
RenewHydro

Partners in RenewHydro

Research partners

NTNU
SINTEF
NHH
NINA
Norwegian Institute for Nature Research

University of South-Eastern Norway
Norges miljø- og biovitenskapelige universitet
NORCE

ETH zürich
LULEÅ TEKNISKA UNIVERSITET
Kathmandu University

User-partners from industry and government

Fornybar Norge
Statkraft
Hafslund
Å ENERGI
Statnett

Sira-Kvina KRAFTSELSKAP
eviny
Hydro
SFE
NVE

Skagerak Energi
Lyse
NTE
TUSSA
MILJØ-DIREKTORATET

Sognekraft
TrønderEnergi®
SKL
TAFJORD
NVKS NORSK VANNKRAFTSENTER

HELGELAND KRAFT
VATTENFALL

ANDRITZ Hydro
VOITH HYDRO POWER GENERATION
Aker Solutions

Norconsult
Multiconsult
SWECO
Enestor
EDR MEDESO

RenewHydro

RenewHydro

Norwegian research centre for renewal of hydropower technology

RenewHydro shall provide knowledge and solutions that enable flexible hydropower to support the energy transition and reach national energy, climate and nature targets

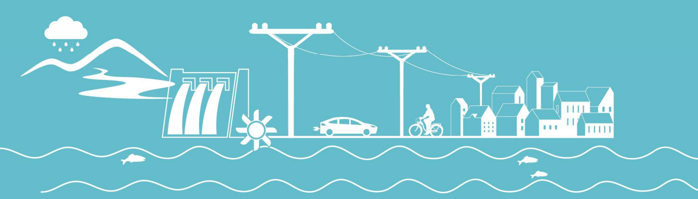
Research partners:

NTNU SINTEF NHH NINA
University of South-Eastern Norway
NORCE
Norges miljø- og biovitenskapelige universitet
ETH zürich
Luleå Tekniska Universitet

Status January 2025
39 partners
8 years (2025 – 2032)
383 mill. NOK
16 active projects
1 associated project
x researchers
36 PhD & Postdoc
Target at >400 MSc
> 3000 m^2 laboratories

Program

Time	Program	Speaker
10:00	Opening and welcome	Liv Randi Hultgreen and Åse Slagtern
10:15	The Research partners introduce themselves	All research partners
11:45	**Lunch**	
12:30	Hydropower in the energy transition – A Norwegian perspective	Asgeir Tomasgard, NTNU
12:45	Hydropower in the energy transition – A European perspective	Robert Boes, ETH Zürich
13:00	RenewHydro – vision, organization and activities	Liv R. Hultgreen
14:00	**Break w/photo session**	
14:30	User partners' research interests in hydropower w/panel discussion	Statkraft, NVE and Multiconsult
15:30	Closing remarks	Liv R. Hultgreen



FME RenewHydro

Norwegian research centre for renewal of hydropower technology

Liv Randi Hultgreen

Executive Director FME RenewHydro

January 14th 2025

NTNU SINTEF NHH NINA RenewHydro

Objective

RenewHydro shall provide knowledge and solutions that enable flexible hydropower to support the energy transition and reach national energy, climate and nature targets.

RenewHydro organization

RenewHydro General Assembly
All partners represented

RenewHydro Executive Board
Chair: Andreas Ulvestad, Statkraft
9 seats; user partner majority

Statkraft: Andreas Ulvestad
Hafslund: Celine Setsaas
Eviny: Toril Christensen
Fornybar Norge: Eivind Heløe
NVE: Kristian Markegård
NTNU: Olav Bolland, Dean at IV-Fac.
SINTEF: Knut Samdal
NINA: Ingeborg Palm-Helland
NHH: Linda Rud

RenewHydro Operation Centre
Centre Coordinator: Berit Garberg Hagen
Communications Leader: Juliet Landrø
Financial Officer: Birk Fiveltun

RenewHydro Management Team
Executive Director: Liv Randi Hultgreen
Leading Scientists: A. Helseth (SINTEF), M. Bjørndal (NHH), O.G. Dahlhaug (NTNU), T. Forseth (NINA)
Research Program Managers

Usercase Advisory group
User partners

Scientific Committee
Lead: NN

Research Programs:

Framework program Perspectives on future frameworks for hydropower
PM: Mette Bjørndal (NHH)

RP1 Future hydropower plants
PM: Jonas Bergmann-Paulsen (NTNU)

RP 2 More power and energy
PM: Linn Emelie Schäffer (SINTEF Energy)

