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Federal Department of the Environment, Transport, Energy and Communications DETEC

Swiss Federal Office of Energy SFOE
Energy Research and Cleantech

National Centre for Climate Services NCCS

SWEET Call 2-2021: Call Guideline

Critical Infrastructures, Climate Change, and Resilience of the Swiss Energy System

This call is a joint activity of the Swiss Federal Office of Energy (SFOE) and the National Centre for Climate Services (NCCS)

The call for pre-proposals closes on
3 December 2021 at 12:00 noon CEST

sweet swiss energy research for the energy transition

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1 Introduction

1.1 SWEET – research for the energy transition

SWEET (SWiss Energy research for the Energy Transition) is a funding programme[1] owned and managed by the Swiss Federal Office of Energy (SFOE). The purpose of SWEET is to fund interdisciplinary and transdisciplinary research[2] and innovation activities with a focus on the goals of Switzerland's Energy Strategy 2050[3] and long-term climate policy[4]. SWEET targets application-oriented research and innovation in the natural sciences and engineering as well as in the social sciences and humanities in the domains of energy efficiency, renewable energy, storage, networks, energy and society, and security and safety of critical energy infrastructures. Within these domains, the SFOE, in collaboration with the Federal Energy Research Commission CORE, set the guiding theme of the current call as "Critical Infrastructures, Climate Change, and Resilience of the Swiss Energy System". In consultation with various stakeholders, the SFOE subsequently formulated the research challenge that is the subject of this call.

Meeting this research challenge specifically and Switzerland's energy- and climate-policy goals generally requires that solutions are developed not just from a technical perspective, but in the context of suitable legal and regulatory frameworks, innovative market designs, and social acceptance. Therefore, interdisciplinary and transdisciplinary approaches that result from close collaborations of natural sciences, engineering, social sciences, and humanities are essential. Such collaborations, in the form of consortia that reflect the diversity of Switzerland's research and innovation community, are central to the SWEET programme.

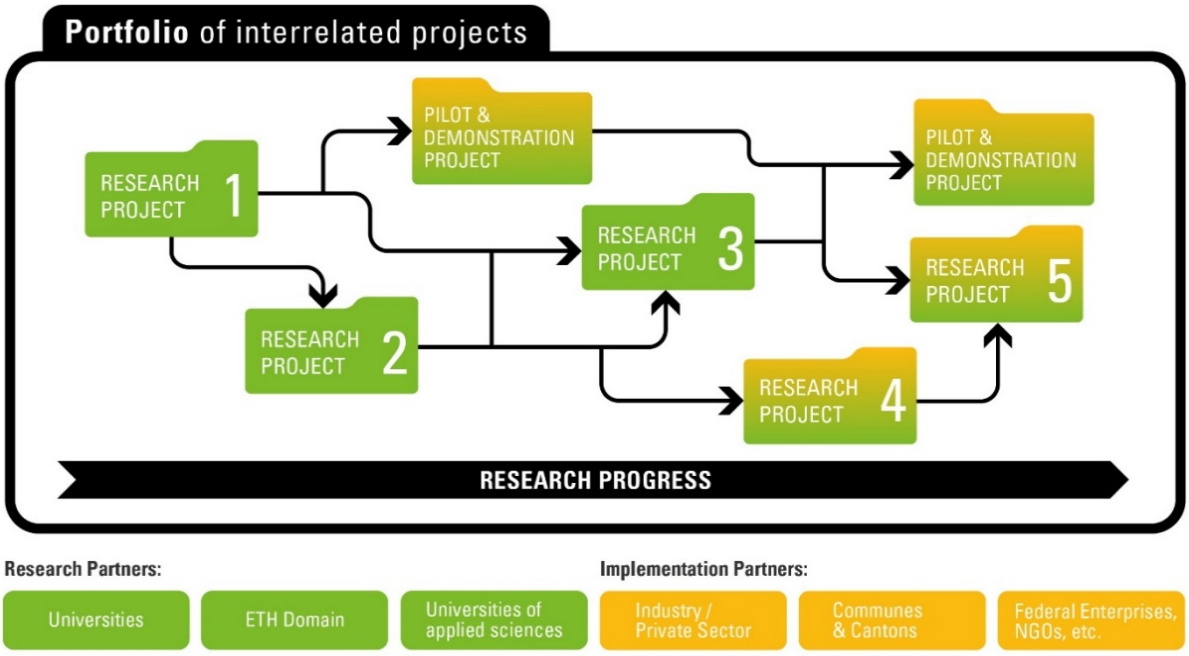

Figure 1-1: Schematic depiction of a portfolio of interrelated projects by a consortium of research and implementation partners.

[1] Further information is available at https://www.bfe.admin.ch/sweet.

[2] See the appendix for descriptions of the terms "interdisciplinary research" and "transdisciplinary research".

[3] https://www.uvek.admin.ch/uvek/en/home/energy/energy-strategy-2050.html

[4] https://www.bafu.admin.ch/bafu/en/home/topics/climate/info-specialists/emission-reduction/reduction-targets/2050-target/climate-strategy-2050.html

In response to SWEET calls, consortia consisting of research and implementation partners are invited to propose portfolios of interrelated research projects, including pilot and demonstration (P+D) projects, see Figure 1-1. The portfolio should be composed of projects focusing on research, development, demonstration, and deployment, structured such that the projects build on and feed into each other. As a result, the consortia and project portfolios should cover significant parts of the innovation system depicted in Figure 1-2. Some projects may start as soon as a consortium is launched, while other projects may follow at a later stage as they build on the output of earlier projects.

Successful consortia will receive SFOE funding to pursue their projects over 6 to 8 years. SFOE's funding is subject to the principles of subsidiarity. In the context of SWEET, this means that the consortium partners contribute financially, each according to its abilities, to supplement SWEET funding and thereby ensure that the total financial resources are sufficient for the work programme of the consortium.

SWEET consortia are managed by a host institution. Preference will be given to consortia comprising researchers, innovators, and implementers that cover the best possible range of partners from the higher education sector, research institutes, private sector, as well as partners from the public sector such as cantons, cities, communes, and districts/regions. Preference will also be given to consortia that achieve gender balance and reflect Switzerland's diversity in terms of languages and regions. It is expected that every member of a consortium delivers complementary and significant contributions to the consortium's work programme.

Since the outputs of the consortia are expected to be relevant to the implementation of Switzerland's Energy Strategy 2050 and climate policy, consortia will be closely accompanied by the SFOE, with particular attention being paid to communication and knowledge and technology transfer (KTT).

