fournir des pistes significatives sur l'avenir de la Suisse, CoSi combinera le processus narratif co-crédatif et les approches de modèles améliorés et nouveaux pour exécuter un ensemble de scénarios CoSi qui fournissent une quantification de ces récits intégratifs. Cela signifie que CoSi repose sur deux piliers interdépendants : i) des structures administratives et ii) un cadre interdisciplinaire afin de créer des informations mutuelles, intégrées dans un cadre transdisciplinaire avec les praticiens.

Au cours de la première période de référence (2023 - 07/2024), les structures administratives du CoSi ont été clarifiées et les différentes équipes de recherche et les différents lots de travaux ont démarré. En raison de difficultés au niveau contractuel, cette phase d'initiation a pris plus de temps que prévu et de nombreuses équipes n'ont pu commencer leurs travaux qu'entre l'automne 2023 et janvier 2024. Cependant, malgré les retards, des mesures importantes ont déjà été prises pour les activités de modélisation et des recherches ont été menées.

Un élément important de CoSi est la poursuite des services et des activités fournis par l'activité SWEET CROSS (CooRdination Qf Scenarios for SWEET). CROSS est fusionné avec CoSi au sein d'un propre Work Package, assurant une transition en douceur et la poursuite de la coordination des activités de modélisation en cours à travers les différents consortiums SWEET. Une dernière comparaison de scénarios avec sept modèles participants a été effectuée pour étudier le rôle de l'intégration du marché suisse et européen ainsi que la rigueur des politiques climatiques. Les résultats constituent la base du premier scénario CoSi prévu pour les années à venir.



Riassunto

Con il progresso di SWEET, è nata l'esigenza di coordinare ed estendere la ricerca basata su modelli, spesso incentrata sulla tecnologia, a una collaborazione di ricerca interdisciplinare e transdisciplinare. Fornire strutture di scenario e identificare intuizioni dai risultati delle simulazioni richiede approcci che vadano oltre le prospettive tecniche. L'inclusione nei modelli di contesti politici, normativi e sociali, nonché di processi decisionali e comportamenti degli attori, e la considerazione di nuovi disegni di mercato e modelli di business richiedono un approccio transdisciplinare, che riunisca le competenze di scienze naturali/ingegneria, economia aziendale e scienze sociali/umanistiche (SSH).

L'ambizione di CoSi (Co-Evolution and Coordinated Simulation of the Swiss Energy System and Swiss Society) è quella di estendere le valutazioni basate su modelli e simulazioni per tenere conto della ricerca SSH e della co-evoluzione dei sistemi energetici e della società per rispondere a come la Svizzera possa condurre una transizione energetica di successo. CoSi rappresenta:

- **Piattaforma di scambio:** Al fine di collegare le discipline coinvolte, sviluppare una comprensione comune e realizzare un processo di co-creazione con le parti interessate, il CoSi fungerà da ponte per le diverse comunità di ricerca sull'energia provenienti, nonché tra i ricercatori e le parti interessate.
- **Laboratorio di prova per nuovi approcci:** Per migliorare l'usabilità dei modelli, delle strutture di scenario e delle intuizioni di simulazione, il CoSi coordinerà le attività di modellizzazione in Svizzera per armonizzare le ipotesi, gli scenari e le narrazioni/storie e fornire una documentazione aperta di questi punti.
- **Finestra sul futuro della Svizzera:** Per fornire percorsi significativi del futuro della Svizzera, CoSi combinerà il processo di narrazione co-creativa e gli approcci ai modelli migliorati e nuovi per eseguire una serie di scenari CoSi che forniscono una quantificazione di tali narrazioni integrative. Ciò significa che CoSi si basa su due pilastri interconnessi: i) strutture amministrative e ii) un contesto interdisciplinare per costruire informazioni reciproche, inserite in un contesto transdisciplinare con i professionisti.

Nel primo periodo di riferimento (2023 - 07/2024) sono state chiarite le strutture amministrative del CoSi e sono stati avviati i diversi gruppi di ricerca e pacchetti di lavoro. A causa di problemi a livello contrattuale, questa fase di avvio ha richiesto più tempo del previsto e molti team hanno potuto iniziare il loro lavoro solo tra l'autunno 2023 e il gennaio 2024. Tuttavia, nonostante i ritardi, sono già stati compiuti passi importanti per le attività di modellazione e sono state condotte ricerche.

