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SUPPORTING RESEARCH FOR SUSTAINABLE DEVELOPMENT

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Abstract

This document presents nine innovation policy initiatives from different OECD countries that support research and innovation for sustainable development by embracing systemic solutions to address the challenge. The three types of initiatives reviewed include: i) grant schemes that support the development of environmental technologies; ii) programmes that foster research collaborations to address environmental challenges; and iii) smart city initiatives that support sustainable development in urban areas often by leveraging the use of digital technologies. The nine policy initiatives, which were selected based on an overview of initiatives gathered by the EC-OECD STIP Compass database, are described with regards to their main features, including policy objective, policy instrument(s) implemented, target groups, selection criteria and procedures, implementation challenges faced as well as their impact.

Keywords: innovation policy, sustainable development, research, environmental technologies

JEL codes: Q01, Q55, Q56, Q58, O13, O30

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Introduction

Sustainable development is high on the policy agenda not least with the UN's Sustainable Development Goals (SDGs) and the Paris Climate Agreement of 2016. Science, technology and innovation (STI) are central to finding new solutions to address pressing environmental challenges such as climate change, biodiversity loss, land degradation and water pollution. To support identifying those solutions, countries are investing in research and development of innovations in the areas of sustainable resource management, and environmental and energy technologies, among others. Many initiatives often combine the objective of addressing sustainability challenges with strengthening industry competitiveness in environmental-related fields, thereby contributing to sustainable growth. What is more, several initiatives embrace a systems' transformation approach by increasing alignment across policy domains; building up collaborative policy making processes and involving the wider community of policy stakeholders in the process of developing solutions for sustainable development.

To illustrate current policy practice in this domain, this report describes nine policy initiatives in support of research and innovation for sustainable development from Australia, Austria, Canada, Denmark, France, Japan, Sweden, the United Kingdom, and the United States. These initiatives, described in Table 1, cover: i) grant schemes that support the development of environmental technologies; ii) programmes that foster research collaborations to address environmental challenges; and iii) smart city initiatives aimed at fostering sustainable development in urban areas, often by leveraging the use of digital technologies. There are other important differences across initiatives with regard to the specific sustainability issue tackled, the target groups and the support schemes applied. Annual budgets also vary, ranging from EUR 6.2 million (Cities of Tomorrow, Austria) to EUR 300 million (Investments for the Future Programme, France).

The nine policy fiches presented in this document first provide a summary of the respective policy initiative and describe briefly the country's context regarding innovation policies for sustainable development. Then, they describe the goals and sustainability challenges addressed by the policy; the target group; the policy instrument(s) used; the selection criteria and procedures; the challenges faced during the programme implementation and adjustments to address them (if any); and an overview of programme impacts (when information is available).

Table 1. Supporting research for sustainable development: Overview of policy examples

Policy initiative	Country	Type	Period	Yearly budget (disbursed)	Main objective
SDTC	Canada	Grant schemes	2001-present	EUR 68.6 m (2016)	Support SMEs development and demonstration of new **environmental technology solutions**
MUDP	Denmark	Grant schemes	2007-present	EUR 6.9 m (average 2007-2015)	Support business development and testing of **new environmental technologies**
MISTRA	Sweden	Grant schemes	1994-present	EUR 20 m (average 1994-2016)	Support scientific research in areas related with **environmental sustainability**
PIA	France	Grant schemes	2010-2025	EUR 300 m (average 2010-2017)	Provide capital finance and grants for business R&D in the area of **sustainability**
ARPA-E	United States	Grant schemes	2009-present	EUR 232 m (2016)	Provide grants for **energy technology** R&D projects
NESP	Australia	Collaborations	2015-2021	EUR 17 m (average 2015-2020)	Connect **environmental pockets-of-excellence research** and foster stakeholder engagement
SATREPS	Japan	Collaborations	2008-present	EUR 48.9 m (2017)	Support international joint scientific research to address **sustainability challenges**
Cities of tomorrow	Austria	Smart cities	2013-present	EUR 6.2 m (average 2013-2018)	Support R&D projects for **green and smart urban development**
Future cities catapult	United Kingdom	Smart cities	2013-present	N.A.	Facilitate collaborative research, provide expertise & testing facilities for innovative **urban solutions**

Note: Where budget information was not provided in Euros, it was converted to US Dollars and subsequently to Euros using 2017 purchasing power parity rates: https://data.oecd.org/conversion/purchasing-power-parities-ppp.htm

The report also builds on OECD work, conducted under the auspices of the OECD's Working Party on Innovation and Technology Policy (TIP), on how the 'system innovation' approach can help orient innovation policy to allow for the transition to sustainable development and, more widely, for delivering on the Sustainable Development Goals (OECD, 2015a; OECD, 2018a). This approach considers the entire policy mix in order to tackle complex societal problems that are systemic in nature (i.e. that involve a set of interacting and interdependent components across the whole socioeconomic system). The document also relates to work on inclusive innovation policies (Planes-Satorra and Paunov, 2017), which involved the in-depth analysis of national innovation policy initiatives aimed at fostering inclusive growth, as well as the development of an interactive policy toolkit (http://oe.cd/inclusiveinno) that collects relevant policy examples from different countries.

Moreover, this document draws on information from the European Commission - OECD Science, Technology and Innovation Policy database (STIP Compass, stip.oecd.org/stip.html) – a rich database that collects information on the national science, technology and innovation (STI) policy initiatives implemented across more than 50 countries. The structure of the database facilitates the identification of cross-country trends and allows for the comparison of different countries' initiatives. The initiatives presented in this document were selected based on information provided in this database.

The statistical evidence used in this document comes from several OECD databases. This includes data for all OECD countries on Governance of Pubic Research Policy (RESGOV, stip.oecd.org/resgov) on sustainable development targets set in their STI strategies, notably in the area of green growth, smart cities and energy technologies. The document also uses the OECD Science, Technology and R&D Statistics database on R&D expenditures for sustainable technologies. Additional information on greenhouse gases (GHG) emissions, energy efficiency, levels of air pollution, and water consumption is taken from the OECD Environment Statistics database (OECD, 2018).

The document is structured as follows. Section 1 provides key takeaways from the analysis of the nine policy initiatives. Section 2 presents grant schemes for research on sustainability and environmental technology development. Section 3 presents collaborative research programmes that address sustainability challenges. Section 4 presents smart city initiatives aimed at fostering sustainable development in urban areas.

1. The rationale, policy approaches and key takeaways

Leveraging innovation to build a more sustainable future is not an easy task as it requires fundamental wide-ranging changes. The OECD's Working Party on Innovation and Technology Policy (TIP), which has played an important role in introducing the 'systems innovation' approach to innovation policy, has investigated how 'system transformation' approaches can help orient innovation policy towards meeting sustainability challenges. This requires engaging with private and public sector actors, taking a longer-term perspective in policy making and ensuring alignment of policies across different areas.

This section draws on TIP's work to present the rationale for taking a system innovation approach to innovation policies for sustainable development. It then provides an overview of current policy trends based on insights from the nine policy initiatives analysed in this document, and presents the main policy lessons learned from those initiatives.

1.1. The rationale for system innovation approach to foster sustainable development

The demands on innovation among policy makers have never been greater and more purposeful. Innovation is seen not only as a way to support growth and job creation, but also to address a wide range of social and environmental challenges that are reflected in the Sustainable Development Goals (SDGs) adopted by the United Nations. The push for a more pro-active and responsive innovation policy is illustrated in the recent calls for "directionality" and "mission-oriented" innovation strategies to tackle grand challenges. Sustainability figures prominently on this broader global agenda and requires collective approaches (OECD, 2018a).

The goals of innovation for growth and sustainability are not incompatible. OECD work on innovation has shown that overcoming the barriers to green innovation – such as the dominance of existing technologies and systems, regulatory frameworks that may favour incumbents, or barriers to access capital – can significantly spur innovation (OECD, 2015b).

Challenges to achieving sustainability and green growth through innovation should however be considered:

First, many of the sustainability challenges are inter-related, such as in the case of the transformation of energy and agricultural systems, requiring diagnostics and policy approaches that take into account the complexity and the direct and indirect impacts of policy changes.

Second, actor interests and capabilities, markets, network structures and institutions all condition the capacity for public policies to impact on the pace and degree of change. Path dependency, disincentives to investments in unproven technologies as well as skills gaps can impede innovations from scaling and diffusing across the economy, resulting in limited gains.

Third, mobilising research and innovation to meet sustainability challenges requires co-ordination across ministries and different levels of government (i.e. regional and local levels).

Fourth, private action is also needed. Policy settings and incentives are key to encourage firms to do a sustainable use of resources and increase the adoption of new environmental technologies and innovations for sustainability.

Decoupling growth from environmental degradation also requires appropriate market prices, the alignment of many policies (e.g. tax policy, industrial policies) as well as public support to research and innovation (OECD, 2015b).

Lessons from the OECD project on system innovation show that policy makers need to rethink the way they fund and support science and technology by developing a balanced policy mix and increasing alignment across policy domains; building up collaborative policy making processes; fostering cross-sectoral collaboration for innovation; strengthening policy intelligence; and adapting policy to the different stages of technology and market maturity. Furthermore, while technological innovation is necessary (in areas such as energy, materials, and collective goods systems), successful transitions will require complementary innovations in organisations and institutions to implement them as well as acceptance by citizens (OECD, 2015b).

1.2. Overview of policy trends based on the review of policy initiatives

This document describes nine policy initiatives in support of research and innovation for sustainable development from Australia, Austria, Canada, Denmark, France, Japan, Sweden, the United Kingdom, and the United States. They cover three dimensions:

First, five grant schemes to support the development of environmental technologies [the Sustainable Development Technology Canada Fund (SDTC) in Canada; the Environmental Technology Development and Demonstration Program (MUDP) in Denmark; the Swedish Foundation for Strategic Environmental Research (MISTRA); and the Investments for the Future Programme (PIA) in France; and the Advanced Research Projects Agency-Energy (ARPA-E) in the United States].

Second, two programmes that foster research collaborations to address environmental challenges [the National Environmental Science Program (NESP) in Australia; and the Science and Technology Research Partnership for Sustainable Development (SATREPS) in Japan].

Third, two smart city initiatives aimed at fostering sustainable development in urban areas (The City of Tomorrow initiative in Austria; and the Future Cities Catapult in the UK).

Common characteristics of initiatives

The nine initiatives presented in this document have some similarities:

- **Programmes set specific environmental sustainability targets jointly with targets regarding research excellence, industry competitiveness and/or addressing societal challenges**. For instance, the ARPA-E in the United States specifically supports the development of advanced energy technologies to address sustainability challenges related to energy generation, storage, distribution and use. At the same time, the project seeks to build technology leaders in those fields. The initiative City of Tomorrow in Austria helps cities to adapt their urban infrastructures to make them greener and less energy-intensive, also with a view to improving the quality of life of their citizens. MISTRA in Sweden has the dual mandate to support research addressing sustainability challenge but also to strengthen Swedish competitiveness in this research field.
- **Many initiatives combine financial and non-financial support for research and innovation**. Grants for proof-of-concept and for technology development are the most common direct funding instruments. Non-financial support includes

business support services for the commercialisation of new technologies, training schemes and coaching services. For instance, the Future Cities Catapult in the United Kingdom provides businesses with expertise, facilities and opportunities for collaborations with other actors. It also supports city authorities in the development of urban strategies and their testing (e.g. with visualisation and modelling techniques), the assessment of economic impacts of urban innovation projects, as well as support for new service design.

- **There is still little information on the aggregate impacts of most of these policy initiatives on reaching their sustainability targets**. In most cases, impact evaluation is conducted at the project level, which are often required to report on both their economic and environmental impacts.

Interesting approaches across projects

There is also substantial diversity in the approaches adopted. Some interesting distinctive aspects of the initiatives presented in this document include the following:

- **Providing flexible targeted financial support**. PIA in France provides grants and repayable advances to firms and research organisations that significantly vary in amount depending on the region where they are based, size, age and purpose of the investment. It also provides capital financing to SMEs operating in specific environmental areas, conditional on equivalent private sector co-funding. The MUDP in Denmark also provides two types of financial support: grants for firms to conduct technical feasibility studies as well as technology development, demonstration and testing activities; and funding for larger and riskier 'light house' projects that may include investments in infrastructure.
- **Using new approaches to involve the wider innovation community and civil society in addressing sustainability challenges.** The Future Cities Catapult in the UK implements open calls, challenges and hackathons open to all (industry, academia and civil society) to identify new solutions to urban challenges. In addition of providing R&D grants, the MUDP programme in Denmark promotes the creation of innovation partnerships, where enterprises, researchers and public institutions get together to discuss around specific environmental challenges, possibilities for developing better solutions, as well as regulation-related issues. Examples include the partnership for biofuels and the partnership for water.
- **Supporting the private sector in adopting sustainable business strategies**. Beyond support aimed at solving environmental challenges, the Swedish agency MISTRA follows up the sustainability focus of its investments through dialogue with firms so that their business strategies are more aligned with sustainable development goals.
- **Promoting international collaboration in research to address global sustainability challenges**. The SATREPS initiative in Japan supports research collaborations between Japanese researchers and researchers in developing countries, with the objective of both providing new solutions to environmental problems and at strengthening research capacities in developing countries. The MUDP in Denmark also promotes international partnerships between Danish companies and companies abroad.

Similarities and differences in grant programmes

- **Programmes that offer funding for R&D target different stages, and amounts and duration also vary.** Grants for proof-of-concept and for technology development are the most common direct funding instruments. This includes support for technical feasibility studies (proof-of-concept) and prototypes. The duration of R&D grants varies across programmes and ranges from 1 year (in the case of the City of Tomorrow initiative in Austria) to 8 years (MISTRA in Sweden). The average amount of funding provided also differs, with some programmes funding generally larger projects (e.g. SDTC in Canada) than others (e.g. NESP in Australia).The amounts also vary significantly across projects within the same initiatives.