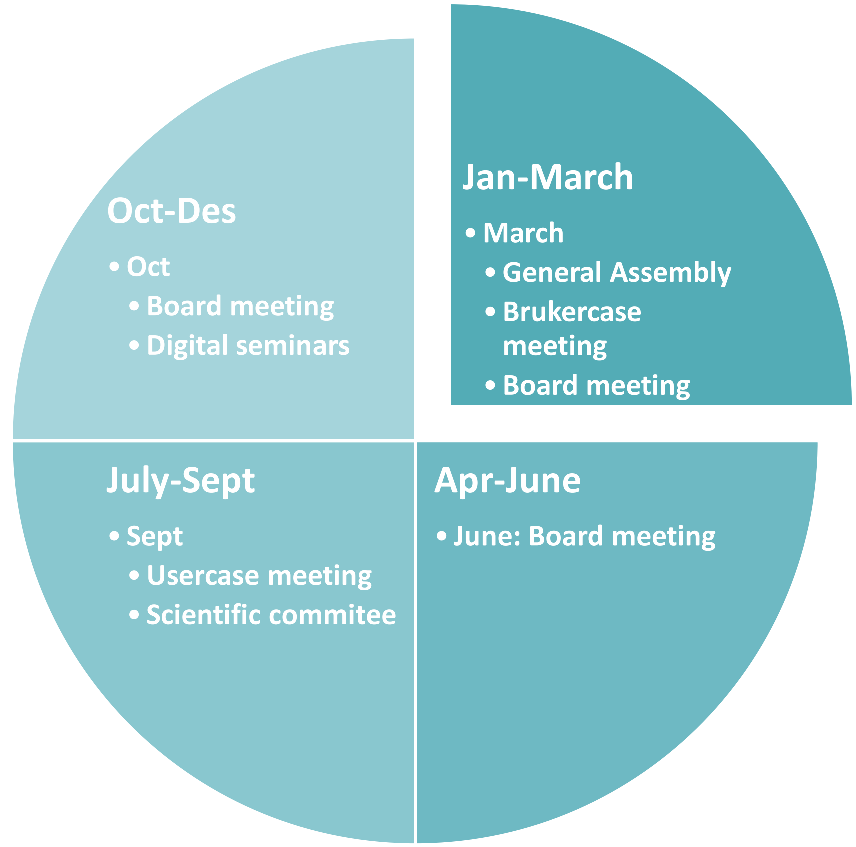
RP 3 Hydropower in a changing climate
PM: Line E. Sundt-Hansen (NINA)

NTNU SINTEF NHH NINA RenewHydro

Organization and meeting points

Governing bodies		Meeting points
General Assembly: 1 repr. per partner		Yearly meeting
RenewHydro Board		3 meetings per year
Executive Director		
Management Team (MT)		Monthly meeting
Perspectives - Framework program		Programs & projects: Monthly meetings
Research Program 1 Research Program 2 Research Program 3	**Usercase committee** **-** innovation & commercialization	
Scientific committee		Yearly meeting

Technical meeting points for all partners	
Center Seminar after General Assembly	Yearly meeting in March
Digital breakfast and/or lunch seminars	Yearly in Sept/Oct
Usercase meetings	In March and September



Research project portfolio

Perspectives
A: Hydropower's role with a large amount of wind and solar power
B: Sustainable development of Norwegian hydropower
C: Development of hydropower in a greatly changed climate

Program Framework conditions from the perspectives
Provide a set of frameworks for technical, economic, climate, and environmental conditions under which hydropower is likely to develop and operate.

Case 1 · Case 2 · Case 3 · Case 4 · Case 5

Research programs

RP1 Future Hydropower Plants
Develop innovative, economically and environmentally sustainable technology for enhanced hydropower flexibility

RP2 More Power and Energy from Hydropower
Explore the potential and designs for sustainable large-scale expansion of Norwegian hydro-power to provide vital flexibility services and security of supply

RP3 Hydropower in a changing climate
Develop innovative solutions and services to adapt, mitigate and enhance hydropower and reservoir capabilities under climate change