Un elemento importante di CoSi è la continuazione dei servizi e delle attività fornite dall'attività SWEET CROSS (CooRdination Of Scenarios for SWEET). CROSS è stato fuso con CoSi all'interno di un proprio Work Package, garantendo una transizione fluida e la continuazione del coordinamento delle attività di modellazione in corso tra i diversi consorzi SWEET. È stato effettuato un confronto finale di scenario con sette modelli partecipanti per indagare il ruolo dell'integrazione del mercato svizzero-europeo e il rigore delle politiche climatiche. I risultati costituiscono la base del primo scenario CoSi previsto per i prossimi anni.



1 Work programme overview

CoSi is shaped around two main pillars:

1. Establish and enhance **inter- and transdisciplinary collaboration** between natural sciences/engineering, economics/business and social sciences/humanities as well as with stakeholders **to study the co-evolution** of the Swiss energy system and society.
2. Incorporate the insights into harmonize scenarios, models, simulations, to **enhance the derived conclusions and recommendations for the Swiss energy transition**.

To achieve this vision, CoSi is structured along six Work Packages that are aligned along two main axes (see Figure 1 below): First, to establish interdisciplinary collaboration between the disciplines we will bridge the gap between the existing techno-economic focused energy modeling community (WP1) and the SSH research communities (represented in WP4-6), horizontally via a conceptual exchange structure (WP2) and an administrative exchange structure (WP3). Second, to achieve a transdisciplinary exchange between scientists and stakeholders, CoSi links the Swiss energy research community with Swiss energy stakeholders from companies, administration and the larger society, represented by the vertical structure in Figure 1 with the scientific WPs on top and the KTT activities (also symbolizing the larger community and stakeholders) at the bottom and centered via the WP3 exchange hub.

The second main objective and challenge of CoSi concerns the conduction of harmonized scenario comparisons. CoSi will establish a joint scenario development process supported by an open call for model participation to develop three CoSi scenario runs over the next nine years. This process is designed to include the expertise and perspective of modelers, SSH researchers and stakeholders. The model and data aspects of this work are supported by incorporating the activities of CROSS (CooRdination Of Scenarios for SWEET) into CoSi as WP1.

To ensure the needed diversity of teams across the disciplines and the capabilities regarding scenario and model design the CoSi consortium consist of 14 research partners from all over Switzerland and establishes exchange structures open to the whole Swiss research community.

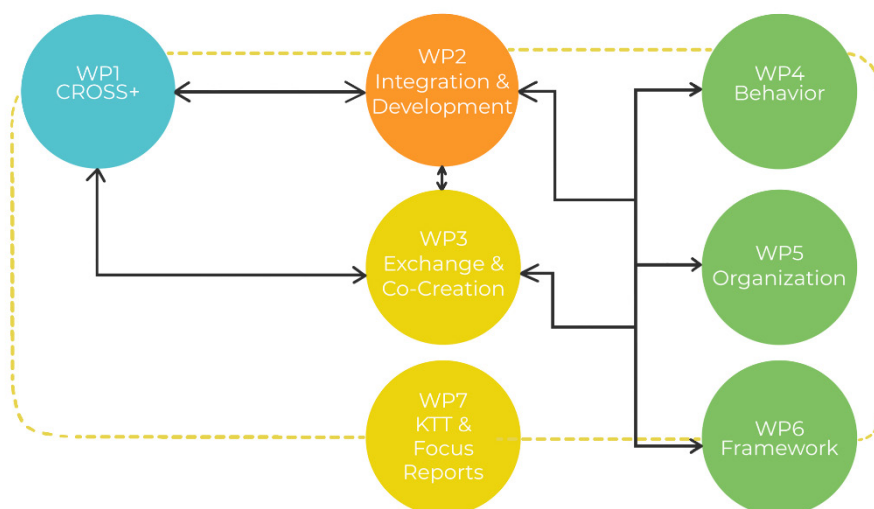


Figure 1 CoSi Overview



2 Progress of activities

CoSi officially started in January 2023 but due to contractual and administrative aspects the actual work of most teams could only start in late 2023 and early 2024. Thus, most WPs and teams were still in the build-up phase during the reporting period.