- **Agencies with in-house technical expertise are responsible for the implementation of 4 out of 9 initiatives.** In France, the Agency for Environment and Energy Management (ADEME) is in charge of project selection, funding, and evaluations. Other agencies include the Swedish Foundation for Strategic Environmental Research (MISTRA), the Advanced Research Projects Agency for Energy (ARPA-E) in the United States, the Japan Science and Technology Agency (JST), the Japan Agency of Medical Research and Development (AMED), and the Japan International Cooperation Agency (JICA).

- **Selection processes of grant programmes involve several stages and expert panels are common, while duration of the process differs.** In the case of SDTC in Canada, MUDP in Denmark, PIA in France, and MISTRA in Sweden, applicants are required to submit a more detailed proposal after a successful pre-screening phase, where applicants send an introductory submission. In the case of ARPA-E in the United States, applicants first submit a concept paper of 5 to 7 pages and experts from science and the technical community review and evaluate each proposal. An expert committee reviews and evaluates projects and sends the selected project to an executive board for approval. The application process takes on average less than a year. For MUDP in Denmark and SDTC in Canada, the process from the initial submission of the application to the final approval takes 5 months, while for ARPA-E in the United States it takes about 9 months.

- **The selection criteria used in the grant programmes include projects' contribution to various targets.** This includes achieving sustainability targets such as a reduction in energy consumption (MUDP in Denmark, PIA in France, SDTC in Canada, and MISTRA in Sweden). Other criteria included their contribution to scientific excellence (NESP in Australia, SDTC in Canada, and MISTRA in Sweden), their commitment to multi-disciplinary research (ARPA-E in the United States, NESP in Australia, and MISTRA in Sweden), and contributions to transformative research (ARPA-E in the United States).

1.3. Lessons learned

Experience from the implementation of these initiatives resulted in the following lessons learned:

- **Connecting with the broader research and innovation community and civil society to address sustainability challenges.** According to the ARPA-E programme experience, collaborating with scientists from different disciplines, industry leaders, government stakeholders, and the financial sector is key for success. The technology-to-market program of ARPA-E helps awardees to develop networks with relevant government agencies, technology transfer offices, companies, and investors. The Future Cities Catapult in the UK has engaged a wider community using open calls, challenges and hackathons to better assess challenges faced when building sustainable cities of the future.
- **Considering the path toward technology commercialisation from the start of the research project.** ARPA-E in the United States introduced the technology-to-market programme, which requires innovators to consider their path toward commercialisation early on, as they begin developing their technology in the lab. That means, for example, talking directly to potential customers and understanding opportunities and constraints. This inevitably provides direction for their experimentation and assures that they are creating technologies that customers want to buy.
- **Streamlining application processes.** SDTC in Canada transitioned from semi-annual calls for applications to a continuous intake process, making it easier to apply for funding at any point during the year. The process resulted in increased interactions with applicants, helping them produce higher quality applications. SDTC also implemented process efficiencies, such as electronic funds transfers to disburse payments for projects, and started simplifying their contracts making them easier to understand and fulfil for all parties.
- **Building the skills to effectively run the programmes.** In Sweden, MISTRA's successful management of research programmes is considered to be the result, to a large extent, of the flexibility and the specialisation of its secretariat. A small team focuses on managing the programme, while field-specific knowledge is outsourced to external experts.
- **Strengthening policy evaluation.** Impact evaluations of project impacts, which are not always available, poses a number of well-known challenges regarding metrics and attribution. Specific challenges arise for many of the initiatives as impacts are expected in the longer term, as multiple objectives (e.g. competitiveness, sustainability, etc.) require complex metrics, and as initiatives alone may be effective but impacts only emerge once complementary system transformations materialise, which challenges the impact evaluation of single initiatives. Several initiatives engage in efforts to improve their metrics and techniques. New metrics have been recently introduced to measure the impacts of SATREPS' projects, making increasing use of advanced econometric models as evaluation methods.

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2. Grant schemes

2.1. Sustainable Development Technology Canada Fund (SDTC), Canada

Summary

- **Short description**: The fund offers grants to support business R&D and innovation activities of small and medium-sized enterprises (SMEs), in particular to implement sustainable technology development projects. Grants range between EUR 1.3-2.7 million disbursed over the project life cycle (up to five years) (SDTC, 2018[1]).
- **Period**: 2001 – present (as of September 2018).
- **Target group**: SMEs.
- **Budget size and allocation**: In 2016, EUR 63 million were allocated to 35 new projects and EUR 68.6 million were disbursed to ongoing projects. Between 2001 and 2016, about EUR 675 million in SDTC funding was allocated to 347 environmental technology projects across Canada. In August 2018, there were 90 active projects in the area of climate change mitigation, 66 in the area of clean air, 30 in the area of clean soil, and 28 in the area of clean water (SDTC, 2018[2]).
- **Authority in charge**: Innovation, Science and Economic Development Canada (ISED), formerly Industry Canada, the department of the Government of Canada with a mandate to foster a growing, competitive, and knowledge-based Canadian economy.

Country's context regarding innovation policy for sustainable growth

i) Environmental topics on the research and innovation policy agenda

Canada's main Science, Technology and Innovation strategy is the "Innovation and Skills Plan", implemented in 2017 with the objective of running until 2025[1]. Among 6 priority research areas, the plan addresses societal challenges related with environmental sustainability, with the specific priority of further developing clean technologies (OECD, 2018[3]).

Canada allocated 3.6% of total government budget allocations for R&D (GBAORD) to environmental R&D in 2014, the latest year for which information is available. The country's expenditures on environmental R&D has been regularly above the OECD average, albeit with a decreasing trend over the last decade. Between 2005 and 2015, environmental expenditures among total GBAORD decreased 1.1 percentage points, and total GBOARD environmental expenditures per GDP decreased 0.01 percentage points (OECD, 2018[4]).

ii) Overview of environmental conditions

Canada's level of greenhouse gases (GHG) emissions stood at 19,400 kilograms per capita, compared to an average of 12 000 kilograms per capita for the OECD in 2016. GHG

emissions per capita decreased by 2.6% between 2006 and 2016, while the OECD average decreased by 7.7% (OECD, 2018[5]).

For energy intensity, Canada used 7.7 tonnes of oil equivalent (toe) per capita in 2016, which was 87.5% above the OECD average. The usage of renewable energy as share of total primary energy supply (tpes) was of 17.5% in 2016, while the OECD average was of 9.7% (OECD, 2018[6]).

The country has improved air quality, having decreased the mean population exposure to fine particulates ($PM2.5^2$) by 14.1% between 2005 and 2015, while the OECD average decreased only 3.1%. With a level of 7.7 micrograms per cubic metre in 2015, it ranked 46.7% below the OECD average. Water consumption[3], measured in gross abstractions per capita in 2013, was 24.7% above the OECD average (OECD, 2018[7]).

iii) Environmental innovation

In 2016, Canada remained below the OECD average in terms of environmental technology patents[4] filed as a share of total patents. Moreover, its revealed technological advantage in environmental technologies, calculated as the share of environmental patents in Canada relative to the share of total patents belonging to Canada, remained below OECD standards both in 2002-05 and 2012-15 (OECD, 2017[8]).

Goals and sustainability challenge addressed

SDTC's objective is to foster job creation, growth, and export opportunities for Canadian companies, and bring environmental and health benefits for all Canadians by providing funding to technologies that prove to contribute positively to at least one of the following areas: climate change mitigation, clean air, clean water or clean soil. SDTC also coaches companies as they move their ground-breaking technologies to market.

Target group

SDTC's mandate is to fund projects of Canadian SMEs to advance innovative technologies that are pre-commercial and have the potential to demonstrate significant and quantifiable environmental and economic benefits.

Policy instrument(s)

The programme provides **direct financial support in the form of grants** for business R&D and innovation. SDTC also offers **coaching** to the selected entrepreneurs and access to their network of entrepreneurs.

Regarding funding general conditions, SDTC funds environmental technology development and demonstration projects focusing on technologies that are beyond proof-of-concept (beyond basic and applied research) but still in pre-commercial phase. Technologies supported are those promoting clean air, clean water or clean soil, and in the area of climate change mitigation. Funding is limited to no more than 33% of eligible costs. Projects can, however, receive funding from other public support programmes as long as all public support does not cover more than 75% of eligible project costs (i.e. private sector contribution must be at least 25% of the eligible project costs). At least 50% of eligible costs must be incurred in Canada (SDTC, 2018[1]).

Selection criteria

SDTC provides funding to promising environmental technology development and demonstration projects (i.e. when the technology itself is beyond proof-of-concept but is still pre-commercial). The technology of selected projects must demonstrate the potential for reductions of carbon dioxide equivalent (CO2e) and greenhouse gas (GHG) emissions, reductions in water consumption, and/or the reduction of water, soil or air contamination. Projects must show a technological inventive step, mitigate existing technology risk and include validation of the economic viability. Selected projects have to be globally competitive.

Between 2001 and 2016, SDTC received more than 3,300 applications from environmental technology entrepreneurs and funded 347 projects. On the calendar year of 2016-2017, 410 applications were received and 35 new projects were funded (SDTC, 2017, p. 6[9]).

The following criteria are used to evaluate projects:

- Environmental benefits (in terms of quantifiable environmental benefits that would result from commercial-scale deployment of the technology in comparison with other existing technologies);
- Strength of technology innovation (in terms of having a strong scientific basis and a clear IP strategy to maintain a competitive advantage);
- Technology readiness level (demonstrate that technology is beyond proof-of-concept, but has not yet been commercialised);
- Management capabilities (in terms of management and technical capabilities the applicant has in order to advance and commercialize the technology);
- Business plan (in terms of having a well-defined commercialisation strategy, with an estimation of potential market size, available project partners and clear value proposition to clients);
- Financial strength (in terms of level of interest in the technology from other investors and funding commitments already secured to date).

Selection procedure

Applications are accepted through a continuous intake process and the selection process has 3 phases (SDTC, 2018[2]):

- Phases 1 & 2: Pre-screening and due diligence

  SDTC reviews information from potential applicants based on an introductory submission form and, if needed, an in-person interview. After a successful pre-screening phase, applicants are required to submit a more detailed proposal and SDTC's experts visit applicants' site.

- Phase 3: Review Process

  The SDTC Project Review Committee reviews each project and prepares a recommendation of what projects should be selected. Ten members including SDTC's CEO and representatives of the private and public sector compose this committee. Recommended projects are presented to the SDTC Board for approval. The Board has 15 members, seven of these are appointed by the Government of Canada, and the remaining eight are appointed by SDTC

members. Once a project is selected, the SDTC contacts successful applicants and assigns a project manager to prepare a contribution agreement.

On average, six months are required from the initial submission of the application to final SDTC Board approval.

SDTC requires companies to report at different stages of their project information about their environmental and market impact. SDTC primary measurement of environmental benefits is via the reduction of greenhouse gas emissions achieved by each project SDTC supports. In this regard, companies report their contribution to CO2e and GHG emission reductions along with estimated cost savings. However, SDTC projects contribute to more environmental benefits and nearly all projects have secondary co-benefits. For these, SDTC simply counts the number of projects addressing each environmental area as measurement of impact (SDTC, 2018[10]). Moreover, two primary metrics are used to measure the economic benefits of SDTC-supported companies: jobs and revenues.

Programme challenges and adjustments

In 2016, SDTC has done several changes to their processes and systems to better assist entrepreneurs. In July 2016, SDTC transitioned from semi-annual calls for applications to a continuous-intake process, making it easier to apply to SDTC. Continuous intake allows applicants to apply for funding at any point during the year and helps SDTC tailor review timelines to meet the individual applicant's needs. Allegedly, the process resulted in increased interactions with applicants, helping them produce higher quality applications, because SDTC can devote more time to better tailor reviews to meet individual applicant's needs (instead of having to interact with all applicants at the same time around specific deadlines for calls). SDTC also implemented process efficiencies, such as electronic-funds disbursement payments for projects, and started simplifying their contracts making them easier to understand, and fulfil, for all parties (SDTC, 2017, p. 14[9]).

Programme impacts

SDTC estimates that its projects contributed to 10.1 mega-tonnes of GHG emissions reductions, and about EUR 92.9 million estimated annual costs avoided due to air quality, clean water and clean soil benefits (SDTC, 2018[10]). The estimation for annual revenues generated by SDTC-funded companies in the market at the end of 2016 was of about EUR 1.28 billion. Since its inception in 2001 up to the end of 2016, SDTC funding has helped to provide 9,437 new direct and indirect jobs in the Canadian environmental technology space.

These environmental and economic benefits estimated by SDTC are based on information reported by applicants. Every applicant is required to estimate future GHG emission reductions using a prescribed methodology based on accepted international practices established by the ISO (International Organization for Standardization) and IPCC (Intergovernmental Panel on Climate Change). SDTC reviews the reasonableness of projected GHG emission reductions reported by applicants and, as new information is reported, SDTC adjusts projections. Likewise, applicants report relevant economic data such as employment and revenues.

SDTC's estimates are informed by internationally accepted best practices and subject to periodic review and auditing by the Government of Canada and other third parties (SDTC, 2017, p. 12[9]).

