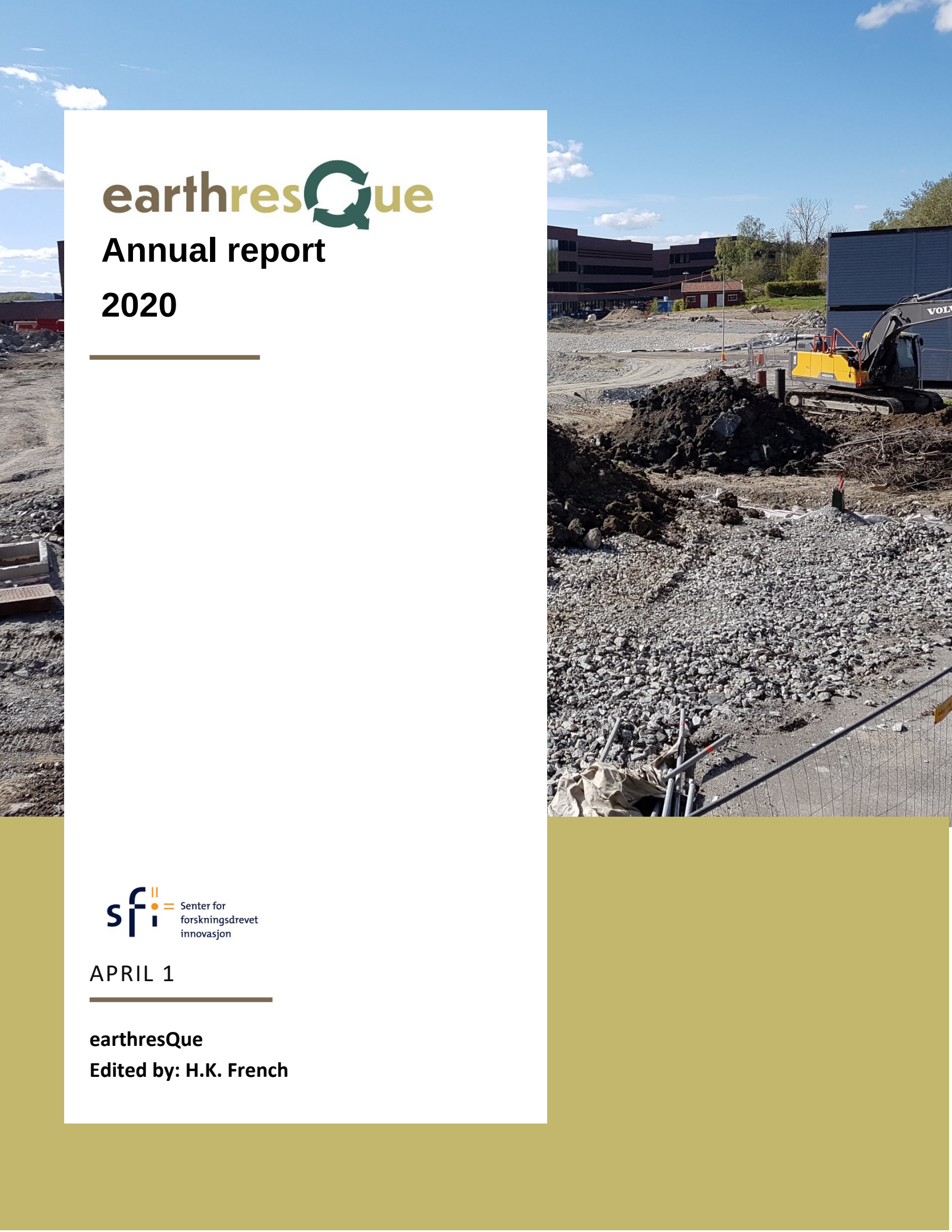




earthresQue

Annual report

2020

sfi = Senter for
forskningsdrevet
innovasjon

APRIL 1

earthresQue

Edited by: H.K. French

Annual report

earthresQue report no.1

ISBN: 978-82-575-1825-7

RCN project 310042

earthresQue, Rescue of earth materials and wastes in the circular economy, is a Centre for Research-based Innovation