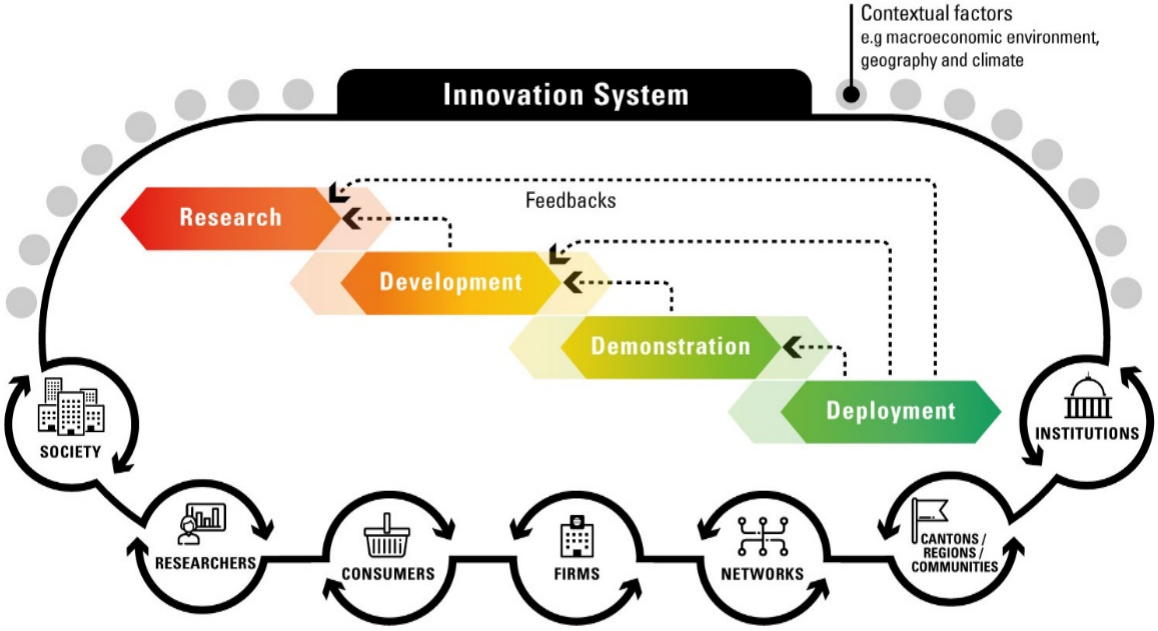

Figure 1-2: A schematic representation of the innovation system, significant parts of which should be covered by SWEET consortia and their project portfolios. The projects are expected to generate and exploit feedbacks, e.g., a market place that demands innovations (deployment) is supplied with new knowledge and/or products from research, development, and demonstration. Adapted from International Energy Agency (2019), *Energy Technology Innovation Partnerships*, building on graphics and text sourced from Global Energy Assessment (2012), *Global Energy Assessment: Towards a Sustainable Energy Future*, Cambridge University Press and the International Institute for Applied Systems Analysis.

1.2 Guiding theme: critical infrastructures, climate change, and resilience of the Swiss energy system

The Swiss energy system is regarded as a critical infrastructure because its functioning is essential to the economy, the well-being of the population, and its vital resources. Analogously, a specific element of the energy system can be regarded as a critical infrastructure if its functioning is essential to the economy, the well-being of the population, and its vital resources. The likelihood of critical infrastructures functioning can be increased by lowering their vulnerability and increasing their resilience. A system is said to be vulnerable if it is susceptible to malfunction, failure, or destruction in response to internal or external shocks. A system is said to be resilient if it can withstand internal or external shocks (robustness) and either maintain functionality as much as possible (adaptation) or reattain functionality (regeneration).[5] A vulnerable system is not resilient.

In the 2020 edition of the National Risk Analysis,[6] the Federal Office for Civil Protection (FOCP) found that two of the top ten risks are associated with the energy system. A sustained shortage of electrical energy, which could be induced by the combination of low water levels in rivers and hydropower reservoirs on the one hand and a shortage of electricity imports on the other hand, represents the highest risk and was estimated to result in damages of about 185 billion Swiss francs. An outage of the electrical supply represents the sixth-highest risk and is associated with estimated damages of about 3.3 billion Swiss francs. (Accidents in nuclear and hydropower plants were estimated to result in damages of about 36 billion and 1.3 billion Swiss francs, respectively.[7])

To meet the energy- and climate-policy goals by 2050, the Swiss energy system is undergoing a fundamental change: New nuclear power plants may not be built, existing nuclear power plants may continue to operate as long as they are safe (i.e., possibly beyond 2050). Distributed renewable energy sources are being integrated, and fossil-fuel use must be mostly eliminated. The future energy system will depend on decentralized renewable energy sources, various energy conversion and storage technologies, and electricity/gas/thermal grids, all of which will be integrated and orchestrated to balance supply and demand across sectors and over time scales ranging from seconds to months. As the Swiss energy system changes, it is necessary to (re-)evaluate the criticality[8] of the underlying existing and new infrastructures, to understand how the system will react to the malfunction, failure, or destruction of one or more of the infrastructures, and to develop and implement suitable mitigation measures.

The re-evaluation must begin by identifying the hazards to the underlying infrastructures and to the energy system as a whole. Following the National Risk Analysis, hazards may be classified as technical, natural, and societal. New technical hazards can originate from the increasing decentralization of the energy system. On the one hand, by phasing out nuclear power plants and expanding small-scale photovoltaic (PV) and wind-turbine installations, the electricity supply will become more volatile. On the other

[5] See the *National Strategy for Critical Infrastructure Protection 2018-2022*, available in German, French, and Italian at https://www.babs.admin.ch/en/aufgabenbabs/ski.html.

[6] https://www.babs.admin.ch/en/aufgabenbabs/gefaehrdrisiken/natgefaehrdanalyse.html.

[7] The damages given were estimated for assumed scenarios and are subject to uncertainties. For example, in the case of an accident in a hydropower plant, the damage was estimated assuming a scenario such as spillover due to a rock slide with sufficient advance warning. More severe scenarios such as the failure of a major dam may put several 10'000 people, their housing, as well as nearby infrastructure at risk.

[8] The criticality of an infrastructure refers to its relative importance in terms of the consequences that its malfunction, failure, or destruction would have on the economy, the well-being of the population, and its vital resources. Criticality depends on the particular level of perspective: for example, some critical infrastructures may have a high level of criticality at local or communal levels (e.g., a transformer station in the distribution grid), while others have a high level of criticality at the national or even international level (e.g., central control systems in the transmission grid). See the *National Strategy for Critical Infrastructure Protection 2018-2022*, available in German, French, and Italian at https://www.babs.admin.ch/en/aufgabenbabs/ski.html.

hand, the electricity is no longer supplied through synchronous generators connected to the transmission grid but through power-electronic converters connected to the distribution grid. The resultant bidirectional energy flows and reduced rotational inertia and self-synchronization can cause instabilities in the electrical grid, which in turn can cause blackouts.

The instabilities can be compounded by the electrification of the energy system, i.e., the increased use of heat pumps and battery-electric vehicles (BEV), which are needed to reduce the greenhouse-gas emissions of the building and transport sectors. Increased demand in the distribution grid that could be caused by the near-simultaneous large-scale activation of heat pumps and charging of BEV can be avoided by smart grids.[9] Smart grids are thus essential to future energy systems, but they can also create new hazards.[10] For instance, the complexity created by interconnecting a large number of devices – whose behaviour can depend on local insolation and wind patterns, consumer behaviour, machine-learning-based control algorithms, and perhaps automated local or peer-to-peer energy markets – makes predicting the behaviour of smart grids very challenging. In addition, the dependence of smart grids on information and communication technologies (ICT), which in turn depend on power supplied by the electricity grid, may create an interdependency in which a limited failure of an ICT system could cause the failure of part of the electricity grid and thus set up a cascading failure that could end in a blackout.[11] The foregoing points to the vulnerability of smart grids to software faults and cyberattacks:[12,13] The large number of interconnected and interdependent devices and systems, especially if procured from a small number of suppliers, creates a cluster risk in that a single fault or attack could pose a hazard to the entire electricity system. It is therefore imperative that smart grids are investigated for elements that must be viewed as critical infrastructures.