More information

Website of the Sustainable development technology Canada (SDTC): https://www.sdtc.ca/en/

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2.2. Environmental Technology Development and Demonstration Program (MUDP), Denmark

Summary

- **Short description**: MUDP provides grants for businesses ranging between EUR 13 000 to 2.6 million per project for the development, testing and demonstration of innovative environmental technology solutions of Danish businesses of any size. In addition to the subsidy scheme, the programme promotes innovation partnerships and the internationalisation of Danish companies providing environmental technology solutions (both by promoting their exporting activities and their collaborations with foreign organisations).
- **Period**: 2007 – present (as of September 2018).
- **Target group**: Companies (both private and public), regardless of size.
- **Budget size and allocation**: In 2018, MUDP allocated EUR 11.6 million to 43 projects. MUDP allocated EUR 15.3 million to 42 projects in 2017 and EUR 16.5 million to 43 projects in 2016. Between 2007 and 2015, MUDP supported 401 projects (an average of more than 40 per year) with a total amount of about EUR 62.5 million (average of EUR 6.9 million per year) (MUDP, 2017[11]; MUDP, 2016[12]). In 2015, 43% of total funding (18 projects) was allocated to projects in the area of water and climate change adaptation; 21% of funding (4 projects) in the area of industrial environmental challenges; 15% (11 projects) in the field of waste and resources; 9% (5 projects) in sustainable building; 8% (8 projects) in cleaner air and less noise; and 4% (3 projects) in projects to reduce chemicals of concern (MUDP, 2016, p. slide 10[12]).
- **Managing authority**: Danish Ministry for Environment and Food.

Country context regarding innovation policy for sustainable growth

i) Environmental topics on the research and innovation policy agenda

The Danish main Science, Technology and Innovation strategy was introduced in 2018 and named "Denmark – Ready to seize future opportunities: The Government's objectives for Danish research and innovation". The strategy sets environmental technologies and green growth as national research and innovation priorities (OECD, 2018[3]).

In terms of public budget, government budget allocations for R&D (GBAORD) for environmental areas accounted for 2.1% of total GBOARD in 2015, while the OECD average was 1.7%. The budget allocations for environmental areas has been above the OECD average during the past decades, having increased by 0.01 percentage points between 2005 and 2015 (OECD, 2018[4]).

ii) Overview of environmental conditions

GHG emissions stood at 9 040 kilograms per capita in 2016, compared to an OECD average of 12 000 kilograms per capita in 2016. Denmark decreased levels of greenhouse gases

(GHG) emissions by 31.1% between 2006 and 2016, outperforming the OECD average which decreased by 7.7% (OECD, 2018[5]).

In 2016, renewable energy accounted for 30% of total primary energy supply (tpes), while the OECD average was of 9.7%. Renewable energy as share of tpes increased 15.7 percentage points between 2006 and 2016, while the OECD average increased 3.3 percentage points during the same period. Energy intensity measured in tonnes of oil equivalent (toe) per capita stood at 2.9 toe per capita, a significant decrease of 22.2% between 2006 and 2016. This level is 29.2% below the OECD average (OECD, 2018[6]).

Air quality in Denmark has been improving. The mean population exposure to fine particulates (PM2.5) decreased by 0.1% between 2005 and 2015. The levels of exposure, at a mean annual concentration of 10.6 micrograms per cubic metre (PM2.5), were 26.6% below the OECD average of 14.5 PM2.5 in 2015. Regarding water consumption, gross abstractions per capita were 85.7% below the OECD average in 2015 (OECD, 2018[7]).

iii) Environmental innovation

Of the total Danish patents filed in 2016, 23.3% were in environmental technologies, a share well above the OECD average of 11.5%. Between 2002-05 and 2012-15, its revealed technology advantage in environment-related technologies, calculated as the share of environmental patents in Denmark relative to the share of total patents belonging to Denmark, increased by 54.7% (OECD, 2017[8]).

Goals and sustainability challenge addressed

The main purpose of the MUDP Program is to support the development and application of new environmental and resource efficient solutions addressing prioritized environmental challenges. Funding is provided support the development, testing and demonstration of new environmentally-friendly technologies (green technologies) with a general focus on: Water; climate change adaptation; circular economy and recycling of waste; cleaner air; less noise; fewer hazardous chemicals; the industry's environmental performance; and ecological and sustainable construction.

Green tech is defined as technologies that directly or indirectly improve the environment, and include purification technologies, more environmentally friendly products, processes and technology systems as well as more efficient resource management. Examples include flue gas cleaning, water purification, animal feed enzymes and detergent powders, energy-saving pumps and environmentally friendly alternatives to problematic chemicals (MUDP, 2018[13]).

Target group

The subsidy scheme targets Danish companies (private and public) that develop technologies that help advance sustainability and resource efficiency (MUDP, 2018[13]).

The programme supports projects at different technological phases, including:

- Technical feasibility studies prior to the development, testing or demonstration;
- Development, testing and / or demonstration stage;

- Larger and riskier "Light house" projects, including large infrastructure investments and opportunity to experiment with untested promising technologies at full scale (MUDP, 2019[14]).

Policy instrument(s)

The program has three pillars:

- **The subsidy scheme** (direct financial support in the form of grants for business R&D and innovation)

  The programme provides grants for business R&D projects in which new environmental technology solutions are demonstrated and tested in a full scale, as well as smaller projects (e.g. conducting technical feasibility studies prior to the development, testing or demonstration).

  The scheme also has "lighthouse projects", which are more ambitious, risky and expensive projects, and may include investments in infrastructure.

  Projects can receive grants from other public schemes, such as local, regional, national or EU schemes on the condition that the total public grants do not exceed the maximum grant rate that is applicable under state aid rules (MUDP, 2019[15]).

- **Innovation partnerships** (collaborative platforms around specific environmental topics)

  The programme promotes partnerships of relevant stakeholders around specific topics (e.g. the partnership for biofuels, or the partnership for water). The objective is to bring different competencies and exploit them in a close interplay between enterprises themselves and between enterprises, researchers and public institutions. The aim of this pillar is to foster discussion around new possibilities to create better and cheaper environmental solutions related to existing environmental challenges and future national and international regulation (MUDP, 2018[16]).

  There is no fixed formula for how a partnership for innovation should be set up and managed. It may vary from area to area and it depends on previous cooperation within the area. Existing partnerships include examples where a few central players join to set up a partnership (as was the case with the partnership for biofuels), and where all the players in a specific area have openly been invited by MUDP to take part (e.g. the water partnership). Each partnership will have a secretariat and steering committee, composed by members of the main organisations in the partnership, to organise its activities.

- **International environmental cooperation**

  This involves the demonstration of technology solutions of Danish companies abroad as well as promoting international partnerships between Danish companies and companies abroad. These build on formal agreements on environmental cooperation targeting export promotion, which have been established with India, China, Vietnam and Russia (MUDP, 2018[17]).

Selection criteria

When assessing an application, emphasis is placed on the following criteria (MUDP, 2018[18]):

- **Potential environmental impacts**: This refers to the degree to which the technology under development improves the environment. This can be measured, for example, by how much energy savings the technology generates, how resource consumption is reduced, or whether it uses more environmentally friendly products and production processes.
- **Business potential**: The Board of MUDP attaches great importance to the assessment of business potential. This includes detailed information about target audience (e.g. what is the new solution being provided, what problem is being solved to what customers, and what alternative solutions exist), and the size of the market and potential for growth. Moreover, applicants should explain their commercialisation strategy as to how the product or service will reach the market along with associated barriers, as well as the key risks and uncertainty related to realizing its business potential.
- **Project's added value and professional quality**: The technology needs to be innovative, providing improved solutions in comparison with technologies already in the market. Moreover, applicants need to show they have the management and technical capabilities in order to advance and commercialize the technology.
- **Quality of the project description**: This is assessed analysing the overall coherence of the proposal, e.g. budgets are realistic, requested grant ratios are within the system limits, or scheduling of activities is well detailed and coherent.

In addition, it is assessed how important support is for the project to take place and to what extent the impact of the project is compatible with other relevant social considerations.

There is no requirement to apply in partnerships, but partnerships with public authorities and research organisations are often judged positively.

Selection procedure and reporting requirements

MUDP's Board publishes annual calls on its website providing the guidelines and application forms for each application process (MUDP, 2018[19]).

In 2019, applications under the subsidy scheme for lighthouse projects included a new procedure. Applicants who were considering applying for funding for a lighthouse project were offered the opportunity in spring 2019 to submit a "one pager", where the project idea was outlined. The project idea was subsequently presented (pitched) at a meeting with MUDP's Secretariat in early April 2019. At the pitch meeting, the Secretariat would verbally comment on the project idea, focusing on whether it is within the scope of MUDP in general, as well as whether the idea is considered to have the potential to become a MUDP lighthouse project. This process was voluntary and was not a prerequisite for applying for a lighthouse project grant.

The Board manages the application process and makes the funding decisions. It is managed by a professional group of 8 members appointed by the Danish Minister of Environment and Food. At least half of the members have a business background (MUDP, 2018[20]).

MUDP projects must be completed with the preparation of an official report describing the content of the entire project, including the description of all undertaken activities, the

challenges faced and how they are tackled. Results also need to be disclosed along with quantifiable measurement (MUDP, 2018[21]).

Programme impacts

In 2017 an evaluation of MUDP was carried out. The evaluation concludes that MUDP creates both environmental impact through the products developed in the projects and through new knowledge and knowledge dissemination. The evaluation also concludes that the biggest environmental impacts are obtained from actors who have not participated in the projects, i.e. the potential domestic and international customers.

The evaluation also shows that most projects (around 40%) are within the area of water. A third of the MUDP projects also targets reductions of CO2. CO2 reductions can be realized by projects in most technology areas through more efficient use of resources and energy. For example, there are many water-related projects where there is a focus on energy optimizing infrastructure and water purification. The most significant environmental impacts identified in the evaluation are achieved in the field of NOx reduction in air pollution, where two projects together have led to an annual reduction of over 27,500 tonnes of NOx since 2010. In both projects, the interaction with environmental regulation has played a major role in the effect achieved. Of the realized environmental effects, there is also a reduction of nutrient load.

The evaluation shows that the MUDP projects have led to significant business activity at the participating companies that have implemented the developed technology. For every EUR 1 million of funding from MUDP, the companies have an average annual turnover of EUR 2.9 million. In addition, MUDP participants expect one year after the end of the projects to increase sales of EUR 6 million on average (for each EUR 1 million of MUDP funding).

More information

Website of the Environmental Technology Development and Demonstration Program (MUDP): https://eng.ecoinnovation.dk/the-danish-eco-innovation-program/

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2.3. The Swedish Foundation for Strategic Environmental Research (MISTRA), Sweden

Summary

- **Short description**: Mistra provides competitive grants (of an average of EUR 6 million per project) to fund scientific research projects aimed at solving key environmental problems and promoting Sweden's future competitiveness[5].
- **Period**: 1994 – present (as of September 2018).
- **Target group**: Universities; firms, research institutes or public bodies provided that they collaborate with universities for the research project
- **Budget size and allocation**: On average, EUR 20 million are disbursed to ongoing projects per year (EUR 18 million were allocated to new grants in 2014, EUR 31.9 million in 2015, and about EUR 16.3 million in 2016). Between 1994 and 2016, over EUR 466 million were invested (MISTRA, 2018, p. 5[22]) (MISTRA, 2016[23]). Between 1994 and 2016, 57 research projects received funding. There are currently 21 projects being funded (as of September 2018) (MISTRA, 2016, p. 4[23]).
- **Managing authority**: The Swedish Foundation for Strategic Environmental Research (MISTRA) has its own management composed by a board of 10 members selected by the government, Swedish public agencies and research organisations.

Country's context regarding innovation policy for sustainable growth

i) Environmental topics on the research and innovation policy agenda

The latest national strategy in Sweden towards Science, Technology and Innovation is the "Government Bill Research and Innovation", implemented in 2016 with the objective of running until 2020. This national strategic plan puts aside 3% of total government budget allocations for R&D (GBOARD) specifically for six prioritised areas, which include "Climate" and "Sustainable Spatial Planning" (OECD, 2018[3]).

In 2015, Sweden allocated 1.5% of total GBOARD to environmental topics, 0.2 percentage points below the OECD average. The share of environment-related expenditures in total GBAORD decreased by 0.7 percentage points between 2005 and 2015, while the OECD average increased by 0.1 percentage points in the same period. Environmental GBOARD expenditures in percentage of GDP were of 0.01% in 2015, close to the OECD average (OECD, 2018[4]).

ii) Overview of environmental conditions

In 2016, GHG emissions were of 5 400 kilograms per capita, below the OECD average of 12 000 kilograms. Sweden has decreased greenhouse gases (GHG) emissions by 20.6% between 2006 and 2016, while the OECD average decreased by 7.7% (OECD, 2018[5]).

In 2016, renewable energy accounted for 37% of total primary energy supply (tpes), significantly above the OECD average of 9.7%. Renewable energy as share of tpes

increased by 8.3 percentage points between 2006 and 2016, while the OECD average increased by 3.3 percentage points during the same period. Energy intensity measured in tonnes of oil equivalent (toe) per capita stood at 4.9 toe per capita in 2016, while the OECD average was of 4.1 toe per capita. Despite levels above the OECD average, energy intensity measured in toe per capita decreased by 11.2% between 2006 and 2016 (OECD, 2018[6]).

Air quality in Sweden has been improving. In 2015, the levels of exposure to PM2.5 were of 7 micrograms per cubic metre, 51.8% below the OECD average. The mean population exposure to fine particulates (PM2.5) decreased by 6.3% between 2005 and 2015, while the OECD average decreased by 3.1% (OECD, 2018[24]).

iii) Environmental innovation

In 2016, the proportion of environmental patents over total patents was 0.8 percentage points below the OECD average. Its revealed technology advantage in environment-related technologies (calculated as the share of environmental patents in Sweden relative to the share of total patents belonging to Sweden) reached 1.2 in 2012-15, while the OECD average was of 1.1 (OECD, 2017[8]).