Contents

Summary	4
Vision and objectives	5
Research plan and strategy	6
Organisation.....	8
Organisational structure	8
Partners.....	12
Research partners	13
Industrial partners.....	14
Partners from the public sector	14
Cooperation between the centre's partners.....	14
Scientific activities and results	15
International cooperation	15
Recruitment	16
Communication and dissemination activities	17
Appendices.....	18
A1 Personnel	18
A2 Accounts	19
A3 Publications.....	19

Summary

This is the 2020 Annual Report of SFI earthresQue, which started 01.11.2020. Rescue of earth materials and wastes in the circular economy, earthresQue, is a Centre for Research-based Innovation (SFI) financed by the Research Council of Norway (RCN) and the consortium partners. The SFI status enables long-term research in close collaboration partners from the private and public sectors, and research partners aiming to strengthen Norway's innovation capabilities and competitiveness within the sector handling surplus masses and wastes. The background for the centre is the current waste of valuable earth materials and the filling up of existing landfills. Current lack of appropriate technologies, markets for recycled earth materials, sustainability certificates and efficient regulative systems requires research and innovation. The Centre will strengthen companies' innovation capacity through long-term research geared towards solving these challenges.

The host institution for SFI earthresQue is the Norwegian University of Life Sciences (NMBU). The other research partners are the Norwegian Geotechnical Institute (NGI), the Norwegian Institute for Sustainability Research (NORSUS), the Norwegian Business School (BI), Institute for Energy Technology (IFE), Norwegian Institute of Bioeconomy Research (NIBIO), Norwegian Institute for Water Research (NIVA) and Norwegian Institute for Air Research (NILU). The user partners comprise both public authorities and private industry, representing all geographic regions of Norway. The centre aims to streamline and improve the circularity and sustainability of value chains from the governance level of existing legacy sites, mass handling plans at building and construction sites and resource use by waste and re-cycling management. This will allow different types of resources which at present to a low extent are reused or recycled, to re-enter the value chain and protect society through safe disposal of hazardous wastes. The user partners have been strongly involved in the definition of the knowledge needs.

The main activities in 2020 were to set-up an organisation to handle communication with and involvement by partners, create platforms for sharing documentation and make detailed research plans for the first year of the project in close collaboration with user partners. A digital kick-off seminar was organized in December, and plans were made for the first workshop held in January 2021. Social platforms to share information and announcements from the centre were established on LinkedIn, Twitter and Facebook in 2020. Preparations of design, logo and an official webpage started in 2020, for publication in early 2021: www.earthresQue.no (Norwegian) and www.earthresQue.com (English)

Vision and objectives

“The ambition of the Centre is to become the nationally leading and internationally renowned research and innovation centre for sustainable use of waste earth materials.”