Beyond the technical hazards, the energy system is also exposed to a range of natural hazards, e.g., storms, cold and heat waves, forest fires, flooding, mass movements[14], earthquakes, and solar storms. Climate change is expected to exacerbate some of these hazards. For instance, the melting of glaciers, the thawing of permafrost, and more frequent severe weather events are expected to lead to more frequent and intense mass movements that can threaten transmission lines and pipelines[15] as well as hydropower dams. In addition to direct hazards to elements of the energy system, climate change also poses indirect hazards. For example, more frequent dry spells during the summer and less snowfall during the winter lead to lower water levels in rivers during the summer, which will reduce the electricity production of run-of-river hydropower plants.[16] At present, the lower water levels, when coupled with higher water temperatures, can result in nuclear plants having to reduce or cease power production.[17] In the future, the lower water levels could negatively affect the large-scale production of hydrogen near run-of-river hydropower plants and the higher water temperatures of rivers and lakes could impact their

[9] https://www.bfe.admin.ch/bfe/en/home/supply/electricity-supply/electricity-networks/smart-grids.html

[10] acatech/Leopoldina/Akademienunion (2021): *Resilienz digitalisierter Energiesysteme. Wie können Blackout-Risiken begrenzt werden?,* available in German at https://energiesysteme-zukunft.de/publikationen/digitalisierung.

[11] Federal Office for National Economic Supply (2021): *2017-2020 National Economic Supply (NES) Report with lessons from the pandemic period*, available in German and French at https://www.bwl.admin.ch/bwl/en/home/wirtschaftliche_landesversorgung/prasentation_wl.html.

[12] National Cyber Security Centre (2018): *National strategy for the protection of Switzerland against cyber risks (NCS) 2018-2022*, available at https://www.ncsc.admin.ch/ncsc/en/home/strategie/strategie-ncss-2018-2022.html.

[13] Swiss Federal Office of Energy (2021): *Strategie Cyber Security für die Stromversorgung*, available in German at https://www.bfe.admin.ch/bfe/de/home/versorgung/digitalisierung.html.

[14] "Mass movement" is an umbrella term for rock falls, debris flows, mudflows, and avalanches.

[15] Federal Office for the Environment (2020): *Climate change in Switzerland: Indicators of driving forces, impacts, and responses*. Available in German and French at https://www.bafu.admin.ch/bafu/en/home/topics/climate/publications-studies/publications/climate-change-switzerland.html.

[16] Federal Office for the Environment (2021): *Effects of climate change on Swiss water bodies: hydrology, water ecology and water management*, available at https://www.bafu.admin.ch/bafu/en/home/topics/water/water--publications/publications-water/effects-of-climate-change-on-swiss-water-bodies.html.

[17] https://www.ensi.ch/de/2018/08/08/hohe-wassertemperaturen-beeinflussen-kkw-betrieb (German and French)

use for cooling and heating and thereby affect the decarbonisation efforts in the building and industrial sectors.

Societal hazards, such as the above-mentioned cyberattacks and others, e.g., sabotage, disinformation, and terrorism, must also be considered in (re-)evaluating the criticality of critical infrastructures. The relationship between critical infrastructures and society is particularly important because certain aspects of society can threaten the energy system and – if the energy system malfunctions or fails or if an element of it is destroyed – society can be threatened by the energy system. This gives rise to questions relating to, e.g., the liability in the case of cascaded failures and failures that are made more likely by climate change, the benefits and costs of a resilient energy system, the prioritization of the mitigation of selected hazards, and the distribution of the benefits and costs associated with reduced risks and increased resilience. The manner in which such questions are addressed may influence the social acceptance of certain infrastructures and the underlying technologies. For instance, reductions in the social acceptance may spring from the increasing decentralization of the energy system, which implies that more infrastructures will be located near and in populated areas, and this may influence the perception of risks associated with their malfunction, failure, or destruction. Such reductions in the social acceptance can be far-reaching if they concern technologies that are crucial to meeting Switzerland's energy- and climate-policy goals. Given the sustained effort required to meet these goals and the population's decisive role in shaping policy, maintaining or increasing the social acceptance of critical infrastructures and the underlying technologies is essential.

SWEET Call 2-2021 is a joint activity of the SFOE and the National Centre for Climate Services (NCCS, http://www.nccs.ch) that complements the NCCS-Impacts programme "Decision Support for Dealing with Climate Change in Switzerland: A Cross-Sectoral Approach". Therefore, by completing its work programme, the successful consortium will also contribute to NCCS-Impacts. This means participating in programme-wide activities of the NCCS, such as meetings and workshops, contributing to synergies, as well as aligning communication to allow for the creation of cross-cutting syntheses.

> NCCS is a network and coordination body of nine federal offices and research institutions, including the SFOE and the FOCP. It bundles existing climate services, promotes dialogue between actors, and works together to develop and communicate tailored information, processes, and solutions. The programme NCCS-Impacts ("Decision Support for Dealing with Climate Change in Switzerland: A Cross-Sectoral Approach") is set to mark a milestone with respect to the analysis of cross-sectoral climate impacts in Switzerland. The aim of the programme is to obtain an overview of future climate impacts in Switzerland and its central challenges for the environment, economy, and society. It will turn the results into actionable and user-centred products in line with the aim of climate services as decision support. The programme hence contributes to closing the gap identified between basic scientific research and measures in the fields of climate adaptation and climate mitigation.

1.3 The application process

To render the application process more efficient for both consortia and evaluators, SWEET Call 2-2021 is organized into two steps, see Figure 1-3. In the first step, consortia submit a pre-proposal. All submitted pre-proposals will be subjected to an admissibility and eligibility check by the SFOE. The admissible and eligible pre-proposals will be evaluated and ranked by a panel of international experts. The highest-ranked consortia will be invited by the SFOE to submit more detailed full proposals. In the second step,