Goals and sustainability challenge addressed

Mistra funds research aimed at solving key environmental problems and research that promotes building bridges among academic disciplines and between researchers, companies, or public agencies. MISTRA does not focus on a specific type of sustainability area. For example, projects were funded in different categories such as in biotechnology, fashion, climate change mitigation, sustainable consumption, or resource management. The research investments Mistra makes are also intended to help develop new goods and services and strengthen Swedish competitiveness in addition to addressing environmental problems (MISTRA, 2018[25]).

Mistra is also an institutional asset owner and financial investor, managing an asset fund of about EUR 300 million. Its asset management is also used to influence the business sector and financial markets in a sustainable direction through shareholder activism (MISTRA, 2018[22]). This means that Mistra follows up the sustainability focus of its investments by regularly reviewing its portfolio and through dialogue with asset managers. Practicing shareholder activism in the area of sustainability means that Mistra not only decides whether or not to invest in a given asset based on having a sustainability focus, but also engages with the assets it owns by trying to make them more aligned with sustainable development goals.

Target group

The programme targets universities, research institutes, foundations, and public entities that conduct research in environmental-related issues. However, while applications need to have a programme host, it does not necessarily have to be a university. It may be, for example, a research institute, or a company, as long as it collaborates with a university in the context of the application. Mistra itself never hosts its own programmes; instead, it is a pure research investor (MISTRA, 2018[26]).

In 2014, Swedish universities received 67% (EUR 10.67 million) of disbursed funds, and 20% (EUR 3.24 million) were disbursed to other Institutes and Foundations. Around 6% (EUR 933 793) were disbursed to foreign companies or institutes, 3% (EUR 498 023) to

Swedish public bodies, 2% (EUR 238 636) to Swedish companies and 1% to foreign universities (MISTRA, 2018[26]).

Policy instrument(s)

Mistra provides competitive grants to research organisations seeking to finance all or part of research projects. These grant schemes can vary from very simple, one-off funding allocations, to complex strategic arrangements built on formal public-private partnerships (within the current 21 projects some have other public or private partners, while others are fully funded by Mistra).

Depending on the call, co-funding from sources other than Mistra is allowed or even required. For example, Mistra did not require co-funding for the project "SIRP – Sustainable Investment Research Platform", while the project "Smart infrastructure maintenance" required co-funding at 30% of the total project budget, from companies, public sector organisations and/or government agencies. Co-funding from other universities and research institutes is also possible. Co-funding may consist of financial or in-kind contributions such as staff involved to assist in the project (MISTRA, 2018[27]).

Most projects have an initial duration of 4 years and, following an evaluation, projects continue for up to eight years (MISTRA, 2018[25]). The available funding for grants comes from a fund with a valuation of more than EUR 300 million, which is managed by Mistra. Based on its current projects, grants range from less than EUR 400 000 to more than EUR 20 million in total per project, with an average of EUR 6 million. The project taking EUR 400 000 consists on grants for researchers to spend a year working abroad. The largest project with about EUR 20 million in funding is the "Stockholm resilience centre", a research institution for global sustainability drawing from the field of ecological economics and systems ecology.

Selection criteria

While each call has specific requirements, all proposals are evaluated according to the following general criteria (MISTRA, 2018[28]):

- Contribution to addressing the sustainable development goal mentioned in the call;
- Approach, i.e. whether the programme has a central, coherent idea and an innovative direction; how well are its objectives formulated and how well reported are the anticipated effects;
- Scientific quality, i.e. how well does the programme meet requirements in terms of skills, theoretical standards and methodological quality;
- Benefits, i.e. how well developed is the collaboration with potential users of the research results and which communication processes and methods will be used to attain effective implementation;
- Management and organisation, i.e. the manner in which the programme will be integrated in the host organisation, how it will be governed and structured, and to what degree it will make efficient use of resources;
- Competitiveness, i.e. the ways in which the programme has the potential to help promote Sweden's competitiveness and prosperity in a broad sense.

Selection procedure

Mistra generates research ideas through dialogue and meetings with researchers, companies, public agencies and organisations. The ideas are analysed by Mistra and, if deemed important, collected in an idea bank (MISTRA, 2018[29]).

Some of the ideas from the idea bank will be further developed, being proposed to Mistra´s Board twice a year. The board decides which ideas to take on through the organisation of "idea groups" tasked with organising seminars and workshops for researchers and users, and compile a background report. This report usually culminates in a proposal to Mistra's Board that specifies the application call for a research programme.

Once a proposal is accepted, a call is launched, inviting research groups, jointly with relevant stakeholders in the society, to submit proposals. Applicants need to submit a programme plan, which is evaluated by an international panel of experts. The selected application needs to be approved by Mistra's CEO (MISTRA, 2018[30]).

The full application process from the day a call is opened until the selected programme starts takes about 11 months. Once a call closes the processes of evaluation and decision take about 2 or 3 months (MISTRA, 2018[28]).

Mistra's board is composed by a group of 10 members selected by the government, Swedish public agencies and research organisations (MISTRA, 2018[31]).

Programme challenges and adjustments

Mistra's former chair Lena Torell argued that one characteristic of Mistra's management that works particularly well is the flexibility of its secretariat, with the necessary skills to effectively set up and run research programmes. According to her, this flexibility and specialisation in managing research programmes is achieved by keeping a small team focused on managing the programme, and outsourcing field specific knowledge to groups of outside experts (MISTRA, 2018[31]).

On challenges to be addressed in the future, Lena Torell expressed Mistra should invest more resources in additional in-depth evaluation of the academic impacts of its research funding, for instance, in terms of measuring the benefits to researchers of taking a PhD and pursuing a career within a Mistra programme.

Mistra has also been a successful investor in financial markets. It has been funding research programmes since 1994 and due to successful asset management, it has been able to increase its available funding budget, because instead of spending all its initial endowment, Mistra invested part of the funds in financial markets and obtained positive returns. Mistra was initially endowed with EUR 259 million that were expected to last for 10 to 15 years, but more than 20 years on, Mistra has more than EUR 300 million to invest in research (MISTRA, 2018[22]).

Moreover, Märtha Josefsson (MISTRA, 2016[32]), Chairwoman of Mistra's Asset Management, stressed that the organisation has been a pioneer in sustainable asset management, and has tried by a variety of means to create wider understanding of it. For instance, by openly publishing its investment policy, producing publications, and attending and arranging seminars. Mistra signed the Montréal Pledge, disclosing the annual carbon footprint of its investment portfolio, and has previously funded a research programme on sustainable financial investment.

Programme impacts

Impact assessment is conducted in a programme basis, not in aggregate for the whole Mistra's portfolio.

Examples of results are provided in Mistra's website. For example, the research project ASTA made key contributions to the development of international measures to combat cross-border air pollution, for example to the European Commission's Thematic Strategy on Air Pollution. New ways of thinking have also been included in efforts to implement the international Geneva Convention on Long-Range Transboundary Air Pollution (CLRTAP). In addition, the programme contributed to the development of advanced monitoring systems and measuring stations for air pollution. Another area based on ASTA's research is the development of theoretical models for long-range transport of air pollutants, which is used as support for CLRTAP. The project resulted in more than 150 peer reviewed scientific publications and 10 doctoral thesis. Another example, the project Greenchem, aimed to initiate a paradigm shift in the chemical industry, from being based on fossil resources to renewable raw materials for manufacture of "green" chemicals. The programme worked towards establishing processes based on modern biotechnology for production of the chemicals of interest to Swedish and international industry from renewable resources. Partnerships were established with 8 industrial groups, more than 50 peer-reviewed academic publications were produced, as well as 9 doctoral theses and 23 master theses.

More information

Website of the Swedish Foundation for Strategic Environmental Research (MISTRA): https://www.mistra.org/en/

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2.4. Investments for the Future Programme (PIA), France

Summary

- **Short description**: Capital finance and grants for business R&D and innovation amounting on average to a total of EUR 7.2 million per project, aimed at stimulating innovation and brining new ideas to market in technological areas centred in sustainability (ADEME, 2017[33]).
- **Period**: 2010-2025.
- **Target group**: Firms, regardless of size.

  Budget size and allocation: For the period of 2010-2020, ADEME is in charge of allocating approximately EUR 4 billion euros in funding. Between 2010 and 2017, about EUR 2.5 billion have been distributed among a total of 745 projects, an average of 93 per year [see ADEME (2017[33]) and (2017, p. 24[34])]. During that period, around 44% of the funding was allocated to the area of sustainable transport, 36% to sustainable energy, 11% to sustainable buildings, industry, agriculture, and green chemicals, and 9% to the circular economy. The PIA 3 phase, also operated by ADEME, started in 2017, with a total of EUR 1 billion in funding available: EUR 600 million in State subsidies and EUR 400 million in capital financing (ADEME, 2017[33]).
- **Authority in charge:** Prime Minister and the High Commissioner for Investment. ADEME is the public agency responsible to implement French public policies in the area of the environment, energy and sustainable development. ADEME is overseen by the Ministry for the Ecological and Inclusive Transition, and by the Ministry of Higher Education, Research and Innovation (ADEME, 2017[34]).

Country's context regarding innovation policy for sustainable growth

i) Environmental topics on the research and innovation policy agenda

The French National Research Strategy was implemented in 2015 with the objective of running until 2020. Among nine strategic areas, "Clean, safe and effective energy" is specified as one of the national priorities (OECD, 2018[3]).

In 2015, environmental research accounted for 3.3% of total government budget allocations to R&D (GBOARD), above the OECD average of 1.7%. Budget allocations for environmental R&D in percentage of GDP stood at 0.02% in 2015, above the OECD average of 0.01%. (OECD, 2018[4]).

ii) Overview of environmental conditions

In 2016, greenhouse gases (GHG) emissions stood at 7 200 kilograms per capita, below the OECD average of 12 000. France has decreased its GHG emissions by 14.7% between 2000 and 2016, while the OECD average decreased by 7.7% (OECD, 2018[5]).

Reduction in emissions came along with an increase in renewable energy usage and reduction of energy intensity of the economy. In 2016, renewable energy accounted for 9.6% of total primary energy supply (tpes). Renewable energy as share of tpes increased

by 3.8 percentage points between 2006 and 2016, while the OECD average during the same period increased by 3.3 percentage points. Energy intensity was of 3.7 tonnes of oil equivalent (toe) per capita in 2016 (8.9% below the OECD average), and decreased by 13.9% between 2006 and 2016 (OECD, 2018[6]).

The mean population exposure to fine particulates (PM2.5) decreased by 8.9% between 2005 and 2015, reaching a level of 12.7 micrograms per cubic metre in 2015, 12.6% below the OECD average. Water consumption, measured in gross abstractions per capita, was 46.6% below the OECD average in 2013 (OECD, 2018[7]).

iii) Environmental innovation

The share of EPO patent in environmental technologies in total EPO patents was 12.8% in 2016, compared to an OECD average of 11.5%. Between 2002-05 and 2012-15, France's revealed technology advantage in environment-related technologies increased by 13.3%, calculated as the share of environmental patents in France relative to the share of total patents belonging to France. In 2012-15, this metric reached 1.2, while the OECD average was 1.1 (OECD, 2017[8]).

Goal and sustainability challenge addressed

The Investments for the Future Programme (PIA) aims to increase the long-term growth potential of the French economy, by strengthening investment in four priority sectors: higher education and research, industries and SMEs, sustainable development, digital economy.

Since PIA's inception, ADEME has been the prime operator in expert analysis and funding of eco-efficient innovations that support energy and environmental transition. Requests for Proposals are designed to stimulate innovation, and to support companies as they bring innovative solutions to market. The four technological areas centred in sustainability of priority to the programme are: renewable energy production, energy storage and smart power grids; energy efficiency in buildings, industry, agriculture, and green chemicals; the circular economy and waste management; and all aspects of transport and mobility.

Target group

ADEME's PIA targets French firms, regardless of size, with new innovative technologies that contribute to environmental sustainability. Foreign companies can benefit from these investment mechanisms for their innovative projects, provided that projects are located in France and benefit the French economy (ADEME, 2018[35]).

From 2010 to 2017, among a total of 1 387 organisations benefiting from ADEME's PIA funding, 662 were micro firms or SMEs (ADEME, 2017[33]).

Policy instrument(s)

Through PIA's funding, ADEME has 2 financial instruments: 1) Grants and/or repayable advances, and 2) Capital financing.

- **Grants or repayable advances** are qualified as "state aid" and comply with European regulations. European state aid regulations set the maximum public funds that investments from private firms can receive. These will vary substantially depending, e.g. on the region a firm is based, firm size, age, or purpose of the investment. For instance, aid for newly created small

enterprises can cover up to 35% of the investment costs during the first 3 years after the inception of the company. In case of SME with more than 5 years, aid can cover 10% of the investment costs for medium-sized firms, and 20% for small firms.

Grants are primarily directed to research organizations and smaller partners in a project. Repayable advances are directed to remaining partners in a project. Repayable advances are similar to grants, with the difference that are only disbursed conditional on whether the project achieves a specific set of goals determined in the contractual arrangement.

- **Capital financing**: *The Eco-technologies* investment fund supports innovative SMEs in the fields of renewable energies and green chemicals, waste sorting and recycling, remediation, product eco-design, smart grids and vehicles of the future. The fund supports SMEs established for more than 3 years, mainly established in France and unlisted. It operates in venture capital and development capital and co-invests amounts of EUR 1 to 10 million along with other private players. This fund is managed by BPI France and relies on the technical and economic expertise of ADEME. This investment in equity is made pari passu with the private actors.