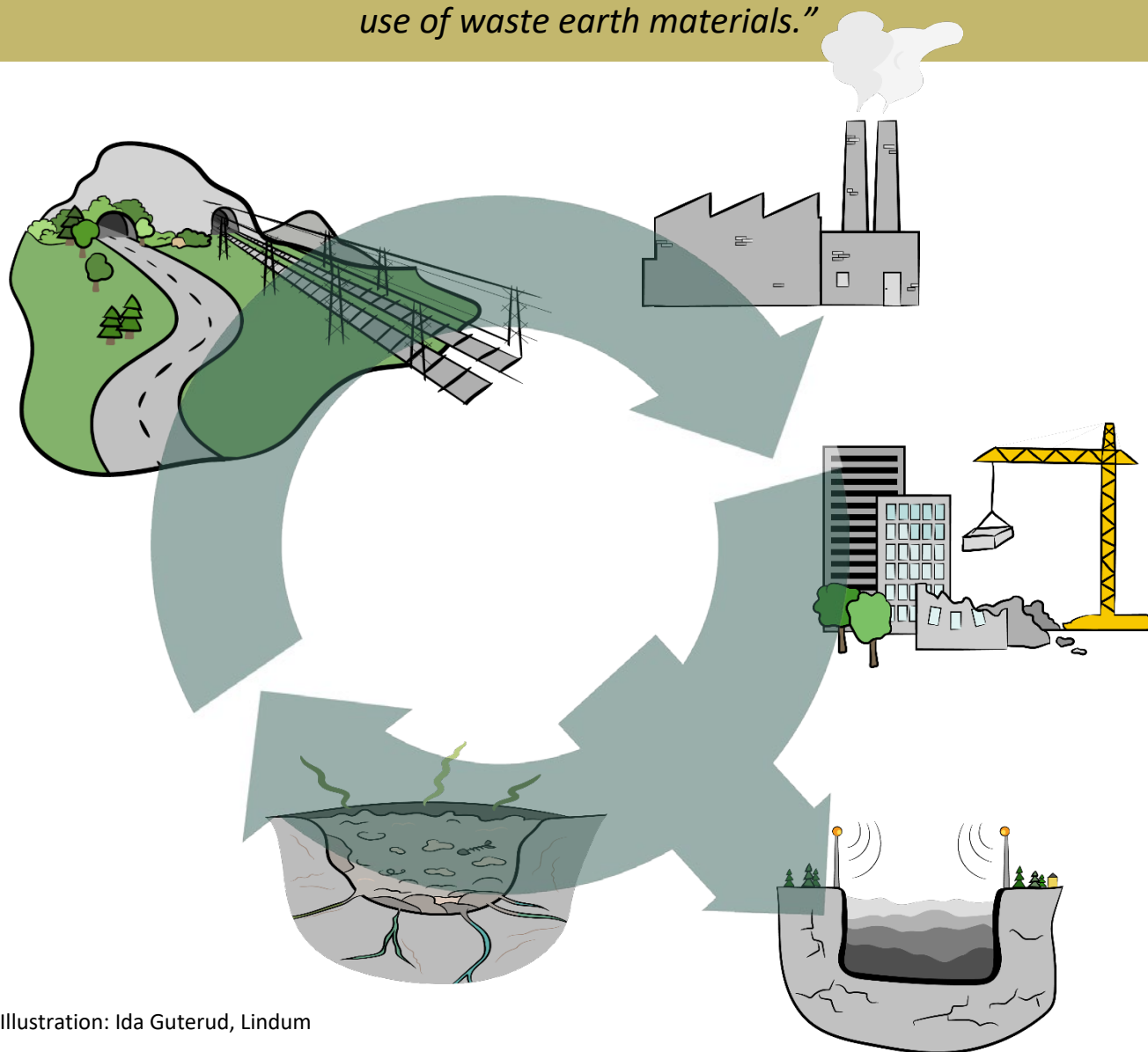


Illustration: Ida Guterud, Lindum

Figure 1. Earth materials and wastes in the circular economy, topics of the earthresQue SFI.

The primary objective is to develop technologies, systems innovation, and a governance framework for the most sustainable management and treatment of wastes and earth materials, building on science-based education and information.

Secondary objectives:

- **Recycling and reuse** through new treatment processes for contaminated soils, surplus masses, C&D wastes, making them suitable as raw materials in new products. Including management of old landfill sites and sustainable solutions for future landfills.
- **Sustainable management, reuse, and recycling of waste materials** by developing methodologies and models to assess and document sustainability, including all aspects of environmental, social and economic aspects of recycled materials and treatment methods, based on internationally accepted standards.
- **Regulatory framework and governance methodology** to remove current obstacles, both in economic, regulatory, and governance terms. This includes optimised material flow and business concepts to encompass society's need for more reuse/recycling and less use of virgin earth materials.

Research plan and strategy

The research strategy is to focus on the most relevant needs for research and innovation through close communication with the user partners. The user partners have been strongly involved in the definition and outline of the knowledge needs starting with the work related to the proposal to detailing the research plans for the short and long term. Solutions to many of the challenges mentioned are expected to lead to innovations and patented solutions. The research will also be incorporated into the educational programs at NMBU and BI to ensure a competent workforce.