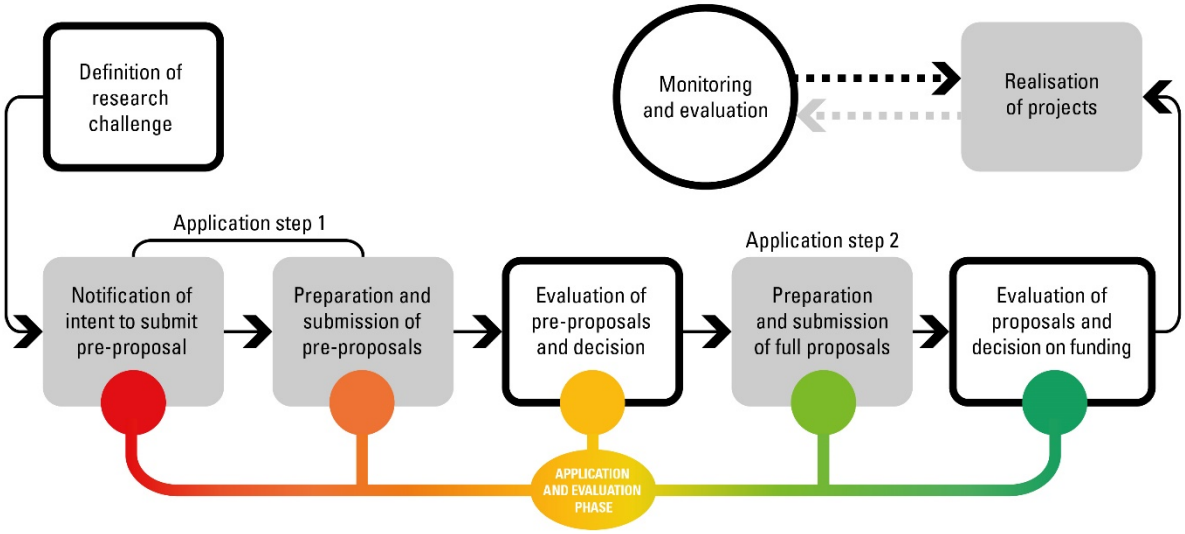

Figure 1-3: The two-step application process of SWEET Call 2-2021. The white boxes and grey boxes indicate activities by the SFOE and the consortia, respectively.

the invited consortia submit full proposals that will again be evaluated by the expert panel. The consortium with the highest-ranked full proposal will be awarded with SWEET funding.

The pre-proposal contains only brief descriptions of the consortium, the objectives, the overall concept and methodology, the work packages, and the budget. Only the host institution must submit a letter of commitment. For the other applicants, letters of intent are sufficient. Only those consortia that are invited to submit a full proposal will have to describe the work packages and budget in more detail and include letters of commitment for all applicants.

The process for submitting pre-proposals is described in Section 5.1. As explained in that section, consortia must notify the SFOE of their intent to submit a pre-proposal. The notification allows the SFOE to better prepare for the evaluation of the pre-proposals and in particular to appoint a sufficient number of evaluation panels. The relevant deadlines and other important dates associated with this call are given in Section 6.4.

2 Research challenge

This call comprises one research challenge. One consortium will be supported with a budget of CHF 10 Mio. to tackle the challenge over a period of 6 to 8 years. Additional funding is available through the SFOE's P+D programme, see Section 3.4.3.

2.1 Critical infrastructures, climate change, and resilience of the Swiss energy system

2.1.1 Specific challenge

Consortia are challenged to address the following questions:

1. How does the criticality of the infrastructures of the Swiss energy system change as the system transforms to meet Switzerland's energy- and climate-policy goals and as it is exposed to climate change?

2. How vulnerable is the changing energy system to technical, natural, and societal hazards?
3. How can the risks to the energy system and the population that result from the malfunction, failure, or destruction of critical infrastructures be mitigated and thereby the resilience of the energy system be improved?

In addressing these questions, consortia must take into account the following:

- The focus is on the energy system as it changes from its present state to a state that meets the energy- and climate-policy goals in 2050. In other words, consortia must not focus just on the energy system in its current state or just on its anticipated state in 2050. Instead, the impacts of events such as the decommissioning of the nuclear power plants as well as trends such as the increasing decentralization, electrification, and digitalization between the present and 2050 must be considered.
- Consortia must consider technical, natural, and societal hazards. Particular attention must be paid to hazards that may arise from the changing energy system itself (i.e., the above-mentioned events and trends) and to hazards that arise from or are accentuated by climate change. Because the focus is on the changing energy system, consortia should consider how the hazards might be influenced by current and foreseeable technical and social trends, e.g., digitalization, artificial intelligence, automation, disinformation, as well as concerns about privacy and climate change.
- In assessing the resilience of the energy system, consortia must also consider its stability, i.e., its temporal response to a disturbance. By analogy to the stability of a power system, the stability of an energy system may be defined as its ability, given an initial operating condition, to regain an operating equilibrium after being subjected to a disturbance.[18] Consortia must consider disturbances that are caused by the malfunction, failure, or destruction of critical infrastructures in Switzerland and should also consider disturbances that might originate in the European energy system.

Given the current and anticipated changes in the distribution grid, any hazards and risks associated with these changes are of particular interest. This includes investigating how microgrids and sector coupling can contribute to increasing the resilience of the energy system, provided that the investigations focus on dynamic aspects. Also of interest is how the changing energy system might be black-started, including investigating the possible roles of new and traditional renewable energy sources and storages at the distribution- and transmission-grid levels.

Consortia should consider how their models can be validated with data from dedicated experiments or with data from past malfunctions, failures, or destructions of critical infrastructures.[19] Consortia should also consider how uncertainties in their results can be quantified in order to increase the credibility of the results and the conclusions deduced therefrom.

[18] P. Kundur et al., *Definition and Classification of Power System Stability*, IEEE Transactions on Power Systems, 19(2):1387-1401, 2004.

[19] The terms “validation” and “verification” are often used synonymously, but should be clearly distinguished when simulations are carried out that are supposed to approximate physical or engineered systems. Although the precise definitions of the terms differ depending on the field in which the simulations are used, a general distinction can be made as follows: validation deals with answering the questions “are you solving the right equations?” or “are you building the right code?”, whereas verification deals with answering the questions “are you solving the equations right?” or “are you building the code right?” In other words, validation is about checking whether the model is an accurate representation of reality (for the purposes of a particular simulation) whereas verification is about checking whether the model is correctly implemented in the code being used for the simulations. For more information, see Chapter 2 of W. L. Oberkampf and C. J. Roy, *Verification and Validation in Scientific Computing*, Cambridge University Press, 2010.

2.1.2 Scope

Prior hazard and risk analyses[20] must not be repeated except if consortia can convincingly demonstrate that additional hazards must be considered or that new findings are likely to significantly alter the results of the prior analyses.

Consortia should consider risks associated with the simultaneous or near-simultaneous manifestation of hazards. Relevant examples are (i) the reduced power supply caused by technical faults, low water levels, or cyberattacks during a period of increased power demand caused by a heat wave and (ii) earthquakes triggering mass movements that have been made more likely by the thawing of permafrost. Multiple and cascading failures are within the scope of this call.

Hazards and risks associated with the transport and storage of nuclear waste and the decommissioning of nuclear power plants are not within the scope of this call. However, consortia are encouraged to study the benefits and risks associated with the continuing operation of nuclear power plants until they are phased out. For instance, the energy system might benefit from the load-following ability of nuclear power plants, but this mode of operation could result in increased maintenance needs and a higher probability of unscheduled shut-downs.

Studying measures to mitigate a loss of social acceptance that might result from real or perceived risks to the population is within the scope of this call, provided that the critical infrastructures that give rise to the risks are necessary for reaching Switzerland's energy- and climate-policy goals.