ADEME's funding has 3 operation models of funding, each targeting different actors and sectors [see ADEME (2018[36]), (2018[37]) and (2018[38])]:

- The "Innovation Contest" model supports innovative projects led by start-ups and SMEs. These projects are mostly from single organisations, have a duration of 1 to 2 years and have a total budget of EUR 600 000 to EUR 5 million. Public support can cover up to 45% of eligible expenses (the proportion of covered costs depends on applicants' size, as smaller organisations have larger coverage.).
- The "Demonstrators and territories with ambitions" model develops energy and environmental transition demonstrators, and provides equity financing for path-breaking innovative infrastructure on a commercial scale. Projects can be from single organisations or consortiums, with a size larger than EUR 2 million. ADEME support can cover up to 70% [1] of total eligible costs.
- The "Accelerating the development of advanced innovation ecosystems" model is dedicated exclusively to transport and mobility. It targets cooperative projects between companies and research institutes, with projects typically larger than EUR 2 million. Only the research activities of these projects are subsidised, with ADEME covering up to 70%[1] of eligible costs.

Selection criteria

Decision criteria for funding and its amount will depend on specificities of the theme of each call. However, seven general criteria apply to all projects (ADEME, 2018, p. 7[39]):

- Assessment of the innovative character of the project;
- Positive environmental impact;
- Economic viability;

- Economic impact in terms of employment generation;
- Importance of receiving public support;
- Social impact of the project (other than environmental impacts);
- Quality of the firm or consortium.

Selection procedure

ADEME opens calls and posts them online. After reviewing applications, ADEME prepares recommendations that are analysed by a steering committee. The steering committee proposes what projects should receive funding alongside with the opinion of PIA's general board of investment. The Prime Minister makes final funding decision.

For each call, ADEME, along with members of relevant ministries, conducts a first analysis in terms of eligibility and timeliness of the applications received. This analysis can lead to a short interview with project leaders before the start of the in-depth review.

A Steering Committee (COPIL), composed of representatives of the ministries in charge of the economy, research, the environment and transport, decides in agreement with PIA's general commissariat for investments (CGI) what projects will pass to an advanced review phase. ADEME conducts an in-depth review of each selected application with the support of internal or external experts. At the end of this evaluation phase, ADEME presents its conclusions to the COPIL, in the form of recommendations of what projects should receive support. The COPIL gives an opinion to the CGI on the projects presented (ADEME, 2018[37]) (ADEME, 2018, p. 9[39]).

The Prime Minister takes the final decision upon advice of the CGI. The whole procedure takes about three months (ADEME, 2018, p. slide 10[38]).

ADEME carries out an evaluation of the economic, social and environmental benefits that each supported project has under the investment program. For this purpose, beneficiaries agree to respond to a qualitative survey and provide all the quantitative elements necessary for the evaluation during the project as well as afterwards (ADEME, 2018[37]).

Programme challenges and adjustments

PIA was established in 2010 and in 2016 the general commissariat for investments (CGI) formed an evaluation committee to evaluate PIA's activity and prepare recommendations about potential improvements to be implemented. Despite a global positive review, the evaluation committee identified a number of areas to be improved. For example, a conflict between the excellence criterion and territorial scientific inclusiveness was identified. Since PIA's aim is to focus on excellence, the territorial dimension should not be a decision criterion. Moreover, in some cases, there were some uncertainties about the time span of possible financial support. Information about lengths and amounts of support should always be made clear (Maystadt, Harfi and Lallement, 2016, p. 66[40]). Finally, more needs to be done towards the evaluation of impact of each funded project. Currently, PIA does not have sufficient human resources to carry out a thorough impact evaluation comprising micro-econometric studies and macro modelling. Also, more unified set of standards need to be defined to evaluate the impact of projects in different fields with a unified framework of metrics (Comité d'examen PIA, 2016, p. 15[41]).

Programme impacts

The total size of the projects financed by ADEME's PIA was of EUR 7.22 million, while ADEME's allocation was of 2.5 million. This means ADEME's PIA had a leverage effect of 1.9, contributing to attract finance from additional sources (ADEME, 2018[42]).

Some examples of impact are provided on a project basis, consisting on information provided by awarded projects. For example, the project Tank2020 is a new milk cooling and storage tank equipped with innovative refrigeration and energy management options. This tank developed by Groupe SERAP with support from ADEME's PIA, will reduce annual electricity consumption from the grid by as much as 80% and cut direct emissions of fluorinated GHGs by more than 90%. In the transport sector, in the project ESSENCYELE, the Groupe Moto-Propulseur (GMP) with ADEME's PIA support, developed a highly efficient engine. The technology has an estimated fuel consumption gain of 15% to 22% by the New European Driving Cycle (NEDC) standards, or 10% to 16% by the Worldwide Harmonised Light Vehicles Test Procedure (WLTP) standards. This lower fuel use will avoid 7 to 10 million tonnes of CO2 emissions in the period up to 2020.

More information

Website of the Investments for the Future Programme (PIA): http://www.agence-nationale-recherche.fr/en/about-anr/investments-for-the-future/

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2.5. Advanced Research Projects Agency-Energy (ARPA-E), USA

Summary

- **Short description**: ARPA-E offers grants for R&D projects from academia, national laboratories, or private industry that focus on high potential, high-impact energy technologies that are too early for private-sector investment, and that have the potential to improve USA's environmental well-being and security. Grants have an average size of EUR 1.7 - 2.6 million, disbursed during one to three years (ARPA-E, 2018[43]).
- **Period**: 2009 – present (as of October 2018).
- **Target group**: universities, national laboratories, large and small private companies, non-profits, and consortia comprising such entities.
- **Budget size and allocation**: the programme's total budget was of EUR 258 for 2016 million and EUR 282 million for 2017 (requested to congress), with a planned disbursement of EUR 232 million and EUR 318 million, respectively (ARPA-E, 2017, p. 401[44]). In the fiscal year of 2016, approximately EUR 333.9 million were allocated to 140 new projects. From 2009 to February 2018, ARPA-E has provided approximately EUR 1.6 billion in R&D funding for more than 660 projects (ARPA-E, 2018[45]; ARPA-E, 2018[46]).
- **Authority in charge**: Department of Energy (DoE). The DoE is the cabinet-level department of the United States Government in charge of implementing United States' energy policy.

Country's context regarding innovation policy for sustainable growth

i) Environmental topics on the research and innovation policy agenda

The main Science, Technology and Innovation strategy in the USA has been the plan "Driving towards Sustainable Growth and Quality Jobs", implemented in 2009 with the objective of running until 2016. The strategy was renewed in 2015. The area of "clean energy technologies" was identified as one of the eight strategic research areas of priority (OECD, 2018[3]).

In 2015, environmental R&D accounted for 0.4% of total government budget allocations for R&D (GBOARD). The share has been constantly below the OECD average of 1.6%. Between 2005 and 2015, environmental expenditures among total GBAORD decreased 0.1 percentage points (OECD, 2018[4]).

ii) Overview of environmental conditions

In 2016, levels of greenhouse gas (GHG) emissions were at 20 200 kilograms per capita in the United States, 68.8% above the OECD average of 12 000. Although GHG emissions are higher than the OECD average, their levels decrease at faster rate than in the OECD. Between 2006 and 2016, the levels of emissions per capita decreased by 17%, while the OECD average levels decreased by 13.3% (OECD, 2018[5]).

In terms of energy intensity, in 2016 the US economy used 6.7 tonnes of oil equivalent (toe) per capita, 63.8% above the OECD average (OECD, 2018[6]). However, between 2006 and 2016, energy intensity decreased by 13.1%.

In terms of air quality, the United States had a level of 10.9 micrograms per cubic metre in 2015, 24.9% below the OECD average. The country has decreased the mean population exposure to fine particulates (PM2.5) by 12.6% between 2005 and 2015. Water consumption, measured in gross abstractions per capita, was 92.1% above the OECD average in 2010 (OECD, 2018[7]).

iii) Environmental innovation

In 2016, the share of environmental EPO patents among total EPO patents was of 11.5%, a similar level as the OECD average. Moreover, its revealed technological advantage in environmental technologies (calculated as the share of environmental patents relative to the share of total patents belonging to the United States) increased 18.8% between 2002-05 and 2012-15, in comparison with the OECD average increase of 3.7%. The country scored 1.2 on this indicator above the OECD average of 1.1 (OECD, 2017[8]).

Goals and sustainability challenge addressed

ARPA-E's mission is to support energy innovations that will create a more secure, affordable and sustainable energy future in the USA. Supported projects contribute to reduce US's dependence on energy imports, reducing energy related emissions, improve energy efficiency across all sectors of the economy; and ensure the US maintains a technological lead in developing and deploying advanced energy technologies (ARPA-E, 2017[47]).

Target group

ARPA-E funds innovative ideas from academia, private industry, national laboratories, start-up companies, or small businesses. State, local and tribal governments are also eligible to apply for funding as a member of a project team, but not as standalone applicants or as the lead organization for a project application (ARPA-E, 2018[48]). Supported projects develop high-risk/high-potential/high-impact energy technologies that are too early for private sector investment but could significantly advance the ways energy is generated, stored, distributed and used (ARPA-E, 2017[49]). Foreign entities, whether for-profit or otherwise, are not eligible to apply for funding, but may be proposed by an applicant as a member of a team. All work under an ARPA-E award must be performed in the USA (ARPA-E, 2018[50]).

Policy instrument(s)

The programme awards **direct financial support in the form of grants** for business R&D and innovation. ARPA-E periodically opens two types of calls for grants: one focuses on specific technologies within the energy sector; the other are the so-called open announcements, which seek any good energy technology idea that fits within the programme's mission.

In terms of amounts, grants can fall under one of the two following categories, according to the stage of development of applicants' technologies (ARPA-E evaluation committee, 2017[51]):

Grants for proof-of-concept projects: projects at the stage of providing the first preliminary data to prove or disprove new technology concepts. They are limited in cost (under EUR 887 000) and duration (6-18 months).

Grants for technology development projects: projects intended to develop technology from ideas to laboratory-scale prototypes. Their duration is typically 36 months and their cost can range between EUR 1.7 – 8.8 million.

ARPA-E also provides awardees with **training** through its technology-to-market programme. This programme provides practical training and critical business information to equip project teams with a clear understanding of market needs to guide technical development and help projects succeed. Awardees are required to provide a technology-to-market plan prior to receiving an award and work closely with ARPA-E's technology-to-market advisors throughout the project, developing market strategies to move projects toward the marketplace (ARPA-E, 2013[52]). ARPA-E also helps awardees develop networks with relevant government agencies, technology transfer offices, companies, investors, and other organizations to facilitate transitioning to the commercial phase.

Regarding general funding conditions, depending on the nature and size of awardees, ARPA-E covers different proportions of projects' costs. For example, large businesses are required to contribute at least about 20% of the total project cost; educational institutions or domestic non-profits are required to contribute only 5%; and small businesses contribute 0% of the cost during the first year of the project, and 10% thereafter. ARPA-E's total contribution will depend on the nature of each project. The programme provides support at the highest funding level only for applications with significant technology risk, tight timetables, and careful management and mitigation of associated risks (ARPA-E, 2018[50]).

Selection criteria

The programme selects projects of applied research or development that have high technical and market risk, with the aim of accelerating the translation from science to markets at proof of concept and prototyping stages. ARPA-E does not finance incremental research, nor pure basic research. Project selection is based on the concept of providing an opportunity for creative "out-of-the-box" transformational research in a short period, as opposed to incremental research on ideas that have already been developed, or pure basic research that requires long-term block grants. Applied research is defined as an original investigation undertaken in order to acquire new knowledge directed primarily towards a specific practical aim or objective. Development is defined as the creative and systematic work, drawing on knowledge gained from research and practical experience, which is directed at producing new products (ARPA-E, 2011[53]).

ARPA-E made its first call or "Funding Opportunity Announcement" in May 2009, and it received 3700 initial applications (or "concept papers"). From these, it encouraged 334 full applications, out of which 37 received funding.

Concept papers (initial applications) are evaluated according to the following criteria (weights in parenthesis):

- Impact of the proposed technology (50%): Reviewers consider the extent to which (1) the idea has potential to be transformative and disruptive, rather than an incremental advancement over current technologies; (2) the idea will positively impact at least one of ARPA-E's mission areas; and (3) the applicant demonstrates awareness of competing commercial and emerging technologies and how the idea could result in significant improvements.

- Overall scientific and technical merit (50%): Reviewers consider (1) the feasibility of the proposed work, (2) the soundness of the technical approach, which should be superior to alternatives, (3) the clarity of the definition of outcomes and deliverables, (4) the identification of relevant techno-economic challenges, and (5) the demonstrated capabilities of the applicant and team.

Among selected concept papers, applicants are invited to submit a full application, which is evaluated according the following criteria (weights in parenthesis):

- Impact of the proposed technology relative to the current state of the art (30%): Applicants are asked to demonstrate (1) the extent to which the idea is potentially transformative and disruptive (not incremental); (2) "profound understanding of the current state of the art" and an innovative approach to significantly improving it; (3) awareness of competing commercial and emerging technologies and how the idea would yield significant improvements over these technologies; and (4) a "reasonable and effective strategy" for bringing the new technology from the laboratory to the market.
- Overall scientific and technical merit (30%): Applicants must demonstrate (1) the extent to which the idea is "unique and innovative"; (2) clearly defined outcomes and deliverables; (3) the feasibility of the proposed work based on preliminary data, background information, and/or sound scientific and engineering practices and principles; (4) a sound technical approach, including "appropriately defined technical tasks"; and (5) identification of major technical R&D risks and feasible and effective risk mitigation strategies.
- Qualifications, experience, and capability (30%): Applicants must demonstrate (1) the skill and expertise necessary to execute their project plan, based on prior experience with R&D of similar risk and complexity; and (2) access to the equipment and facilities necessary to execute the plan.
- Management plan (10%): Applicants must demonstrate (1) a plausible plan for managing people and resources; (2) allocation of appropriate levels of effort and resources to tasks; (3) a reasonable project schedule, including major milestones; and (4) the appropriateness of the budget relative to the task.