Innovations in earthresQue will come in three main forms, all contributing to more sustainable innovations and a more circular society:

- Substitution innovations: replacing existing methods and technologies with new technologies.
- Efficiency innovations: improving technologies and methodologies to improve their results and outcome.
- Market-creating innovations: The latter form embraces new configurations

The user partners of earthresQue identified the following key waste fractions, generated by their activities, and in dialogue with researchers among the consortium partners their associated research aims were outlined which will be the focus of the centre:

- ***Contaminated soils:*** i) reduce transport (cost and distance) ii) reduce costs for soil disposal and purchase of natural aggregates, iii) preserve landfill space, vi) conserve mined natural aggregate resources and reduce environmental and ecological impacts.
- ***Tunnel boring machine material, TBM:*** reduce volumes of full-face tunnel boring machines from larger tunnelling projects to waste sites.
- ***Soft clays, lime-cement stabilized clays and dredged sediments:*** reduce surplus masses from both building and construction (B&C) and harbour dredging disposal to landfills.
- ***Construction & Demolition wastes:*** develop treatment methods for e.g. concrete, in order to re-use wastes in construction materials.
- ***Acid drainage producing bedrock,*** these are a challenge in geologic regions with sulphide containing gneiss (Lillesand region) and black shale (Oslo region): develop novel methods for testing and treatment to mitigate oxidation both on-site (road construction) in in-situ stabilization at landfills.
- ***Ashes from bioenergy plants and bottom ashes from municipal solid waste incineration:*** develop novel methods for utilising ashes as a secondary resource.
- ***Old landfill sites and emissions:*** improve technologies towards obtaining 100% collection and utilization of methane from landfills and reduce pollutants and current risks associated with land fill leachate.
- ***Landfill mining (LM):*** develop methods to, and analyse cost-benefits of, reclaiming old landfills e.g.: remove contaminants, spatial development, recycle materials, extract energy carriers, or reduce costs for aftercare.
- ***New landfills:*** develop safe storage, and control for potential re-use, of toxic compounds and critical waste fractions. Develop methods to keep them out of the recycling loop until safe technology may become available in future.



ill. photo: H.K. French, Nes miljøpark, AF Decom

An important part of the work in 2020 was to create detailed plans for the research to be carried out in 2021 and the next few years ahead. The plans were worked out from the tasks described in the proposal, but some activities were adjusted to include recent development projects/activities and focus among the user partners. Close dialogue between research and user partners resulted in some modifications of specific tasks and their organisation. One example is the introduction of nature restoration of reclaimed/closed landfill areas. For each task objectives, innovative aspects and work plans and expected deliverables were detailed. Most of the activities and recruitment processes will start in 2021.

Organisation

Organisational structure

The Centre administration is located at the Norwegian University of Life Science, Faculty of Environmental Science and Natural Resource Management. The centre is led by Centre Director Professor Helen K. French together with Vice-Director Gudny Okkenhaug and administrative manager Ivan Dragicevic. The overall outline of the centre organisation is shown in Figure 2.