2.1.3 Expected outcomes

The consortium's work is expected to lead to the following outcomes:

1. Identification of those infrastructures of the energy system with the highest criticality in response to technical, natural, and societal hazards. The identification should be based on an initial evaluation of the hazards, followed by quantitative investigations of a selection of hazards and infrastructures.
2. Findings for relevant stakeholders (e.g., policy makers, federal/cantonal/local authorities, infrastructure owners and operators, and equipment suppliers) on how the vulnerability of the energy system changes over time. Wherever feasible, the recommendations should be based on quantitative investigations (such as simulations).
3. Recommendations for relevant stakeholders on how the resilience of the energy system can be increased, e.g., using structural/topological and operational measures. Wherever feasible, the recommendations should be based on quantitative investigations, deduced from suitable resilience metrics, and weighed against the economic and environmental impacts of the measures.

2.1.4 Collaborations and coordination

Close collaboration with relevant federal,[21] cantonal, and municipal authorities is strongly encouraged.

[20] Such as, e.g., seismic hazards for nuclear power plants (PEGASOS project, https://www.ensi.ch/en/topic/pegasos-erdbeben-schweizer-kernkraftwerke/) or impacts of extreme flood events on hydropower and nuclear power plants on the river Aare (EXAR project, https://www.wsl.ch/en/projects/exar.html).

[21] Such as, e.g., the FOCP, the NCCS, the Federal Electricity Commission, the Federal Office of National Economic Supply, and the National Cyber Security Centre.

As part of its 2025 update of the National Risk Analysis, the FOCP will re-evaluate the Hazard Files,[22] taking into account the effects of climate change. Since consortia are expected to investigate quantitatively the hazards posed by climate change on a selection of infrastructures of the energy system, and this selection should be based on an initial evaluation of the hazards, it makes sense to coordinate this evaluation with the re-evaluation by the FOCP. Therefore, consortia are strongly encouraged to include in their work programme a re-evaluation of those Hazard Files that are affected by climate change.[23] Furthermore, consortia are strongly encouraged to base the re-evaluation on the CH2018 Climate Change Scenarios,[24] to collaborate with the NCCS on the re-evaluation, and to ensure that the results are shared with the FOCP in written form no later than Q3 2023. The schedule and work packages in the pre-proposal should reflect the sharing of the results.

The four consortia funded as part of SWEET Call 1-2020, i.e., DeCarbCH, EDGE, PATHFNDR, and SURE, are investigating various aspects of the Swiss energy system. The consortium that will be funded as part of this call is expected to coordinate its investigations of the changing Swiss energy system with the four consortia from Call 1-2020 to avoid inconsistent assumptions and unnecessary duplication and to exploit synergies.[25]

3 Participation

3.1 Need for consortia

Answering the research challenge requires an interdisciplinary or a transdisciplinary approach. To this end, the research and innovation community has to organize consortia consisting of diverse partners, see Figure 3-1, that establish portfolios of interrelated projects. A consortium is a network of several

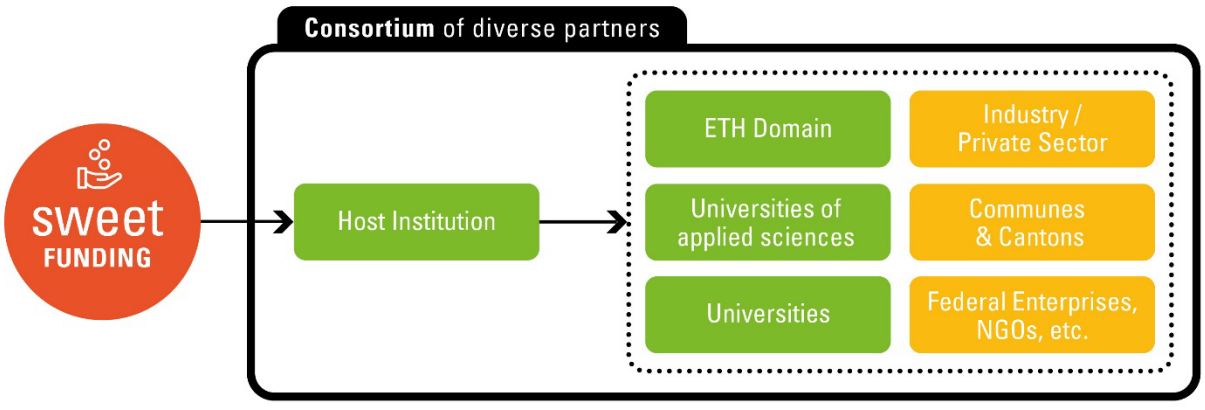

Figure 3-1: Structure of a SWEET consortium: The SFOE administers SWEET funding that flows via a host institution to the consortium partners. In return, the consortium implements a portfolio of interrelated projects that addresses the research challenge.

[22] https://www.babs.admin.ch/en/aufgabenbabs/gefaehrdrisiken/natgefaehrdanalyse/gefaehrddossier.html (German, French, and Italian)

[23] For each hazard that is affected by climate change, the reevaluation of the respective Hazard Files should focus on the section entitled “Scenario” and answer questions such as: How much more/less frequent is the hazard expected to become? How much more/less intense is the hazard expected to become?

[24] https://www.nccs.admin.ch/nccs/en/home/climate-change-and-impacts/swiss-climate-change-scenarios.html

[25] Overviews of the activities of the consortia from Call 1-2020 can be found at https://www.bfe.admin.ch/bfe/en/home/research-and-cleantech/funding-program-sweet/calls-for-proposals-overview/sweet-integration-of-renewables.html.

members that adhere to the rights and obligations set forth in their compulsory consortium agreement. The consortium is managed by a host institution that represents the consortium to the SFOE and signs a subsidy contract with the SFOE. The subsidy contract ensures, among other things, the flow of funds that support the consortium's work programme and specifies the beneficiaries that receive SWEET funds via the host institution.

3.2 Consortium structure

3.2.1 Host institution

The host institution must be a Swiss institution of higher education entitled to receive SFOE funding[26] and is the legal entity applying for the funding on behalf of a consortium. The host institution must provide a letter of commitment to demonstrate its intention to fulfil the obligations associated with its role in the consortium (see Section 4.2.1).

Upon award, the host institution will negotiate a subsidy contract with the SFOE and a consortium agreement with all the applicants. The consortium agreement must be signed by all the applicants before the SFOE will sign the subsidy contract.

The host institution must appoint a member of its staff to act as the consortium coordinator. The coordinator represents the consortium on behalf of both the consortium and the host institution and serves as the single point of contact for the SFOE regarding all administrative, legal, and financial matters. The coordinator is responsible and accountable for the preparation and submission of the pre-proposal and full proposal. Once the subsidy contract is signed, the coordinator is responsible and accountable for the administrative and financial management of the consortium.

3.2.2 Applicants

Applicants request SWEET funding from the SFOE through the consortium. Each applicant is a legal entity with due representation. Each applicant must submit a letter of intent with the pre-proposal (see Section 4.2.2).