Research questions

- RQ1. How can we increase the flexibility of hydropower technology?
- RQ2. How can we maintain and extend the lifetime while increasing the flexibility of hydropower technology?
- RQ3. How can digitalization increase the reliability and reduce the cost of maintenance of hydropower technology?
- RQ4. How can nature-based solutions contribute to the protection of biodiversity and ecosystem function in regulated watercourses?
- RQ5. What is the land use and carbon budget of present and future hydropower developments, and how can restoration and compensation contribute to nature-neutral or positive expansions?
- RQ6. How can environmental effects of hydropeaking be mitigated by operational and physical measures, and can technological solutions be developed to minimize ecosystem changes for pump-storage between reservoirs by preventing the transfer of fish species?
- RQ7. How can nature-based solutions and environmental technology innovations provide new solutions to ensure two-way fish migration in regulated rivers?
- RQ8. How can societal legitimacy of hydropower projects be obtained through a better balance of economic, environmental and social impacts?
- RQ9. How will climate change affect hydropower infrastructures and production and how to develop the role of hydropower in climate adaptation (flood protection) and environmental mitigation?
- RQ10. How will electricity markets and regulations develop under different perspectives about the future?
- RQ11. How should different market designs incentivize provision of flexibility and ancillary services from hydropower?
- RQ12. How can hydropower contribute to security of supply under different market designs and regulatory regimes?
- RQ13. What will characterize operational patterns and revenue streams for hydropower technology in the future power system?

Research questions in the programs

Research questions	FP	RP 1	RP2	RP3
RQ1. How can we increase the flexibility of hydropower technology?		1.1-3	2.1, 2.2	3.1-4
RQ2. How can we maintain and extend the lifetime while increasing the flexibility of hydropower technology?		1.1-4	2.2, 2.3	3.3
RQ3. How can digitalization increase the reliability and reduce the cost of maintenance of hydropower technology?		1.1-4	2.3	3.3
RQ4. How can nature-based solutions contribute to the protection of biodiversity and ecosystem function in regulated watercourses?		1.1	2.1	3.2
RQ5. What is the land use and carbon budget of present and future hydropower developments, and how can restoration and compensation contribute to nature-neutral or positive expansions?	4		2.2	
RQ6. How can environmental effects of hydropeaking be mitigated by operational and physical measures, and can technological solutions be developed to minimize ecosystem changes for pump-storage between reservoirs by preventing the transfer of fish species?		1.1	2.2	

Research questions in the programs

Research questions	FP	RP 1	RP2	RP3
RQ7. How can nature-based solutions and environmental technology innovations provide new solutions to ensure two-way fish migration in regulated rivers?	4	1.1		
RQ8. How can societal legitimacy of hydropower projects be obtained through a better balance of economic, environmental and social impacts?	4			
RQ9. How will climate change affect hydropower infrastructures and production and how to develop the role of hydropower in climate adaptation and environmental mitigation?	5			3.1, 3.2
RQ10. How will electricity markets and regulations develop under different perspectives on the future?	2		2.2, 2.3	
RQ11. How should different market designs incentivize provision of flexibility and ancillary services from hydropower?	1, 2, 3	1.2	2.1, 2.2, 2.4	
RQ12. How can hydropower contribute to security of supply under different market designs and regulatory regimes?	3		2.3	
RQ13. What will characterize operational patterns and revenue streams for hydropower technology in the future power system?	1, 3, 5	1.2	2.1, 2.2, 2.4	3.1, 3.4

Research questions

RQ9. How will climate change affect hydropower infrastructures and production and how to develop the role of hydropower in climate adaptation (flood protection) and environmental mitigation?
FP5, RP3.1-2

Program Framework conditions from the perspectives
Provide a set of frameworks for technical, economic, climate, and environmental conditions under which hydropower is likely to develop and operate.

Research programs

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RP3 Hydropower in a changing climate
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RQ1. How can we increase the flexibility of hydropower technology?
RP1.1-3, RP2.1-2, RP3.1-4

RQ2. How can we maintain and extend the lifetime while increasing the flexibility of hydropower technology?
RP1.1-4, RP2.2-3, RP3.3

RQ3. How can digitalization increase the reliability and reduce the cost of maintenance of hydropower technology?
RP1.1-4, RP2.3, RP3.3

Research questions

RQ11. How should different market designs incentivize provision of flexibility and ancillary services from hydropower? FP1-3, RP1.2, RP2.1, 2.2 and 2.4

Program Framework conditions from the perspectives
Provide a set of frameworks for technical, economic, climate, and environmental conditions under which hydropower is likely to develop and operate.