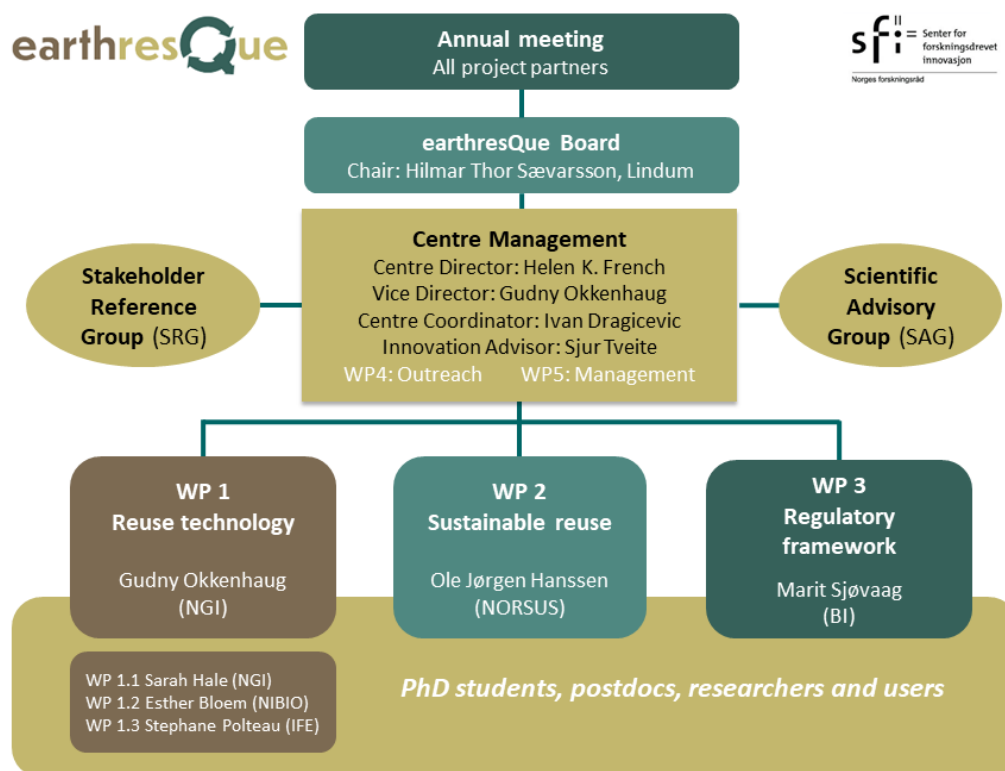


Figure 2. earthresQue organisation.

The Centre Board is the ultimate decision-making body of earthresQue SFI. The majority of its members, including the chairman, are representatives from the private and public user partners. The Board was constituted in December 2020 and consists of the following 9 members representing major users, the host institution, and the research institutions with WP leadership:

earthresQue Board members:

Hilmar Thor Sævarsson, chairman (Lindum AS), Hans Fredrik Hoen (NMBU), Guro Grøneng (NGI), Thomas Hoholm (BI), Hanne Lerche Raadal (NORSUS), Thomas Henriksen (AF Decom), Andreas Olaus Harstad (Skanska), Magnus Sparrevik (Forsvarsbygg), Lise Reinertsen (Bergen kommune), *Observing member* Lenka Hannevold, seniorrådgiver, The Research Council of Norway.

The board meets four times a year while the centre management meets with the Board leader every month for informal updates.



The centre management is supported by the Stakeholder Reference Group (SRG) representing the stakeholder community and the Scientific Advisory group (SAG), described under International cooperation. SRG will help the Centre reach a larger group of relevant stakeholders and implement results into relevant organizations and governance units.

Stakeholder Reference Group (SRG) members:

Gunnar Grini, from the Federation of Norwegian Industries. Jonas Vevatne, nye Asker kommune. He was previously the Norwegian government's key advisor in construction and property affairs (Statsbygg), building commissioner, property manager and property developer. Gry Dahl, BANENOR, the Norwegian government agency owning and responsible for maintaining and operating the Norwegian railway network. Lene S. Heier, the Norwegian public road administration. Cecilie Lind Norwegian Waste Management and Recycling Association. Eli Mathisen, the Environment Directorate responsible for regulations and control mechanisms for contaminated masses and land fill sites and Olaf Brastad, Bellona, a NGO implementing sustainable environmental solutions.

Research carried out in earthresQue is organized into five work packages which are connected through tiers of activities illustrated in Figure 3. Workpackage (WP) 1 Reuse

technology consists of 3 sub-work packages that are strongly linked and require close collaboration dealing with recycling and reuse of earth materials and waste (WP1.1), better designs and monitoring of old landfills (WP1.2) and new landfills (WP1.3). Most of the private user partners operate at tier 1 but are strongly dependent on the regulatory framework, while our public user partners operate at the regulatory level but manage tier 1 challenges and solutions. The success of new technology developed in WP1 is strongly dependent on the assessment of sustainability of reuse and recycling technologies and practise (WP2) and the regulatory framework (WP3), hence the work tasks require an iterative approach. The activities in WP 1 will closely integrated with WP2 (Sustainable reuse) and WP3 (regulatory framework), where WP2 and 3 will give input to the work in WP1 from idea generation to new solutions have been developed and tested. Work in the WPs is driven by the research and innovation needs highlighted by the user partners and supporting the dissemination activities (WP4). The management activities (WP5) will encompass all WP activities and partners involved.