Applicants may join more than one consortium provided that they inform the coordinators of all affected consortia and that they do not offer substantially the same contribution to more than one consortium.

Upon award, all applicants become beneficiaries of the subsidy contract between the SFOE and the host institution. All applicants will establish a consortium agreement and are henceforth referred to as members of the consortium.

3.2.3 Cooperation partners

Partners that choose not to apply for funding may participate in the work programme of the consortium as so-called cooperation partners. Cooperation partners must finance their activities from sources other than SWEET.

Cooperation partners may join more than one consortium.

[26] All institutions pursuant to Article 4 letter c of the Federal Act on the Promotion of Research and Innovation (RIPA; SR 420.1) are eligible as host institutions, see www.fedlex.admin.ch/eli/cc/2013/786/en.

3.2.4 Changes to the consortium structure

Upon request and subsequent SFOE approval, the host institution may change during the application phase and the consortium's execution phase, provided that the new host institution makes similar commitments and that contracts are reassigned.

During the application phase, applicants may change subject to the restrictions given in Section 6.3. Similarly, during the consortium's execution phase, consortium members may change subject to approval by the review panel and the SFOE. Changes in the cooperation partners must be reported to the SFOE. New members and cooperation partners must fulfil all previously mentioned requirements.

The consortium has the right to reallocate SWEET funds to its members provided that the funding rules (see Section 3.4) are adhered to and that a transparent and traceable process is in place.

3.3 Consortium requirements

A consortium must meet the following requirements:

1. It is led by one host institution.
2. It consists of at least 5 applicants from different legal entities.
3. It consists of at least one applicant from each of the following entities:
    a. Swiss university or institute of the ETH domain (ETH Zurich, EPF Lausanne, Empa, Eawag, PSI and WSL),
    b. Swiss university of applied sciences.

In addition, a consortium should:

1. Consist of applicants and cooperation partners that span the innovation system (see Figure 1-2) and thereby enable an interdisciplinary or a transdisciplinary approach commensurate with the research challenge.
2. Consist of applicants and cooperation partners that deliver complementary and significant contributions to the consortium's work programme.
3. Be gender-balanced[27] and reflect Switzerland's diversity in terms of languages and regions.

3.4 Funding rules

The SFOE funds in accordance with the principle of subsidiarity: To ensure that the overall funding is sufficient for the work programme of the consortium, members and cooperation partners contribute, each according to its abilities, with own and third-party contributions to supplement the requested SWEET funding. Therefore, consortia are encouraged to apply for additional funding through other national and international programmes. The amounts of own and third-party contributions by applicants and cooperation partners do not enter into the evaluation of pre-proposals, but will enter into the evaluation of full proposals.

[27] The Swiss Confederation attaches great importance to the adequate representation of women in management positions. Through its involvement in the Technology Collaboration Programme "Clean Energy Education and Empowerment (C3E)" (www.c3e-international.org) of the International Energy Agency (IEA), the SFOE actively supports the development of a community of women leaders in the field of clean energy across various sectors.

3.4.1 Core budget

The potential financial award as specified in the subsidy contract is referred to as the core budget and represents the SFOE's funding for research projects as well as management, coordination, communication, and KTT activities. P+D projects are not funded through the core budget, but may be funded through the SFOE's P+D programme, see Section 3.4.3.

The core budget is subject to annual parliamentary appropriations and the schedule of payments agreed to in the subsidy contract. The core budget cannot be revised to higher amounts.

3.4.2 Supplementary budget

Subject to the availability of additional funds, the SFOE may grant a supplementary budget in response to a request by the consortium or by the SWEET Office. The supplementary budget is limited to 10% of the core budget over the term of the consortium. The supplementary budget is intended to support new activities that were not included in the proposals and that are designed to answer questions that have arisen from the consortium's work. A consortium may receive a supplementary budget no earlier than 3 years after the launch of the consortium.

3.4.3 Funding for pilot and demonstration projects

Through the SFOE's P+D programme,[28] additional funds are available to support P+D projects. To apply for these funds, legal and budgetary considerations require that a separate formal application be submitted, just like for P+D projects that are not part of a SWEET project portfolio.

It is important to note that consortia are not expected to propose fully elaborated P+D projects in the pre-proposal and the full proposal. Instead, the proposals should describe P+D projects at a conceptual level only, akin to a P+D project note. Once the activities of the consortium are under way and a P+D project has been fully elaborated, the above-mentioned formal application for funding must be submitted to the P+D programme.

The conceptual descriptions of the P+D projects will be assessed by the evaluation panel, including whether they are well integrated into the project portfolio. Favourable assessments of these projects do not guarantee funding by the P+D programme, however. Any decisions by the SFOE on P+D projects are subject to legal hearings and formal objections.

3.4.4 Further particulars

SWEET funding is primarily envisaged for research and innovation activities that are undertaken by Swiss institutions of higher education and non-commercial research organisations. For other entities, the following rules apply:

- Foreign institutions of higher education and foreign non-commercial research organisations may apply for SWEET funding if their contributions are essential to achieving the consortium's objectives and cannot be provided by Swiss applicants. The inclusion of foreign applicants must be justified in the notification of intent to submit a pre-proposal (see Section 5.1.1) and is subject to approval by the SFOE.

[28] https://www.bfe.admin.ch/bfe/en/home/research-and-cleantech/pilot-and-demonstration-programme.html

- Swiss private for-profit entities may be allocated SWEET funding provided that their contribution to the consortium's work programme, including P+D projects, is in the form of pre-competitive research.
- Swiss cantons, cities, communes, districts/regions, and enterprises affiliated with the Swiss Confederation may be allocated SWEET funding.
- Federal departments and their administrative units are prohibited from receiving SWEET funding, but may participate as cooperation partners.

Research projects at technology readiness levels[29] (TRL) 1 to 4 may be fully funded by SWEET, while research projects at TRL 5 and 6 may be partially funded. P+D projects cover TRL 4 to 9, will be financed at the agreed level, but at no more than 40% of the non-amortizable additional costs.[30] Research projects in the domains of social sciences and humanities may be fully funded by SWEET.

In preparing their budgets, consortia must take into account the following:

- For research projects, the maximum remuneration must follow specified hourly rates.[31] For P+D projects, the maximum remuneration for applicants from institutions of higher education must follow these rates, while the maximum remuneration for other applicants should follow these rates.
- At least 10% of the core budget must be allocated for management, coordination, communication, and KTT activities. While these activities need not yet be detailed in work-package descriptions in the pre-proposal, the reservation of this amount must be taken into account when preparing the budget that must be submitted with the pre-proposal.
- The SFOE funds research activities through its SWEET programme pursuant to Article 16 of the Federal Act on the Promotion of Research and Innovation Promotion Act (RIPA).[32] Overhead costs are therefore not eligible.

There is no entitlement to funding.

3.5 Data availability

3.5.1 Open access

The SFOE subscribes to the notion of Open Science and expects that results and data generated by funded projects are publicly accessible. Measures must be included to provide open access (free online access, such as the 'gold' model) to peer-reviewed scientific publications that result from the project.