Selection procedure

ARPA-E opens periodic calls for funding (Funding Opportunity Announcements), generally issued every two to three years. Applications for ARPA-E funding follows a three-step process.

- Phase 1: concept paper submission

  Applicants submit a five- to seven-page concept paper and leading external experts review and evaluate each proposal. External reviewers convene in person and form a "review panel". These reviewers include world-class scientists, engineers, and leaders from the technical community, and must disclose any actual or apparent conflicts of interest. Reviewers are asked to evaluate the applications, assign numerical scores, and provide comments. This initial stage is intended to save applicants the time and cost of preparing applications with little likelihood of success. Following this review, the

programme director considers the evaluations and compiles a tentative list of concept papers that can be invited to submit full applications. Each call has an "ARPA-E Merit Review Board" that executes a "Merit Review Plan", usually chaired by the call's programme director who initiated the relevant call. The board will review and discuss the lists of papers with the programme director, and the final list of promising concept papers is finalized through consensus. The ARPA-E director reviews the Board's recommendations and makes the final decision as to which applicants should be encouraged to submit a full application and which should be discouraged from doing so. Applicants can expect to receive a notification regarding ARPA-E's determination to invite or not invite a full application submission within approximately 60 days after submission of a concept paper (ARPA-E, 2013[54]).

- Phase 2: Full application review and reply to reviewers' comments

  Following review of concept papers, ARPA-E encourages some applicants to submit full applications providing additional information about prior, current, and pending sources of funding (both private and public) and an explanation of why other funding sources will not support the project. Applicants have approximately 45 days from receipt of the notification to prepare and submit a full application. Programme directors and other personnel, along with leading external experts in the field, review full applications. External experts are asked to evaluate the applications and provide a list of comments. ARPA-E sends reviews to applicants providing the opportunity to prepare a reply to reviewers' comments prior to the final funding decision discussions.

- Phase 3: Final decision

  The Merit Review Board reviews the evaluations and meets in person with the review panel to discuss applications. The Merit Review Board then considers the evaluations, any rebuttal comments from applicants, and the technical merit review criteria and programme policy considerations, and makes its recommendation to the ARPA-E "selection official" (the ARPA-E director). The selection official decides which applications will be selected to negotiate terms of an award. In this decision, there is no obligation to use the scoring by the reviewers as the sole factor in determining which projects are selected, or to rank applications according their reviewer scores. The selection official can take into account other strategic considerations as the benefit of each project to the full range of ARPA-E's portfolio. The full length of the selection process since the deadline for concept papers to final funding decision is about 9 months (ARPA-E, 2018[55]).

Once final decisions are taken ARPA-E engages in negotiations with potential recipients of final awards. The parties must reach an agreement on how patents and other intellectual property rights will be handled, and establish a work plan with technological milestones that should be specific, unambiguous, and quantifiable, and include specific key decision points over the course of the project. ARPA-E remains closely engaged with awardees from the inception of a project through its conclusion. When a project is not meeting its milestones, ARPA-E acts to address the situation with frequent meetings with the awardees. Actions taken include complete termination of the project, limited extensions of time to allow projects to meet a given milestone, and revision of milestones and objectives. As of

May 2015, 21 projects were terminated prior to the end of their end dates because of failure to achieve stipulated milestones (ARPA-E evaluation committee, 2017[51]).

Programme challenges and adjustments

ARPA-E's calls are offered only every two to three years and submissions are accepted only for a limited period of time, usually about 90–120 days. Consequently, innovators who have an idea for a submission outside of that limited time window must wait until another call is announced, possibly as long as 3 years. While a rolling continuous-intake would probably be beneficial, it is unlikely that ARPA-E could adopt such open system without a larger budget and less budgetary uncertainty (ARPA-E evaluation committee, 2017[51]).

The first generation of ARPA-E projects reflected a "blue sky" character in its early days, funding projects with less streamlined and grounded strategic goals. Over time, as successive programmes came into existence, a baseline was created, and subsequent programme directors were hired with consideration of their specific expertise in broad thematic areas ARPA-E had identified as strategic (ARPA-E evaluation committee, 2017[51]).

The programme has been adjusting its technology-to-market programme. After more than 600 projects, two key insights common to all successful projects were identified. First, innovators need to consider their path toward commercialisation early on, as they begin developing their technology in the lab. That means, for example, talking directly to potential customers and understanding opportunities and constraints. This inevitably provides direction for their experimentation and assures that they are creating technologies that customers want to buy. Therefore, these types of early-stage interactions are fostered on the technology-to-market programme. Second, large problems require relying on the broader energy innovation community. Successful innovators force themselves out of their technical silos to solve problems. Collaborating with scientists from different disciplines, industry leaders, government stakeholders, and the financial sector is key for success. These type of collaborative interactions are consequently also incentivised in the technology-to-market programme (Henshall, 2017[56]).

Programme impacts

While the full market impacts of the technologies that ARPA-E has funded can only be measured in the mid- to long-term, some intermediate outcomes are evident now. Roughly half of the projects funded between 2009 and 2015 have published results of their research in peer-reviewed journals (more than 1,700 articles), and about 13% have obtained patents (245 patents issued by the USPTO). One quarter of the supported project teams or technologies have received follow-on funding for continued work. In fact, several are either already commercially available or ready to enter the commercial market (ARPA-E evaluation committee, 2017[51]). As of February 2018, 74 ARPA-E projects have attracted more than EUR 2.3 billion in private-sector follow-on funding. In addition, 71 ARPA-E project teams have formed new companies to advance their technologies, and 109 ARPA-E projects have partnered with other government agencies for further development, most notably from the Department of Defense, which has seen value in ARPA-E projects. These technologies can lower the costs of powering U.S. military bases overseas, eliminate the military's reliance on foreign fuels, and improve troop mobility and health. (ARPA-E, 2018[43]).

While, the programme has in place an extensive data gathering and recordkeeping system at the project level and monitors internal metrics to facilitate programme management, it

has a less extensive system for collecting, tracking, and reporting publicly available high-level innovation metrics such as publications; funding from other sources; and intellectual property information, including disclosures and patents over time. Nevertheless, as reported in ARPA-E's evaluation (ARPA-E evaluation committee, 2017[51]), the programme is in a good position to develop a framework for prospectively mapping project-level data from program creation, through project selection and management, to mission success and achievement of goals.

More information

Website of the Advanced Research Projects Agency-Energy (ARPA-E): https://arpa-e.energy.gov/

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3. Collaborative research for sustainability

3.1. National Environmental Science Program (NESP), Australia

Summary

- **Short description:** NESP provides funding to support applied scientific research collaborations in environmental science focused on biodiversity and climate systems.
- **Period**: 2015-2021.
- **Target group**: Australian research institutions, in partnership with other universities, non-government organisations and state/territory governments.
- **Budget size and allocation:** EUR 17 million funding available per year, and a total of EUR 98.5 million available over the six years of the program- (NESP, 2014, p. 4[58]). In 2018, 47 new projects were approved, having been allocated a total of about EUR 8 million. Funding is shared among 6 hubs, and in 2018 the allocation was as follows: funds for 16 projects were allocated to Threatened Species Recovery Hub (EUR 1.15 million in total); 1 project to Northern Australia Environmental Resources Hub (EUR 90,000); 14 projects to Tropical Water Quality Hub (EUR 2.62 million); 5 to Marine Biodiversity Hub (EUR 461 000); 9 to the Earth Systems and Climate Change Hub (EUR 3.48 million); and 2 to Clean Air and Urban Landscapes Hub (EUR 237 000).
- **Authority in charge**: Department of the Environment and Energy (DoEE). The DoEE is responsible to design and implement the strategies established by the Australian Government towards protecting and conserving the environment, promoting climate action, and providing an adequate, reliable and affordable energy to meet future energy consumption needs (NESP, 2018[59]).

Country's context regarding innovation policy for sustainable growth

i) Environmental topics on the research and innovation policy agenda

Sustainability or environment-related objectives are not included in Australia's main STI strategy ("Australia 2030: Prosperity through Innovation") – while they do in 27 out of 31 OECD countries. However, in 2015, the Australian government developed the "National Science and Research Priorities" designed to increase investment in areas of immediate and critical importance to the country (Australian Government, 2015[60]). The plan provides a framework for the Australian Government to coordinate research investments towards the identified areas of competitive advantage and national importance. Four out of nine priority areas are related to environmental sustainability: soil and water quality; energy efficiency; sustainable mineral resource exploration, and environmental change.

The government budget allocations for R&D (GBARD) on environmental areas has increased over time, from USD 78 million in 2005 to USD 171 million in 2015. In 2015, Australia allocated 3.8% of total GBARD expenditures to environmental R&D, significantly above the 1.7% average across the OECD. Such expenditures account for 0.016% of GDP in 2015 (above the OECD average of 0.011%) (OECD, 2018[4]).

ii) Overview of environmental conditions

Australia's level of greenhouse gases (GHG) emissions was of 22,800 kilograms per capita in 2016, 90% above the OECD average (58% above in the case of emissions per GDP), despite a decreasing trend between 2006 and 2016 (OECD, 2018[5]).

The energy intensity of the Australian economy was of 5.48 tonnes of oil equivalent (toe) per capita in 2016, 34% above the OECD average, despite the decrease by 4.5% between 2006 and 2016 (OECD, 2018[6]). In 2016, the share of renewable energy over total primary energy supply (tpes) was of 6.5% (around 3% below the OECD countries on average) (OECD, 2018[6]).

The population exposure to fine particulates (PM2.5) is well below the OECD average, with a mean annual concentration of 5.2 micrograms per cubic metre in 2015, compared to 14.5 across the OECD. The levels of exposure decreased by 15% between 2005 and 2015 (OECD, 2018[24]).

Regarding water resources, Australia registered of 697 million cubic metres of freshwater abstractions per capita in 2016, 7% below the OECD average (OECD, 2018[7]).

iii) Environmental innovation

Between 2011 and 2013, there were a total of 210 environment-related technology inventions in Australia, accounting for 11% of the total number of inventions in the country[6], very close to the OECD average of 12% (OECD, 2017[61]).

Goal and sustainability challenge addressed

NESP's objective is to fund scientific research collaborations that have the potential to support decision-makers understanding, managing and conserving Australia's environment with the best available information. The key sustainability challenges of interest are divided into the six following hubs: Clean Air and Urban Landscapes Hub; Marine Biodiversity Hub; Threatened Species Recovery Hub; Earth Systems and Climate Change Hub; Northern Australia Environmental Resources Hub; and Tropical Water Quality Hub.

The program connects leading scientists in each thematic hub with relevant policy makers, industry leaders, indigenous people and communities. The connection with local agents is particularly interesting in order to involve citizens with scientific and technological research orientation and to make policy proposals more grounded on the needs of local communities (NESP, 2018[62]). In order to establish relationships with relevant stakeholders for each topic, hubs are required to develop a knowledge brokering and communication strategy. The strategy should illustrate how the hub will contribute to building relationships and knowledge-sharing networks between researchers, government, industry and communities. The strategy should also detail how the hub will facilitate adoption of research outcomes by environmental decision makers across government, industry and communities.

Target group

NESP targets the leading scientists in the fields related with each hub from different universities in Australia. For each hub, the program opened a call for partnerships of universities, companies, or local public authorities, to compose an application. The host organisation must be an Australian research institution (NESP, 2014, p. 15[58]).

Policy instrument(s)

NESP funds research consortiums (selected via a competitive grants process) to undertake robust, peer-reviewed, collaborative and end-user driven research. Applications are sought from collaborative, multi-disciplinary consortiums of organisations. The consortium must nominate a host institution and a principal researcher employed by the host institution to act as the hub leader. The host institution must be an Australian research institution (NESP, 2014, p. 10[58]).

NESP funding is to be directed primarily to the conduct, collaboration and communication of research and intended to be primarily spent in Australia. Funding may be used for:

- Salaries for researchers and support staff, fellowships and student stipends;
- Direct support costs of research;
- Indirect support costs of research;
- Capital items, such as equipment necessary for conducting research.

Selection criteria

Applications were competitively ranked and needed to score highly on each of the following merit criteria:

- National scientific and research leadership capability (35%)
- Capacity to plan and lead a substantial cross-disciplinary research programme (35%)
- Risk management, managerial and financial competency (10%)
- Communication, knowledge brokering, synthesis and analysis (20%)

In the competitive assessment phase, an assessment panel ranked applications against each other, producing a list running from high priority to low priority or not recommended for funding.

Application and selection procedure and reporting requirements

In order to compose a hub, consortiums of legal entities, such as universities, companies, or local public authorities, prepared a joint application. The host organisation, which has to be an Australian research institution, submitted the application, which was accompanied by letters of support from all the partner organisations that compose each consortium (NESP, 2014, p. 15[58]).

The initial funding period for NESP hubs is up to six years, commencing in January 2015. Program funding is distributed across six hubs. Every year the organisations integrating each hub submit new projects for approval in annual "research plan versions".

An assessment panel from the DoEE reviewed all applications, engaging with independent scientific experts to assist the panel when required. The panel developed recommendations to advise the minister making the final decision. Applications may have been approved either in full or in part, and approvals may have included specific conditions.

All hubs are expected to commit and deliver to the program a level of co-investment (cash and/or in-kind contributions) equivalent to or greater than the amount of NESP funding

they receive, and all partner organisations in a hub are expected to contribute resources to the hub (NESP, 2014, p. 14[58]).