Research programs

RP1 Future Hydropower Plants
Develop innovative, economically and environmentally sustainable technology for enhanced hydropower flexibility

RP2 More Power and Energy from Hydropower
Explore the potential and designs for sustainable large-scale expansion of Norwegian hydro-power to provide vital flexibility services and security of supply

RP3 Hydropower in a changing climate
Develop innovative solutions and services to adapt, mitigate and enhance hydropower and reservoir capabilities under climate change

RQ10. How will electricity markets and regulations develop under different perspectives about the future? FP2, RP2.2-3

RQ12. How can hydropower contribute to security of supply under different market designs and regulatory regimes? FP3, RP2.3

RQ13. What will characterize operational patterns and revenue streams for hydropower technology in the future power system? FP1, FP3, FP5, RP1.2, RP2.1, 2.2, 2.4, RP3.1 and 3.4

Research questions

RQ8. How can societal legitimacy of hydropower projects be obtained through a better balance of economic, environmental and social impacts? FP4

RQ5. What is the land use and carbon budget of present and future hydropower develop-ments, and how can restoration and compensation contribute to nature-neutral or positive expansions? FP4, RP2.2

Program Framework conditions from the perspectives

Provide a set of frameworks for technical, economic, clim
conditions under which hydropower is likely to develop and operate.

RQ7. How can nature-based solutions and environmental technology innovations provide new solutions to ensure two-way fish migration in regulated rivers? FP4, RP1.1

Research programs

RP1 Future Hydropower Plants
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RP2 More Power and Energy from Hydropower
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RP3 Hydropower in a changing climate
Develop innovative solutions and services to adapt, mitigate and enhance hydropower and reservoir capabilities under climate change

RQ4. How can nature-based solutions contribute to the protection of biodiversity and ecosystem function in regulated watercourses? RP1.1, RP2.1

RQ6. How can environmental effects of hydropeaking be mitigated by operational and physical measures, and can technological solutions be developed to minimize ecosystem changes for pump-storage between reservoirs by preventing the transfer of fish species? RP1.1, RP2.2

Framework Program

Programme	Framework	**Duration**	2025-2032	**Responsible**	NHH	**Program Manager**	Mette Bjørndal
Title	Perspectives on the future frameworks for hydropower						
Objective: Provide a set of frameworks for technical, economic, climate, and environmental conditions under which hydropower is likely to develop and operate.							**Project leaders & *Partners***
FP1 Enabling and competing technologies (2025-2029) Provide insight into the characteristics of future competitors in the markets for energy and power.							**Michael Belsnes**, SINTEF *NHH, USN, SINTEF*
FP2 Market design developments (2025-2032) Understand how different electricity products are traded and priced in the Norwegian and European electricity market and how changes in market design can incentivize flexibility.							**Mette Bjørndal,** NHH *IØT NTNU, NHH, USN, SINTEF*
FP3 Future power price dynamics (2025-2032) Understand the price dynamics in the future European and Norwegian electricity markets.							**Kyriaki Tselika,** NHH *USN, NHH, SINTEF*
FP4 Societal and environmental frameworks (2025-2030): Understand how international agreements, European and national regulations and strategies affect hydropower industry and how insights on societal legitimacy will help design more realistic and acceptable policy and technology solutions.							**Kristin Linnerud**, NMBU *NMBU, NINA, SINTEF*
FP5 Trends in runoff under climate change and effects on hydropower production (2025-2030) Develop inflow scenarios for representative cases based downscaled climate change scenarios and explore implication for hydropower production.							**Øyvind Paasche**, NORCE *NORCE, SINTEF*

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Research Program 1

Programme	RP1	**Duration**	2025-2032	**Responsible**	NTNU	**Program Manager**	Jonas B.-Paulsen
Title	Future Hydropower Plants						

Objective: Develop innovative, economically and environmentally sustainable technology for enhanced hydropower flexibility.	**Project leaders** **& *Partners***
RP1.1 New hydro power plants - design and new construction (2026-2029) Enhance efficiency and performance through advancement of hydro-power technology.	**Kaspar Vereide**, NTNU *NTNU (IBM, EPT, IGP), NORCE, NINA, SINTEF*
RP1.2 Design for intermittent operation and high ramping rates (2025-2031) Improved flexibility and grid integration through technology that can withstand increased stress and fatigue loads on water ways, turbine and generator, and development of control systems.	**Jonas B.-P.**, NTNU *NTNU (IBM, IEL, EPT), USN, NINA, SINTEF*
RP1.3 Holistic monitoring and condition prediction of hydro power plants (2025-2032) Development of methodologies and strategies for optimal planning, flexible operation, predictive maintenance, and mitigation of environmental impact.	**Thomas Øyvang**, USN *IEL NTNU, USN, NINA, SINTEF*
RP1.4 Sediment handling (2025-2028) Development of technical equipment to reduce the impact from sediment erosion.	**Elena Pummer**, NTNU *NTNU (EPT, IBM), KU*

Research Program 2

Programme	RP2	**Duration**	2025-2032	**Responsible**	SINTEF Energi	**Program Manager**	Linn-Emelie Schäffer
Title	More power and energy						