3.5.2 ARAMIS publication

By signing the application form, the applicants declare that they agree to the publication and distribution of the findings gained from the project in compliance with the Federal Act on Freedom of Information in the Administration.[33] Specifically, final reports and the main project information will be published on the

[29] See Appendix I of the SFOE's "Directive on the submission and evaluation of applications for financial support of energy research, pilot and demonstration projects", available at https://pubdb.bfe.admin.ch/en/publication/download/9952.

[30] See Section 2 and Appendix II of the SFOE's "Directive on the submission and evaluation of applications for financial support of energy research, pilot and demonstration projects", available at https://pubdb.bfe.admin.ch/en/publication/download/9952.

[31] See Appendix VI of the SFOE's "Directive on the submission and evaluation of applications for financial support of energy research, pilot and demonstration projects", available at https://pubdb.bfe.admin.ch/en/publication/download/9952.

[32] https://www.fedlex.admin.ch/eli/cc/2013/786/en

[33] https://www.fedlex.admin.ch/eli/cc/2006/355/en

ARAMIS information platform (www.aramis.admin.ch) and, if deemed beneficial, on the geoportal of the Confederation (map.geo.admin.ch).

4 Application

The application to be submitted in response to this call for pre-proposals consists of the pre-proposal and letters of commitment and intent.

4.1 Pre-proposal

The pre-proposal must be prepared in English using the template that is available on the SWEET website. The font, font size, line spacing, and borders must not be changed and the page limits specified in the template must be obeyed. Proposals that do not conform to these requirements will not be considered for evaluation.

4.2 Letters of commitment and intent

The host institution must submit a letter of commitment whereas applicants must submit letters of intent. There are no templates for the letters. They must be printed on the institution's official stationery, addressed to the SFOE, and signed by authorized representatives in order to demonstrate the credibility of the institution's commitment to the consortium.[34]

4.2.1 Letter of commitment of the host institution

The letter of commitment of the host institution must demonstrate the institution's real and active participation in the consortium through own and/or third-party contributions (financial and/or in-kind) for the benefit of the consortium. Since the host institution will be the contractual partner of the SFOE, the commitment must be confirmed by the board of the school/institution.

The letter must be submitted with the pre-proposal as well as the full proposal and must contain the full name and address of the person who is authorized to act as the consortium coordinator.

4.2.2 Letters of intent of applicants

By signing and submitting a letter of intent, applicants express their intention to become members of the consortium should it be awarded funding. The letter should demonstrate the applicant's real and active participation in the consortium through own and/or third-party contributions (financial and/or in-kind) for the benefit of the consortium. The letter must include a list of the work packages that the applicant will participate in.

If the consortium is invited to submit a full proposal, applicants will be required to submit letters of commitment.

[34] Cooperation partners are not required to submit letters of commitment or intent as part of the application. It is the responsibility of the host institution to secure appropriate letters from cooperation partners, especially if their contributions are critical to the consortium's work programme.

5 Submission

5.1 Submission process

5.1.1 Notification of intent to submit a pre-proposal

Consortia that intend to submit a pre-proposal must inform the SFOE by sending a notification of intent to submit to sweet@bfe.admin.ch no later than **11 October 2021 at 12:00 noon CEST**. The notification must be prepared in English using the template that is available on the SWEET website. The SFOE will acknowledge having received the notification by contacting the coordinator named in the notification.

The template includes sections that must be completed if the consortium includes foreign applicants (see Section 3.4.4). The SFOE will strive to inform the coordinator within 10 working days whether the applicants are approved.

The notification is mandatory, i.e., if a consortium did not submit a notification by the deadline given above, its pre-proposal will fail the admissibility check and hence not be evaluated (see Section 6.1). However, the notification is not binding, i.e., a consortium may choose not to submit a pre-proposal although it had previously notified the SFOE of its intention to do so.

5.1.2 Submission of application

The coordinator submits the application by sending it to sweet@bfe.admin.ch no later than **3 December 2021 at 12:00 noon CEST**. A complete application must consist of:

1. A Microsoft Word document containing only the pre-proposal, named *Acronym*_preproposal (where *Acronym* is replaced by the consortium's acronym).
2. A single pdf document containing the pre-proposal (distilled from the MS Word document) and all letters of commitment and intent, named *Acronym*_ALL.

The SFOE will acknowledge having received the application by informing the coordinator.

If the combined size of the two documents exceeds 20 MB, they must be submitted via the file transfer system of the Swiss federal administration (www.filetransfer.admin.ch). To receive the required access credentials, the SWEET Office should be contacted well in advance of the submission deadline.

5.2 Data protection

Proposals submitted in response to this call will be treated confidentially. They will be checked by the SFOE and evaluated by an expert panel. Following the selection of a consortium for funding, the proposals will be studied by the SFOE and a review panel to monitor the progress of the consortium.

Proposals and evaluation reports will be stored on secure servers. The experts will be required to sign declarations concerning confidentiality and conflicts of interest before they will be granted permission to access proposals.

By submitting proposals, consortia agree to them being forwarded to experts for the purposes of evaluation and monitoring.

6 Evaluation

6.1 Admissibility and eligibility check by the SFOE

The SFOE will check all applications for admissibility (completeness of the application and satisfaction of pre-proposal requirements) and eligibility (satisfaction of consortium and applicant requirements) prior to the pre-proposal being evaluated by the expert panel. An application is admissible and eligible if all of the questions in Table 6-1 have been answered with “yes”.

If any admissibility and eligibility criteria are not fulfilled, the application will be rejected and not evaluated. The SFOE will inform the coordinator of the rejected application in writing and state which of the criteria were not met.

Table 6-1: The admissibility and eligibility criteria.

Admissibility	
A1	Did the consortium notify the SFOE of its intention to submit a pre-proposal and did it do so by the deadline given in the call text (see Section 5.1.1)?
A2	Was the application received before the deadline given in the call text (see Section 5.1.2)?
A3	Is the application complete (see Section 5.1.2)?
A4	Was the pre-proposal prepared with the correct template and formatting and does it satisfy the page limits given in the template?
A5	Did the host institution submit a duly signed letter of commitment with the requested minimum content (see Section 4.2.1)?
A6	Did all applicants submit letters of intent (see Section 4.2.2)?
A7	Has at least 10% of the core budget been allocated for management, coordination, communication, and KTT activities (see Section 3.4.4)?
Eligibility	
E1	Is the host institution entitled to receive SFOE funding and has one consortium coordinator been appointed on its behalf (see Section 3.2.1)?
E2	Does the consortium consist of at least 5 applicants from different legal entities (see Section 3.3)?
E3	Does the consortium consist of at least one applicant from (a) Swiss universities or the institute of the ETH domain and (b) Swiss universities of applied sciences (see Section 3.3)?
E4	Did the SFOE approve all foreign applicants (see Section 3.4.4)?

6.2 Evaluation by the expert panel

Admissible and eligible pre-proposals will be evaluated by an independent panel appointed by the SFOE. The panel will consist of recognized experts from fields relevant to this call.