One main activity during the first phase has been the continuation of the CROSS activities and the transition from CROSS to CoSi. The ETHZ team continued coordinating the final CROSS scenario comparison with seven model teams. The first results were presented and discussed at a workshop in March 2024. Together with inputs from the climate modelling community, first ideas and perspectives on new model approaches as well as scenario adjustment and novel scenario design have been discussed and gathered. This forms a first basis for the transition to CoSi scenarios. A second step has been taken in June 2024 at the SSH energy workshop, gathering the insights, perspectives and ideas of social scientists on Swiss energy scenarios. The two perspectives will be merged and discussed at the CoSi Assembly in October 2024 and extended by the stakeholder perspectives to form the basis of the first CoSi Scenario run in 2025.

A second main activity during the first phase has been establishing the CoSi exchange structure and the overall interdisciplinary collaboration within CoSi. Utilizing the first CoSi Assembly in January 2024, we conducted several interdisciplinary workshops on expectation management and mapping of different topics (stakeholders, benefits from interdisciplinary collaboration, impact for the Swiss energy transition, use cases for collaboration, challenges and risks). Those helped to identify necessary to-dos during the build-up phase (see Section 3). A first joint seminar series has been established to provide an outlet for direct topical discussions and result presentation between the teams. CoSi is also in charge of continuing the exchange structure established via the Swiss SSH Energy Research Workshops to support discussions within the SSH energy research community and interaction with non-SSH researchers. The 4th workshop carried out on June 17. / 18. 2024 had a focus on the impact of SSH research on the energy transition and as explained above has also been used to enhance the discussion on energy modeling and scenarios.

In addition to those major collaborative activities, the CoSi teams have established first concepts and conducted research, in terms of a consumer decision framework, business ecosystems and business models for the energy transition, factors influencing Positive Energy Districts (PEDs), and a framework to integrate societal development conditions into models. However, those research activities will take some more time to provide first qualitative and quantitative outputs and outcomes.

Furthermore, CoSi has conducted the seventh wave of the Swiss Household Energy Demand Survey (SHEDS, formerly conducted via the SCCER CREST framework) providing a comprehensive description of the Swiss households' energy-related behaviours, their longitudinal changes and the existing potentials for future energy demand reduction. In relation with the Odyssee-MURE project, CoSi teams are monitoring Swiss energy efficiency and energy policy activities.



3 Highlights of outputs

An important part of CoSi and the overall SWEET program is the investigation of future socio-techno-economic pathways towards the 2050 goals. Within the CROSS scenario outlook those pathways were investigated in a comparative setting. During the first reporting period, seven models and two existing studies were integrated into a comparative setting with four common scenarios. The results provide a good overview of alternative configurations of the energy system in a carbon neutral world, highlighting important synergies and differences across modelling results. We furthermore identified that efficiencies of certain technologies, which were not part of the harmonised assumptions, are a key parameter affecting the results.

The scenarios are defined along two dimensions: integration with the EU energy system and climate policy. These dimensions were selected because each addresses different drivers of energy use and because both are levers on which policymakers can exert influence to achieve the goals of the Swiss Energy Strategy. The scenario outlook provides the following main insights:

Regarding the Swiss electricity system, the main development trends are an increase in electricity demand and a dominance of hydropower and PV generation across the models (see Figure 2). Total electricity demand is projected to fall within the range of 75–100 TWh, representing an approximate 30–60% increase compared to today's demand. Significant contributions come from the electrification of transportation and heating. Hydropower, solar PV and, to some extent, wind are the dominant technologies in the electricity mix for 2050 while geothermal and hydrogen make minor contributions to the electricity mix in most models.