Objective: Explore the potential and designs for sustainable large-scale expansion of Norwegian hydropower to provide vital flexibility services and security of supply.	**Project leaders & *Partners***
RP-2.1 Sustainable flexibility services from hydropower (2025-2028) Develop methods and metrics for quantifying flexibility services from hydropower.	**Linn Emelie,** SINTEF *IBM NTNU, NINA, NORCE, NHH*
RP-2.2 Sustainable upgrading and expansion of the hydropower system (2025-2032) Develop and investigate concepts for increasing capacity and storage from hydropower, incl pumped storage, market designs, and environmental and societally acceptable solutions.	**Tonje Aronsen**, NINA *NTNU (EPT, IEL, IBM), NMBU, NINA, SINTEF*
RP-2.3 Provision of energy security and adequacy from hydropower (2025-2032) Establish a framework for assessing energy security and adequacy from hydropower.	**Stefan Rex**, SINTEF *USN, IEL NTNU, NHH, SINTEF*
RP-2.4 Hydropower resource allocation and markets (2027-2031) Understand how hydropower resource allocation best can adapt to the future.	**Stein-Erik Fleten**, NTNU *NHH, IØT NTNU, SINTEF*

Research Program 3

Programme	RP3	**Duration**	2025-2032	**Responsible**	NINA	**Program Manager**	Line E. Sundt-Hansen
Title	Hydropower in a changing climate						

Objective: Develop innovative solutions and services to adapt, mitigate and enhance hydropower and reservoir capabilities under climate change.	**Project leaders & *Partners***
RP-3.1 Adaptation and opportunities for hydropower due to changed hydrological inflow and seasonality (2025-2029) Demonstrate new management strategies for hydro-power under changed climatic conditions and the new role of hydropower in the energy system (case-based).	**Oddbjørn Bruland**, NTNU *NTNU (IBM, EPT), NORCE, SINTEF*
RP-3.2 The role of hydropower in climate adaption (2025-2031) Develop knowledge and strategies for the role of hydropower with reservoirs in climate adaptation.	**Kim Magnus Bærum**, NINA *IBM NTNU, NMBU, NHH, SINTEF, NINA*
RP-3.3 The impacts of climate change on hydropower infrastructures (2030-2032) Develop criteria, methods and solutions for the operation and maintenance of the hydro-power infrastructure under more frequent, large variations in weather conditions	NN
RP-3.4 Climate change and ecological flows (2027-2030) Utilize changed inflow patterns for ecological flows	**Ana Bustos**, SINTEF *NORCE, NINA, SINTEF*

Explanation to partner abbreviations

- NTNU
  - EPT: Energy and Process Engineering (turbines, pumps, …)
  - IBM: Civil and Environmental Eng. (dam, waterway, tunnel, hydrology, …)
  - IEL: Electric Energy (generators, net, …)
  - IGP: Geoscience
  - IØT: Industrial Economics and Technology Management
- NHH: Norwegian School of Economics
- SINTEF Energy
- NINA: Norwegian Institute for Nature Research
- USN: University of South-Eastern Norway
- NMBU: Norwegian University of Life Sciences
- NORCE: Norwegian Research Centre
- KU: Kathmandu University
- LTU: Luleå Technical University
- ETH Zürich: Eidgenössische Technische Hochschule Zürich

User cases

User cases involving hydropower plants

- Driva Kraftverk (Trønderenergi)
- Litjfossen Kraftverk (Trønderenergi)
- Sira-Kvina vassdraget (Sira Kvina)
  - Environment-friendly extreme reconstruction of the Sira-Kvina system for scenarios with 2000, 5000 og 10 000 MW power- and pumped storage plant
- Gravann pumpekraftverk (Sira Kvina)
  - New pumped storage plant between Sirdalsvann and Gravann
- Tordsvatnet and Tafjordvassdraget (Tafjord)
  - Gentle utilization of resources in protected areas
  - Development of Tafjordvassdraget to maximize value creation
- Holen I og II Kraftverk (Å Energi)
- Two new power plants for intermittent operation (user partner)

User cases – involvement and organization

- Each project can choose 1-2 user cases, within 6 months after start-up
- The program managers will keep an overview on who selects which case
- Every case should have duration 1-3 years
- The user partner will provide a CaseRep who will be point of contact
- We will have a seminar during Autumn 2025 where the researchers work with the cases together with CaseReps
- A user case can have workshop series, and also have shorter and more intensive duration
- Cases will be presented on the yearly center seminars

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RenewHydro website