All successful applicants are subject to financial and performance monitoring and evaluation to ensure that they are meeting specified milestones and performance indicators as detailed in the Funding Agreement. In addition, each hub is expected to develop a monitoring and evaluation plan to demonstrate its ongoing performance against NESP outcomes. This is done in consultation with the DoEE. The outcomes of activities funded by the NESP are measured by reporting against performance indicators determined by the DoEE and relevant portfolio agencies, and may be subject to change during the life of the program. Periodic qualitative assessments of the program are also undertaken to measure the use of NESP research outputs in decision-making. Program evaluations at the middle and end of the NESP will examine the efficiency and effectiveness of program delivery (NESP, 2014, p. 20[58]).

Program impacts

Impact assessment is not performed at NESP's level, but by the different hubs. For example, the research hub on Earth Systems and Climate Change has produced research providing information about sea level rise at a regional level. Prior to this research, information on future sea-level rise was not available at the council level (for local governments), but was only available for 24 locations for three future emissions scenarios at 2030 and 2090. As a result of the Hub's research, sea-level rise information was produced and made available for 255 coastal councils around Australia for each decade from 2020 to 2100 under four emissions scenarios. This enables Australian local governments to plan decisions on a more informed basis than in the past.

Another example is the hub's research about extreme fire conditions. Previous fire weather studies and datasets were based on model output and station data. Station data are useful for understanding the fire weather at a given point location, but are not as helpful for understanding how fire weather varies across a region. The new research and dataset produced by the hub uses gridded observations of fire weather conditions throughout Australia, allowing to identify regions with exceptionally dangerous fire weather. The fire weather dataset has been used by the Bureau of Meteorology's Climate Information Services group, which prepares warnings and other guidance information used by fire agencies to plan for potential bushfire conditions.

More information

Website of the National Environmental Science Program: http://www.environment.gov.au/science/nesp

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3.2. S&T Research Partnership for Sustainable Development (SATREPS), Japan

Summary

- **Short description**: SATREPS provides competitive grants of approximately EUR 890 000 a year per project to support international joint scientific research to address sustainability challenges (SATREPS, 2018[63]).
- **Period**: 2008 – present.
- **Target group**: Organisations (including universities, public research institutions and firms) that conduct research activities of public interest in targeted fields.
- **Budget size and allocation**: Around EUR 50 million were disbursed in 2017, distributed across 55 ongoing projects. Between 2008 and 2016, 101 projects were launched in 43 countries, and 59 were completed (SATREPS, 2017, pp. 61-63[64]). In 2017, SATREPS was funding 14 projects in the area of bio resources, 13 in the area global-scale environmental and energy issues, 10 in disaster prevention and mitigation, 10 in infectious diseases control, and 8 in projects related with carbon emission reductions (SATREPS, 2017, p. 61[64]).
- **Authority in charge**: Japan Science and Technology Agency (JST), Japan Agency of Medical Research and Development (AMED) and Japan International Cooperation Agency (JICA). JST, AMED and JICA are the Japanese public agencies responsible implementing the policies established by the Japanese government in the area of science and technology, medicine and international cooperation, respectively.

Country's context regarding innovation policy for sustainable growth

i) Environmental topics on the research and innovation policy agenda

The main Japanese Science, Technology and Innovation strategy ("The Fifth Science and Technology Basic Plan 2016-2020") was introduced in 2016. The strategy addresses societal challenges related with sustainability (e.g. natural resources, energy, environment, or climate change), as well as societal challenges related with smart cities (e.g. sustainable urban systems, or urban development), and energy technologies (e.g. energy storage, or environmental technologies) (OECD, 2018[3]).

Environmental R&D accounted for 1.9% of total government budget allocations for R&D (GBAORD) in 2015, above the OECD average of 1.6%. GBAORD in environmental areas has increased in the last decade. In 2015, environmental GBOARD stood at 0.01% of GDP, a share similar to the OECD average (OECD, 2018[4]).

ii) Overview of environmental conditions

In Japan, total levels of greenhouse gas (GHG) emissions stood at 10 210 kilograms per capita and remained below the OECD average of 12 000 kilograms per capita in 2016. From 2006 to 2016, Japan reduced emissions by 3.1%, while the OECD average reduction was of 13.3% (OECD, 2018[5]).

In 2016, renewable energy accounted for 4.8% of total primary energy supply (tpes) – below the OECD average of 9.7%. Renewable energy as share of tpes increased by 1.6

percentage points between 2006 and 2016. The energy intensity of the Japanese economy was of 3.3 tonnes of oil equivalent (toe) per capita, below the OECD average of 4.1 toe per capita. Energy intensity has decreased by 17.8% between 2006 and 2016 (OECD, 2018[6]).

Air quality, measured by the mean population exposure to fine particulates (PM2.5) reached a level of 15.5 micrograms per cubic metre in 2015, while the OECD average was 14.5. Levels of PM2.5 experienced an increase of 6% between 2005 and 2015. Water consumption, measured in gross abstractions per capita in 2014, was 23.3% below the OECD average (OECD, 2018[7]).

iii) Environmental innovation

EPO patents in environmental technologies accounted for 11.2% of total EPO patents in 2015, while the OECD average was 11.5%. In the period 2012-15, the revealed technology advantage in environment-related technologies calculated as the share of environmental patents in Japan relative to the share of total patents belonging to Japan, was of 1, while the OECD average was 1.1. Between 2002-05 and 2012-15, this revealed technology advantage decreased 7% in Japan, while the OECD average increased 3.7%. (OECD, 2017[8]).

Goal and sustainability challenge addressed

SATREPS is a Japanese programme supporting international joint research aiming to address global issues, such as climate change, disaster prevention or public health, by developing new knowledge and technologies of practical benefit to both local and global society.

The programme aims at enhancing international cooperation in science and technology between Japan and developing countries with the objective of developing new knowledge and technologies that help addressing global issues such as the Environment/Energy, Bio resources, Disaster Prevention and Mitigation, and Infectious Diseases (SATREPS, 2018[63]).

In conjunction with this, it also aspires to improve the development of human resources and research capabilities in recipient countries by conducting joint research. The research projects should lead to future social and economic benefits, achieved by using newly obtained knowledge and technology to enhance government services or to develop products that can be deployed in the market (SATREPS, 2018, p. 1[65]).

Target group

SATREPS targets organisations carrying out activities with a public nature in the targeted fields, such as universities (including private universities) and public research institutions (except military-affiliated research institutions). In addition, they must have structures that are suitable for conducting international joint research (JICA, 2018[66]). Private firms can also participate as long as being incorporated in Japan, conducting activities with a public nature in the targeted fields of SATREPS. Private firms can also participate if in a partnership with a university or similar institution (SATREPS, 2018[67]).

Policy instrument(s)

The programme provides competitive grants for scientific research collaborations between researchers at universities and research institutes in Japan and in developing countries. Projects take between 3 and 5 years (SATREPS, 2018[68]).

As a basic condition, selected projects need to be aligned with SDGs in the following areas (SATREPS, 2018[69]):

- Global-scale environment and energy: Research contributing to the solution to global-scale environmental issues (contributing to SDGs regarding response to climate change, conservation of ecosystems and biodiversity, sustainable use of natural resources, and pollution prevention and control);
- Energy transition to low carbon society: Research contributing to advance energy systems for low carbon society (contributing to SDGs regarding clean energy and climate action);
- Bio resources: Research contributing to sustainable production and utilization of bio resources (contributing to SDGs regarding food security, health promotion, nutrition improvement, and sustainable agriculture, forestry, and fisheries);
- Disaster prevention and mitigation: Research on disaster prevention and mitigation towards social sustainability (contributing to SDGs regarding analysis of disaster mechanisms, prior countermeasures, and disaster occurrence to post-disaster recovery and reconstruction processes).

Applications are not eligible if they consist merely of transfer of Japanese technology without entailing any joint research, or solely of surveys and other simple operations that do not make any contribution to the advancement of science and technology, or if it produces outcomes that can only be of benefit to one particular country.

Selection criteria

Successful projects share the following characteristics (SATREPS, 2018[69]; JICA, 2018[66]):

- Develop outcomes to be applied to the benefit of broader society as well as in the developing country. It should not be a research project for the sake of research itself;
- There must be the expectation of improving the scientific and technological standards of both the recipient country and Japan;
- The contents of the research plan must be narrowed down and it must be highly specific. There must also be the expectation that a certain degree of results will be brought about from the research within the cooperation period;
- Cover topics in developing countries for which the scientific research is needed to resolve an issue, and for which capacity building of researchers is required;
- Contribute to the resolution of global issues and scientific and technological progress.

Application and selection procedure

SATREPS provides funding for researchers at universities and research institutes in Japan and developing countries. However, since the funding comes from different institutions, the application process has to follow two different channels:

- For Japanese researchers, the JST and AMED invite researchers at universities and research institutes in Japan to submit research proposals.
- Requests from developing countries need to apply for Official Development Assistance (ODA) to the Ministry of Foreign Affairs (MOFA). Official requests for ODA technical cooperation must be submitted by the research institution in the developing country to MOFA by the specified deadline, via the ministry or agency in the developing country responsible for the ODA and the local Japanese embassy. These applications are reviewed by MOFA in conjunction with JICA in Japan. Therefore, it is essential for researchers in Japan to coordinate with researchers in the ODA recipient country in order to confirm the details of the joint research when making an application to JST and AMED (SATREPS, 2018, p. 7[70]).

Additionally, to implement the international joint research, a Record of Discussions must be signed by the research counterpart(s) in the developing country and JICA to confirm that they agree on the details of the ODA technical cooperation. In addition, a Memorandum of Understanding or similar document about the joint research must also be signed between the research institutions in Japan and the ODA recipient country (SATREPS, 2018, p. 8[70]).

In 2017, the application period for JST and AMED ran from September to October 2017. The deadline for ODA applications to reach MOFA was mid-October. Documents were screened from mid-November to mid-December, 2017. Interviews took place in February/March, 2018, and final selection took place in mid-May, 2018. Projects started in May 2018 or later (SATREPS, 2018, p. 12[70]).

Project evaluation

Ongoing projects are reviewed by JST, AMED, and JICA, acting in collaboration. JST/AMED evaluate international joint research projects, both in Japan and in the developing countries, assessing whether the project outcome benefits society by contributing to the resolution of global issues, and whether the project constitutes an advance in science and technology.

JICA evaluates the joint activities confirming that the project has contributed to developing human resources and enhancing capacity in the developing country, and has contributed to the developing country's needs (SATREPS, 2017, p. 13[64]).

To further enhance project effectiveness and quality, JICA has been promoting evidence-based project implementation and emphasizing the application of impact evaluation as a major tool for this purpose. Using statistical and econometric methods, impact evaluations assess the achieved changes in developing improving and solving development issues (JICA, 2018[71]).

The following types of performance reviews are conducted:

- Mid-term review, conducted in or about the middle year of the period of international joint research (the third year of a five-year project);
- Final review, conducted before the end of the research period;

- Follow-up review, conducted a certain period after the research period has ended. JST and JICA use different terms for these same processes.

The JST reviews are published as reports and made available online. The findings of the Mid-term reviews are used as reference for subsequent adjustments to research plans and allocation of resources (including changes to budgets for research expenses and to the composition of the research team).

For research projects of less than five years, the need for conducting a Mid-term review will be decided following a discussion between the entities involved in each specific project (SATREPS, 2018, p. 27[70]; JST, 2012[72]; JST, 2012[73]).

Programme challenges and adjustments

The programme has been improving progressively its metrics to measure projects' effects. In particular, in order to assess projects' effectiveness more rigorously, JICA has introduced advanced econometric models as evaluation method, in addition to those traditionally used. These evaluation results can then be used as reliable evidence by JICA for project management and by partner countries for policy-making (JICA, 2018[71]).

The advisory committee on evaluation proposed JICA should develop an evaluation strategy and select projects to be evaluated and strengthen the learning from evaluations. As a result, SATREPS has been trying to reduce workload to deal with the increasing number of ex-post reviews. At the same time, it has been selectively conducting deeper analyses for projects with more learning outcomes. In 2016, the reports of internal ex-post reviews were simplified and the relevant procedures were changed to be more efficient (JICA Evaluation Committee, 2016[74]).

Strong efforts have also been done in order to disseminate results from evaluations so that more agents can learn from them. In this context, seminars have been organised with private companies such as development consulting firms to share lessons learnt in the form of case studies. In order to promote information dissemination to the public, an online brochure was developed in addition to the annual reports (JICA Evaluation Committee, 2017[75]).

Programme impacts

Impact assessment is not performed to the programme as a whole, but for each individual project. For example, the project Water Conservation in the Nile Basin, had the objective of solving water shortage problems in Egypt through efficient irrigation, appropriate crop cultivation for local conditions, and reuse of water. The project identified two promising irrigation methods (applying drip irrigation and strip irrigation) that are expected to save up to 20% to 30% of the water for irrigation in the Nile Delta. This amounts to 10 billion tons per year (equivalent to 6.5 times the entire volume of water supply in the entire Metropolitan area of Tokyo).

More information

Website of the S&T Research Partnership for Sustainable Development (SATREPS): https://www.jst.go.jp/global/english/

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4. Smart city policy initiatives

4.1. City of Tomorrow, Austria

Summary

- **Short description:** Grants to R&D projects, on average of EUR 408 000 per project for the period of 1 year, that promote digitalisation and innovation for green cities, exploring synergies between infrastructure and urban energy systems (City of Tomorrow, 2010[76]) (Bockstefl, 2014, p. slide 7[77]) (BMVIT, 2013, p. 33[78]).
- **Period**: 2013 – present.
- **Target group**: Actors within the 'smart city' community (e.g. universities, firms, partnerships among different actors)
- **Budget size and allocation**: Between 2013 and 2018, the programme has made available EUR 31.3 million for funding (an average of about EUR 6.2 million per year) (City of Tomorrow, 2013[79]). In its first call in 2013, 24 projects were funded.
- **Authority**: Austrian Federal Ministry of Transport, Innovation and Technology.