WP5: Management

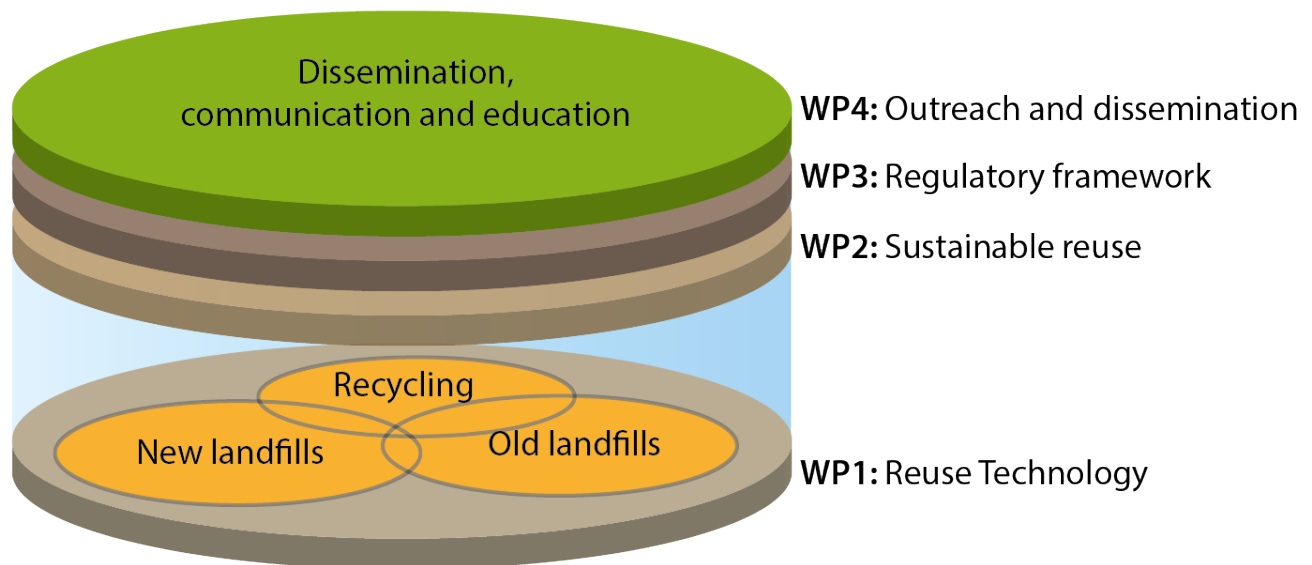


Figure 3. Tiers of workpackages and their interactions.

As the centre leader, NMBU takes the responsibility of the management and dissemination activities of the project, while the research WPs are coordinated by members of the research partners. An overview of lead research scientist of each WP or Sub-WP is given in Table 1. Their background is described further in the Appendices.

Table 1. Main contact person for the work packages.

Work package	Responsible contact	Institution
WP1 Reuse technology	Gudny Okkenhaug	NGI
WP1.1. Recycling and reuse	Sarah Hale	NGI
WP1.2. Old landfills	Esther Bloem	NIBIO
WP1.3. New landfills	Stephane Polteau	IFE
WP2 Sustainable reuse	Ole Jørgen Hanssen	NORSUS
WP3 Regulatory framework	Marit Sjøvaag	BI
WP4 Dissemination and outreach	Helen French	NMBU
WP5 Management	Ivan Dragicevic	NMBU

An informal *Research Forum* will be established for exchange of results and discussion among PhD students, post-docs, researchers and users that are directly linked to research activities through their facilities, e.g. old landfills, instalment of new steps in reuse/cycling treatment plants. A strong link will be established with existing and new Master programs, and other educational components of the centre's activities.

The Centre will have several interlinked field and laboratory activities and the WP leaders will be responsible for the coordination of these. The WP leaders will evaluate yearly work-plans and progress based on submitted tasks and progress reports as defined by the proposal. Periodic reports will contain information about work progress, use of resources, any discrepancies in the work schedule and results. NMBU in collaboration with the research partners will organise annual partner meetings.

Partners

Our user partners range from municipalities and entrepreneurs to small start-up companies and business clusters, geographically distributed over all of Norway (Fig. 4). They represent an enthusiastic group which combined with our scientific partners creates an inspiring working environment. Close collaboration between the different groups is a prerequisite for understanding the challenges of the industry and society which in turn nurtures creative research and innovation.



Figure 4. Geographical distribution of earthresQue user partners.