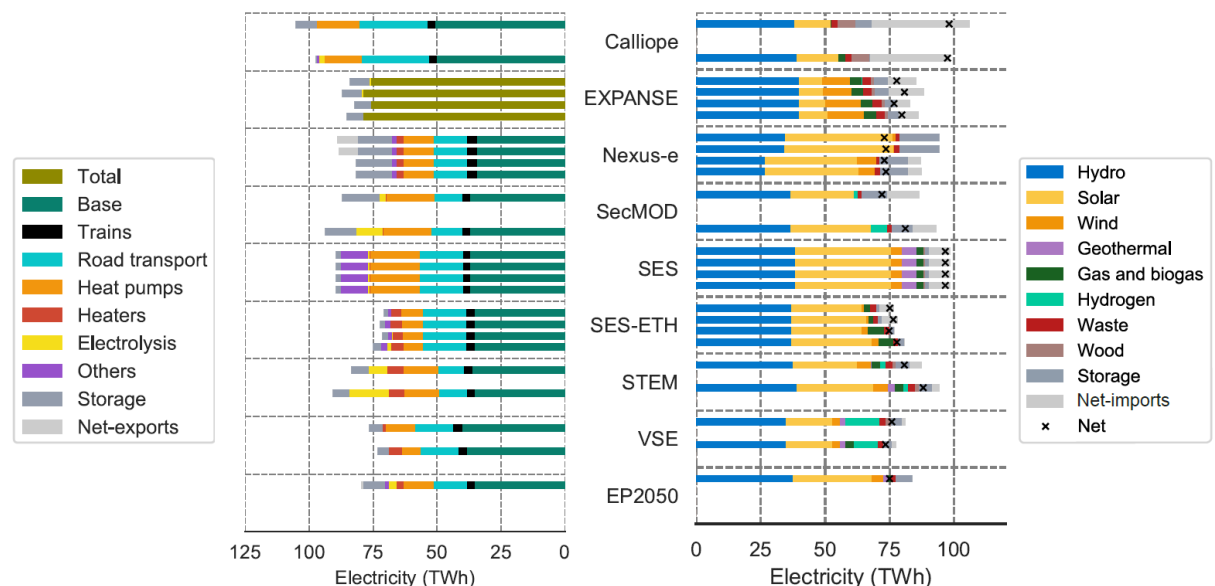


Figure 2: 2050 annual electricity supply and demand by model. The order of the scenarios is: together-abroad, together-domestic, alone-abroad, alone-domestic



With respect to the considered scenario dimensions, changes in the carbon target do not have a large effect on the resulting technology mix. A low market integration with Europe results in limited changes in the overall electricity demand and the technologies that compensate the imported electricity vary across models, including solar PV, wind and gas with CCS; highlighting the importance of the interplay between Europe and Switzerland for the actual investment needs to achieve a net-zero energy supply in 2050.

Regarding flexibility provision, electric vehicles, pumped hydro storage, and demand side management in the base electricity demand are the primary flexibility providers across all models. Especially, hydropower effectively complements solar PV by storing excess energy for short term flexibility (i.e. hourly and daily). The usage (and production) of hydrogen and industrial heat supply show the most divergent results across models.

The CROSS results will be used to inform ongoing political debates and are the underlying model and data structure is the starting point for the first CoSi scenario run.

Regarding the internal exchange structure and build-up of an interdisciplinary collaborations, the first CoSi Assembly in January was used to map the perspectives and experiences of the different research teams and identify aspects we need to include in the ongoing CoSi roadmap. The identified main aspects include amongst others:

- Stakeholders: a clearer definition of relevant stakeholders (e.g. also about how much CoSi aims to address the general population), their roles and expectations needs to be developed
- Internal Communication: beside sound documentation, CoSi should establish a consistent “vocabulary” of types/roles of stakeholders and research concepts within the WPs, and improve the communication of the modelling process
- Templates for Cooperation: specific opportunities and formats for collaboration need to be specified, a handful of typical impact pathways should be developed, and cases for a larger interdisciplinary team structure need to be identified

We are currently working on addressing those points and developing respective approaches and solutions which hopefully will also be helpful for the larger SWEET program and the Swiss energy research community.



4 References

Detailed information on the CROSS activities is provided at the CROSS webpage: <https://sweet-cross.ch/>

Information on SHEDS is available at: <https://sweet-cross.ch/sheds/>

Information on the monitoring activities is available at: <https://sweet-cross.ch/monitor/>

Further information on CoSi as well as updates on current outputs and events are provided at the CoSi webpage: <https://www.sweet-cosi.ch/>