Country's context regarding innovation policy for sustainable growth

i) Environmental topics on the research and innovation policy agenda

The Austrian Research Technology and Innovation National Strategy ("Becoming an Innovation Leader") was introduced in 2011 with the objective of running until 2020. It addresses topics of societal challenges related with sustainability, and includes climate change and scarce resources as key national priorities for research and innovation efforts (OECD, 2018[3]).

In 2015, environmental R&D accounted for 0.7% of total government budget allocations for R&D (GBOARD), below the OECD average of 1.7% (OECD, 2018[4]).

ii) Overview of environmental conditions

In Austria, greenhouse gas emissions (GHG) stood at 9 200 kilograms per capita in 2016, below the OECD average of 12 000 kilograms. Austria has been decreasing its levels of greenhouse gases (GHG) emissions over the last decade, in line with the OECD average. Its levels of emissions in 2016 were 11.3% below the levels in 2006 (OECD, 2018[5]).

Renewable energy accounted for 30% of total primary energy supply (tpes) in 2016, significantly above the OECD average – at 9.7% of tpes – increased 3.3 percentage points during the same period. Regarding energy intensity, the country used 3.8 tonnes of oil equivalent (toe) per capita in 2016. This is 6.5% below the OECD average (OECD, 2018[6]).

The levels of exposure to PM2.5 were still 8.5% above the OECD average in 2015. Nonetheless, Austria has managed to decrease the mean population exposure to fine particulates (PM2.5) by 11.1% between 2005 and 2015, while the OECD average decreased by 3.1% in the same period (OECD, 2018[24]).

iii) Environmental innovation

In 2016, Austria remained above the OECD average in terms of proportion of environmental patents in overall patents. However, between 2002-05 and 2012-15, its revealed technology advantage in environment-related technologies (calculated as the share of environmental patents in Austria relative to the share of total patents belonging to Austria) decreased by 14.3%.

Goal and sustainability challenge addressed

The main objective of the programme is to develop and scale intelligent energy solutions for urban buildings on a building- as well as a district-level. In particular, City of Tomorrow aims to:

- Support resilient cities and districts with high resource and energy efficiency, an increased use of renewable energy production and a high quality of life;
- Optimise and adapt urban infrastructures in light of ongoing urbanisation and the associated increase in resources and energy;
- Develop and secure both the technological leadership and the international competitiveness of Austrian companies and research institutions.

City of tomorrow is organised in annual calls for tenders that set alternative priorities (City of Tomorrow, 2018[80]).

The first tender was launched in autumn 2013, prepared by a broad public consultation process in the summer. The following thematic research and development topics were addressed:

- System design and urban services;
- Solutions for the built infrastructure;
- Technologies for urban energy systems.

The second call for projects took place over the period of September 2014 to January 2015, and included the following topics:

- Energy spatial planning and design;
- Innovative business models/Smart services;
- Technology development for building optimisation and modernisation;
- Demonstration projects;
- Technologies for urban energy systems.

Based on the results of an open public consultation process in summer 2015, the third call for projects addressed the following topics:

- Energy spatial planning and design;
- Technology development for building optimisation and modernization;
- Demonstration projects at district level;
- Technologies and services for urban energy systems;

- Strategic questions and crazy ideas.

The fourth call for projects was launched in autumn 2016 and addressed new thematic fields like digitalization and innovations for green cities (City of Tomorrow, 2018[80]).

Target group

The tenders are open to all type of actors within the "Smart City" community, including businesses, universities, as well as partnerships between different types of agents (City of Tomorrow, 2018[80]).

Policy instrument(s)

The programme provides grants for R&D projects.

Selection criteria

Projects are selected on the basis of providing technological solutions that use renewable energy production and optimise urban energy systems. Preference is given to projects that can be scaled-up and transferred to other urban areas and to projects that are affordable and improve welfare (City of Tomorrow, 2018[80]).

An international jury evaluates submissions, which are chosen according to the Relevance of the project in relation to the call, the quality of the project, the suitability of applicants/project participants and the scientific/ economic potential of the project (BMVIT, 2013, p. 35[78]).

Programme impacts

Not available in English for the whole organisation. As an example of impact generated by one of its funded projects, the urban pv+geotherm project combined heat pumps (tapping into geothermal energy) with photovoltaics and other ways of exploiting renewables to heat and cool an urban development area. The objective was to maximize energy efficiency and cost-effectiveness using pioneering storage technologies and building frameworks. An ecological audit was carried out to determine the levels of emitted CO2 and energy consumption. In comparison with a system running on natural gas, the project could save 47 GWh of fossil primary energy and 9 500 tons of emitted CO2 per year. The savings from lower CO2 emissions involves a cost increase of EURO 580 000 per year as against conventional natural-gas heating, so the energy grid plus photovoltaic thermal collectors involve unit avoidance costs of around Euro 60 per ton of CO2 (BMVIT, 2016, p. 12[81]).

More information

Website of the City of Tomorrow programme: https://nachhaltigwirtschaften.at/en/sdz/

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4.2. Future Cities Catapult, United Kingdom

Summary

- **Brief description**: Organisation that provides relevant expertise, facilities and opportunities for collaboration, as well as opportunities for testing ideas and business models.
- **Period**: 2013 – present.
- **Target group:** Organisations (including universities, firms, local authorities) working in the fields of urban innovation and smart cities.
- **Budget size and allocation**: N.A.
- **Authority in charge**: Receives core public funding from Innovate UK, which is the public agency supporting business innovation in the UK. It is part of UK Research and Innovation, a non-departmental public body funded by a grant-in-aid from the UK government.

Country's context regarding innovation policy for sustainable growth

i) Environmental topics on the research and innovation policy agenda

The UK's main Science, Technology and Innovation strategy was introduced in 2014 and named "Our Plan for Growth: Science and Innovation". Among eight strategic areas, the plan includes a focus on "Big data and energy-efficient computing", and "Energy and its storage". Moreover, the "Smart Specialisation Strategy for England" plan set in 2015 specifies 10 strategic areas of specialisation, including "Offshore wind" (OECD, 2018[3]).

In 2015, 2.2% of total government budget allocations for R&D (GBAORD) were allocated to environmental research, above the OECD average of 1.7%.

ii) Overview of environmental conditions

Greenhouse gas (GHG) emissions per capita stood at 7 400 kilograms in 2016. The United Kingdom reduced its levels of greenhouse gases (GHG) emissions by 29.5% between 2006 and 2016, while the OECD average decreased by 7.7% (OECD, 2018[5]).

In 2016, renewable energy accounted for 8.2% of total primary energy supply (tpes), while the OECD average was 9.7% of tpes. Between 2006 and 2016, renewable energy as share of tpes increased by 6.3 percentage points, while the OECD average increased by 3.3 percentage points. Energy intensity as measured in tonnes of oil equivalent (toe) stood at 2.7 toe per capita in 2016, while the OECD average was 4.1 toe per capita. Levels of energy intensity decreased by 25% between 2006 and 2016 (OECD, 2018[6]).

In 2015, the levels of exposure to PM2.5 were 10.7 micrograms per cubic metre, 26.2% below the OECD average. Air quality in the UK has been also improving. The mean population exposure to fine particulates (PM2.5) decreased by 13.1% between 2005 and 2015, while the OECD average decreased by 3.1% (OECD, 2018[24]). Water consumption in England and Wales, measured in gross abstractions per capita in 2013, was 83.1% below the OECD average (OECD, 2018[7]).

iii) Environmental innovation

The number of environmental technologies as share of total inventions was of 12% in 2016 in comparison with an OECD average of 11.5% (OECD, 2017[61]). Between 2002-05 and 2012-15, its revealed technology advantage in environment-related technologies increased 18.1%, calculated as the share of environmental patents in the UK relative to the share of total patents belonging to the UK. In 2012-15, this metric had the value of 1.2, while the OECD average was 1.1 (OECD, 2017[8]).

Goal and sustainability challenge addressed

By bringing together architects, engineers, designers, academics and business professionals, the organisation aims to help transform cities on a global scale strengthening the UK's ability to turn excellent urban innovations into commercial reality. Examples of projects in the area of sustainability are clean air technologies and electric vehicles.

Target group

Primarily, Future Cities Catapult works with universities, large businesses, SMEs and city authorities. However, the organisations claims to be open-minded and always interested in working with anyone who is passionate about urban innovation (Future Cities Catapult, 2018[82]). The organisation's target group will largely depend on the type of project being undertaken.

Policy instrument(s)

Future Cities Catapult provides relevant expertise, facilities and opportunities for collaborations. It is based in the Urban Innovation Centre in London – a collaborative hub for organisations working in urban development and smart cities. The Centre is designed to bring together companies and individuals at the forefront of their fields and give them space to collaborate.

The organisation is not a funding agency and does not offer grants, loans or other direct financial support (Future Cities Catapult, 2018[83]). As part of its SME support, however, they can provide advice about raising private finance, help identifying the best grant-funding sources, or potentially collaborating on larger bid applications.

The organisation provides the following core services:

- Urban strategies: Understanding trends, technologies and what cities and business can learn from them;
- Insights and service design: Making products and services work better for cities and their citizens;
- Market development: Quantifying economic impact and assessing markets to make city ideas profitable;
- Prototyping: Development of early working versions of products and services, with a focus on user experience and interface design;
- Urban analytics: Analysis, visualization and modelling for evidence-based urban strategies and innovation;

- Performance in use: In partnership with leading UK and US universities, the organisation has developed the Performance in Use (PIU) toolkit – a practical guide for conducting impact assessment for urban innovation projects;
- City standards: Developing new standards for urban innovation to help the market grow;
- Convening and dissemination: Bringing together expertise and knowledge, sharing insights and best practice.

The organisation has about 114 employees (Linkedin - Future Cities Catapult, 2018[84]). Its core public funding comes from Innovate UK, but in the long term, it plans to match this funding with extra contributions from both competitively won collaborative research and development grants and privately-funded business contracts (Future Cities Catapult, 2018[82]). The main operational models for these extra contributions are the following (Future Cities Catapult, 2018[85]):

- Contract R&D bid collaborations: Future Cities Catapult frequently apply for large collaborative Research & Development contracts and are always looking for suitable partners to collaborate with;
- Commercial opportunities: their work often requires highly specialised expertise — from data science and economics, to prototype development and user-centred design. This requires partnering with SMEs from around the UK;
- Open calls: Many funding streams require undertaking formal open calls, which adhere to EU funding guidelines for procuring the services of companies to undertake work. The organisation guides partners through the process making it clear and easy for them;
- Challenges: When not required to perform a formal open call, Future Cities Catapult uses a similar framework to run what is called Challenges. Challenges are a competitive process which moves faster than open calls, allowing to select the most suitable candidates for a specific piece of work at greater speed;
- Hackathons: An urban hackathon is a collaborative sprint-like design event where teams work intensively for a short period (24-48 hours) on specific challenges, set by cities or companies. Outcomes include proof of concepts that can be further developed into prototypes.
- Testing opportunities: For those SMEs not collaborating with the organisation on specific projects, there are opportunities available to use the Urban Innovation Centre to test products and services;

Selection criteria

The selection criteria will depend on the type of call for collaborative projects, or service being provided.

In order to join the co-working space at the Urban Innovation Centre, applicants need to have or be developing products or services related to urban innovation and its development must result in an improved quality of life in cities. Accelerators and incubators that work closely with urban start-ups and SMEs are also eligible (Future Cities Catapult, 2018[86]).

Procedures

Calls for collaborating with Future Cities Catapult are regularly posted online. The projects the organisation works on are multi-disciplinary and vary in size, requiring expertise from numerous organisations. Interested organisations can collaborate with Future Cities Catapult on a project from its outset, or undertake a discrete piece of work as contractors (Future Cities Catapult, 2018[85]).

Apart from that, interested parties are invited to join the organisation's events and workshops, or participate in a "drop in session", in the case of start-ups and SMEs, to learn about potential services. Future Cities Catapult also provides a co-working space at the Urban Innovation Centre in London (Future Cities Catapult, 2018[86]) (Future Cities Catapult, 2018[87]).

More information

Website of the Future Cities Catapult: https://futurecities.catapult.org.uk/

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[1] Information is based on the OECD Database on Governance of Public Research (database), https://stip.oecd.org/resgov/ (accessed 03 October 2018).

[2] Fine particulates (PM2.5) refer to suspended particulates smaller than 2.5 microns in diameter that are capable of penetrating very deep into the respiratory tract and causing severe health effects. They are potentially more toxic than small particulates (PM10) and may include heavy metals and toxic organic substances. The indicator is expressed as the average annual exposure levels of an average resident in micrograms per m^3.

[3] Freshwater resources are of major environmental, economic and social importance. Freshwater abstractions (particularly for public water supply, irrigation, industrial processes and cooling of electric power plants) exert a major pressure on water resources, with significant implications for their quantity and quality.

[4] Environmental technologies include technologies for waste treatment; conservation, irrigation, distribution, and storage of water; renewable energy; enabling technologies (i.e. energy storage, batteries, thermal storage, fuel cells, and smart grids); CO2 capture and storage technologies; and transportation technologies (e.g. electric vehicles, hybrid vehicles).

[5] Own calculations based on Mistra's allocations to all ongoing projects.

[6] Calculated as the share of environmental patents in Australia relative to the share of total patents belonging to Australia.