Research partners

BI - Norwegian Business School, IFE - Institute for Energy Technology, NGI - the Norwegian Geotechnical Institute, NORSUS - Norwegian Institute for Sustainability Research, NIBIO - Norwegian Institute of Bioeconomy Research, NILU - Norwegian Institute for Air Research, NIVA - Norwegian Institute for Water Research and NMBU - Norwegian University of Life Sciences as centre coordinator.

Industrial partners

AF Decom, Borg havn, Borregaard, Eyde-klyngen, Frevar, Kronos Titan, Lindum, Mivanor/Iris, Innherred renovasjon, NCCE, NOAH, Perpetuum, Scandi Energy, Skanska, Stena Recycling

Partners from the public sector

Bergen municipality, Forsvarsbygg / The Norwegian Defence Estates Agency, Fredrikstad municipality, Lillestrøm municipality, Oslo municipality, Rogaland county, Skien municipality, Viken county and Ås municipality.



Cooperation between the centre's partners

Collaboration between several of the partners of the project existed prior to the establishment of this project, between research partners, user partners and between researchers and user partners. Examples are collaboration on how to handle, and risks associated with, black shale in infrastructure projects with collaboration between Skanska and NMBU. Specific research activities were started prior to the official start

date on November 1st 2020 and will lead to a Master's thesis in 2021. Other collaboration examples are those between Lindum and Stena recycling on the handling of bottom ash. Collaboration between Mivanor and NIBIO on treatment of land fill leachate.

In the run up prior to project start-up, all partners were invited to signal their involvement in case sites, pilot studies and work with specific materials. In addition, smaller meetings were organised to further specify interests and give ideas to relevant research questions, methods to be applied and where such studies could be conducted. It was also important to map which topics were ready to start which would thus affect the recruitment process of PhD candidates and which topics needed further scoping.

Scientific activities and results

Although the main work in the two start-up months in 2020 was to set-up the organisation, there were some scientific activities in 2020. Initial visits to user partner's sites were organised in smaller groups during the fall of 2020: Skanska's road construction project through black shale at Jevnaker, AF Decom's washing plant for contaminated soil at Nes treatment park, and a tour of Brånåsen (closed landfill site at Lillestrøm). These visits helped scope and further detail research to be conducted in earthresQue. With the various levels of covid-19 restrictions, these visits were useful to get to know each other and see the sites that inspired the work plans.

Two MSc students at NMBU started up their work on earthresQue topics in 2020, one working on black shales and one on landfill leachate. In addition, several PhD students funded through partners will be linked to earthresQue (an overview is given in the Appendices). Example of topics these students are working on are: methane gas release from Brånåsen and methods for immobilising PFAS in contaminated soils.

International cooperation

International collaboration is important to ensure state of the art knowledge is brought into the centre, but also to make the centre well known internationally. This will be done through student and staff exchanges, stays abroad and recruitment of international scientists. To strengthen the connection of earthresQue SFI with international scientific

community a Scientific Advisory Group (SAG) has been established. Members of this group are internationally recognised experts within their areas.

Scientific Advisory Group (SAG) members:

- Dr. Thomas Pabst, Polytechnique Montreal, Canada (Hydrogeology and mine-tailings)
- Dr. Christian Maurice, Luleå University of Technology, Sweden (Reuse of surplus masses and mineral waste)
- Prof. Anders Damgaard, Danish Technical University, Denmark (Modelling of incineration, landfilling and recycling of household waste)
- Prof. Andrew Binley, Lancaster University, UK (Hydrogeophysics)

The main responsibility of the Scientific advisory group will be to give expert advice to earthresQue by participating in all partners meetings, conferences and other activities where research and innovation plans and main results are being discussed. This group will also help in ensuring that all participating project partners have access to the state-of-the-art knowledge important for achieving designated project goals.

Recruitment

The first new recruitment of earthresQue was to hire an administrative coordinator and Dr. Ivan Dragicevic was employed in December 2020. In addition to organisational skills and experience from research coordination he has a PhD in soil contamination from NMBU in 2018. Two PhD students were recruited to start up in January 2021 (Table 2). See full list of Personnel in the appendices.