6.2.1 Overview of evaluation process

The evaluation process consists of the following steps:

1. The panel will use the criteria given in Section 6.2.2 to determine a weighted score and to compile an evaluation report for each pre-proposal.

2. The panel will rank the pre-proposals according to their weighted score. If two or more pre-proposals have equal weighted scores, the pre-proposal with the better gender balance at the level of coordinator and work-package leaders will be ranked higher.
3. The panel will produce a shortlist of the highest-ranking pre-proposals. To be shortlisted, a pre-proposal must reach two thresholds:
   - Individual threshold: The score of each criterion must be at least 3.
   - Overall threshold: The scores of the criteria must sum to at least 10.

   For this call, the maximum number of pre-proposals on the shortlist will be 2.
4. The SFOE will inform coordinators about their pre-proposal's rank and provide them with the evaluation report. Coordinators of shortlisted pre-proposals will be invited to submit a full proposal and provided with the corresponding template and instructions.

The panel's evaluation cannot be rebutted. Coordinators of pre-proposals that are not shortlisted can submit a formal objection within 30 days. After this period, the SFOE's decision enters into force.

If a pre-proposal is not short-listed, suitably improved and expanded parts of it may be submitted to the research programmes and the P+D programme of the SFOE.

6.2.2 Evaluation criteria and scores

Pre-proposals will be evaluated according to the criteria shown in Table 6-2. For each criterion, the evaluation panel will assign a score from the scale 1 (poor), 2 (fair), 3 (good), 4 (very good), 5 (excellent). From the scores assigned to each criterion, a weighted score will be determined using the weights given in Table 6-2.

Table 6-2: Evaluation criteria and their weights.

Criterion 1: Excellence – Weight 35%	5 points (max.)
a. Clarity of the objectives and pertinence for the research challenge b. Soundness of the proposed concept c. Credibility of the proposed methodology (in particular appropriateness of the interdisciplinary or transdisciplinary approach and scientific merit) d. Novelty and originality, extent to which proposed work is beyond the state of the art and demonstrates innovation potential (e.g., ground-breaking objectives; novel concept and methodology; new products, services, or business and organizational models)	
Criterion 2: Impact – Weight 35%	5 points (max.)
a. Extent to which the consortium's results are likely to attain the expected outcomes described in the call guideline b. Appropriateness of the concept for KTT and communication of the results to different stakeholders	
Criterion 3: Consortium and work programme – Weight 30%	5 points (max.)
a. Consortium as a whole: • Gender balance and reflection of Switzerland's diversity in terms of languages and regions • Complementarity of the applicants and cooperation partners and extent to which the consortium as a whole brings together the necessary expertise and enables an interdisciplinary or a transdisciplinary approach	

- Appropriateness of the roles and extent to which all applicants and cooperation partners have a substantial role and adequate resources in the project to fulfil their roles

b. Work programme:
   - Quality and effectiveness of the work programme, including the extent to which the resources assigned to work packages are in line with their objectives and deliverables
   - Appropriateness of the project portfolio given the consortium objectives, including the interrelation of research and P+D projects

c. Appropriateness of the coordination with other SWEET consortia and cooperation with other institutions

6.3 Preparation of full proposal

Consortia that have been invited to submit full proposals will be expected to take into account the feedback contained in the evaluation report. Changes to the work programme between the pre-proposal and the full proposal will have to be detailed in a dedicated section of the full-proposal template. Changes to the consortium through the addition or departure of applicants will also have to be detailed and will be permitted only if the associated total redistribution of SWEET funding amounts to less than 30% of the total requested SWEET funding.

6.4 Schedule

Important dates relevant to this call are:

11 October 2021	Deadline for notifying SFOE of intention to submit pre-proposal
3 December 2021	Deadline for submission of pre-proposals
February 2022	Announcement of evaluation results
February 2022	Invitation to submit full proposals sent to shortlisted consortia
April 2022	Deadline for submission of full proposals
July 2022	Announcement of funding decision
October 2022	Consortium starts operations

Dates in italics are provisional. The deadline for submission of the full proposals will be announced together with the invitation to submit full proposals.

7 Consortium monitoring and reporting

The SFOE will appoint a consortium-specific review panel to monitor the consortium. Beyond standard reporting (final reports on research and P+D projects), consortia are required to provide annual progress and finance reports. Detailed monitoring guidelines including reporting templates will be provided after the publication of the funding decision.

8 Contacts and further information

Questions about this call, including questions about the collaboration with the FOCP and the NCCS, should be directed to the SWEET Office via email or letter no later than 1 November 2021:

Swiss Federal Office of Energy
SWEET Office
Section Energy Research and Cleantech
P.O. Box
CH-3003 Berne / Switzerland
sweet@bfe.admin.ch

The questions and answers will be published on the SWEET website and regularly updated.

Appendix: Descriptions of interdisciplinary and transdisciplinary research

As stated in Section 1.1, the purpose of SWEET is to fund interdisciplinary and transdisciplinary research. Because these terms are not well defined, the following provides brief descriptions of them as interpreted by the SFOE in the context of the SWEET programme.[35]

To clarify the characteristics of interdisciplinary and transdisciplinary research, it is instructive to contrast them with multidisciplinary research. In multidisciplinary research, a master discipline receives input from other disciplines, for example in the form of knowledge and data, but the discipline boundaries remain distinct. Each discipline retains its paradigms, nomenclature, knowledge, methods, and tools and hence there is little to no lasting impact of the research on the disciplines. Multidisciplinary research is adequate for problems that can be solved by a single discipline but where the solution benefits from the input of other disciplines.

In interdisciplinary research, the disciplines provide inputs to each other to solve a problem that could not be solved by one discipline by itself. Thus, although the discipline boundaries remain distinct, there is an integration of the disciplines. The integration enriches each discipline's paradigms, nomenclature, knowledge, methods, and tools. The enrichment in turn leads to the development of new knowledge, methods, and tools, thereby having a lasting impact on the disciplines.

Transdisciplinary research may be viewed as a deeper and broader form of interdisciplinary research. It is deeper because it transcends disciplines and thereby blurs discipline boundaries. It is broader because it includes not just scientists, but also stakeholders such as citizens and authorities, who should ideally participate in all phases of the research process. Transdisciplinary research represents a unified problem-solving approach in which problems are tackled not only from a disciplinary perspective but grappled with in their entire complexity. Therefore, transdisciplinary research is necessary to solve problems that arise at the intersection of science and society or what is sometimes referred to as the "life-world".[36] The outcomes of transdisciplinary research cannot be assigned to a single discipline and include not just new knowledge, methods, and tools, but also new paradigms.

[35] A comprehensive overview of definitions of transdisciplinarity may be found in Annex A1 of C. Pohl and G. Hirsch Hadorn, *Principles for Designing Transdisciplinary Research, Proposed by the Swiss Academies of Arts and Sciences*, oekom Verlag, Munich, Germany, 2007.

[36] See, e.g., G. Hirsch Hadorn et al., The Emergence of Transdisciplinarity as a Form of Research, in: *Handbook of Transdisciplinary Research*, G. Hirsch Hadorn et al. (eds.), Springer, 2008, pp. 19-39.