Table 2. PhD recruitment started in 2020

Work package	PhD candidate	Period
WP1.1. Recycling and reuse	Cathrine Eckbo, NGI	2021-2023
WP3 Regulatory framework	Olav Bjerke Soldal, BI	2021-2025

Communication and dissemination activities

The main communication from the centre in 2020, was the announcement of the SFI-funding both at NMBU and by the earthresQue partners own pages. In addition, many of the partners presented the centre to their own organisation and at external meetings. Work towards establishing the earthresQue websites was started in 2020 both in Norwegian (www.earthresque.no) and English (www.earthresque.com). Both websites will be used to disseminate activities and results. In addition to the centre's website earthresQue launched LinkedIn and Twitter profiles and a Facebook group to communicate more directly to the project partners and the general public.

In accordance with the project proposal a communication plan that will define how earthresQue will communicate both internally and externally is under development. The communication plan will be approved by the Board in April 2021.

Appendices

A1 Personnel

Key Researchers		
Name	Institution	Main research area
Helen French	NMBU	Hydrogeology, contaminated transport, modelling, hydrogeophysics
Gudny Okkenhaug	NGI	Environmental geotechnics and geochemistry
Sarah Hale	NGI	Remediation of contaminated sediments and soils, pollutant fate
Marit Sjøvaag	BI	Jurisprudence and governance at Center for Sustainability and Energy
Ole Jørgen Hanssen	NORSUS	Industrial ecology and environmentally friendly design, life cycle assessment, sustainability and circular economy
Stephane Polteau	IFE	Geology, fluid migration and de-risking petroleum systems
Esther Bloem	NIBIO	Hydrogeophysics, soil physics, hydrogeology, water and solute transport
Sissel Rannekleiv	NIVA	Environmental chemistry and monitoring water quality
Evert Bouman	NILU	Life cycle assessment and environmental sustainability

PhD students with financial support from the Centre budget				
Name	Nationality	Period	Sex M/F	Topic
Cathrine Eckbo	Norwegian	2021-2023	F	Concrete recycling and methods for re-use.
Olav B. Soldal	Norwegian	2021-2025	M	Regulatory framework and tax regimes for recycling earth materials

PhD students working on projects in the centre with financial support from other sources					
Name	Funding	Nationality	Period	Sex M/F	Topic
Karen Ane Skjennum	Lindum/NRC	Norwegian	2019-2022	F	Stabilisation of PFAS contaminated soil
Christian Alexander Schöpke	IFE	Norwegian & German	2020-2023	M	Methane emission from old landfills

Master's degrees		
Name	Sex M/F	Topic
Tonje Strømø	F	Black shale in road construction and potential leachate
Aud Helene Rosenvinge	F	Contaminated landfill leachate monitoring
Reidar Dahl Rasmussen	M	Leaching of hexavalent chromium from concrete

A2 Accounts

Annual accounts for 2020

Funding (1000 NOK)	Amount	Costs (1000 NOK)	Amount
The Research Council	685		
The Host Institution NMBU	94	NMBU	286
Research Partners*	67	Research Partners	610
Enterprise partners**	495	Enterprise partners	495
Public partners***	144	Public partners	94
		Equipment	
Total sum	1485		1485

* NMBU, NGI, BI, NORSUS, NIBIO, IFE, NIVA, NILU

** AF Decom, Borg havn, Borregaard, Eyde-klyngen, Frevar, Innherred renovasjon, Kronos Titan, Lindum/Lindum Oredalen, Mivanor/Iris, NCCE, NOAH, Perpetuum, Scandi Energy, Skanska, Stena Recycling

*** Bergen kommune, Forsvarsbygg, Fredrikstad kommune, Lillestrøm kommune, Oslo kommune, Rogaland fylkeskommune, Skien kommune, Viken fylkeskommune, Ås kommune

The total budget of SFI earthresQue is 224 mill NOK and all partners have a substantial in-kind contribution to the centre. The financing of earthresQue is based on contributions from the Norwegian research council (NRC), and cash and in-kind contributions from the public, private enterprises NMBU and the research partners.

A3 Publications

Many of the partners have given presentations about the project internally (or with associated partners), there are no reviewed publications the first two months of the project.



ill. photo: H.K. French, old concrete pipes, resources deposited in the wrong place

