REPORT

SpareBank 1 Østlandet Green Hydropower portfolio

CLIENT

SpareBank 1 Østlandet

SUBJECT

Hydropower

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REPORT

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1 Introduction

On assignment from SpareBank 1 Østlandet, Multiconsult has assessed the impact of Norwegian hydropower on climate gas emissions. This includes a description of hydropower in general and general comparisons of international hydropower and run-of-river and small-scale hydropower in Norway. The bank's portfolio is assessed regarding power production and the related avoided emission.

2 Loan Portfolio Analysis SpareBank 1 Østlandet

The Green loan portfolio of SpareBank 1 Østlandet consists of hydropower plants that meet the criteria as formulated below.

2.1 Eligible hydropower assets

Eligibility criteria:
Hydropower plants with power density > 5 W/m^2 or emission intensity below 100 gCO_2/kWh are eligible for green bonds.

Multiconsult has investigated a sample of SpareBank 1 Østlandet's portfolio and can confirm that the assets, both planned and in operation, are very likely to have low to negligible GHG-emissions related to construction and operation, and well below a threshold of 100 CO_2e/kWh.

All power produced by power stations in the portfolio are in stations with capacities in the range of 0.03 - 10 MW. About half of the capacity and annual power production originates from run-of-river plants that in all cases shoots well above the 5 W/m^2 power density. The other half are hydropower plants with very small reservoirs and hence very high power density of several thousand W/m^2 (ratio between capacity and impounded area).

Power density is a good indicator of climate gas impact, and density higher than 5 W/m^2 is for the assets in the portfolio considered acceptable without further detailed investigation, as described in section 4.1.

Multiconsult has conducted a brief general assessment of eligibility based on available reports on performance of national hydropower. The assets have not been examined in detail using designated tools (e.g. G-RES) nor assessed against all elements of "do no significant harm" mentioned in ongoing work on an EU taxonomy.

2.2 Availability of data

Data about the assets are available from Norwegian Water Resources and Energy Directorate (NVE) as all assets are subject to licencing. The bank has also provided essential data on the assets and this information is spot checked against the NVE dataset and found to be corresponding. The bank has provided planned production in not yet commissioned plants. The bank has also provided its share of financing to prevent double counting of impact.

3 Hydropower – general description

3.1 Hydropower's position in the Norwegian energy system

Hydropower is the clearly dominant power production solution in Norway and has been for 100 years since the beginning of the industrialisation. Hydropower accounts for about 90% of the national power production in a normal year.

3.2 Licencing

All hydropower developments in Norway are subject to licencing and the Norwegian Water Resources and Energy Directorate (NVE), a directorate under the Ministry of Petroleum and Energy, is responsible for processing applications.

Licenses grants rights to build and run power installations with conditions and rules of operation stated in the licence. The processing of license applications is to ensure that benefits of the proposed project is greater than the disadvantages that follow. NVE puts particular emphasis on preserving the environment.

Licensing procedures differ depending on many variables, with project size and expected impact being the most important. All applications for licenses have to come with a sufficient description of the project's impact on nature etc. This is often done through an environmental impact assessment (EIA).

Smaller energy projects with lesser environmental impacts may be handled through simplified handling procedures. The Norwegian part of the NVE homepage gives detailed information about different requirements for different types of projects[1].

The plants will not be granted a licence or permission to start production until adequate power grid and transformer plants for power evacuation is in place.

4 Climate gas emissions and environmental and social impact

4.1 Climate gas

All human activity affects the environment and the climate in some form, including hydropower production. Over the last 20 years this has been a topic of much discussion and research. Research shows that some hydropower reservoirs can, under unfavourable conditions, contribute with significant greenhouse gas (GHG) emissions, whereas others can act as net GHG sinks. Emissions are mainly related to decomposition of organic matter left in the reservoir before impoundment, as well as decomposition of plant matter growing inside the reservoir during periods of low water level followed by submergence. The lifetime of a reservoir is very long, hence the age of the reservoir impacts the resulting GHG emissions.

The greatest GHG emissions occur when organic matter decomposes in anaerobic conditions, producing methane as a decomposition product instead of carbon dioxide, where methane is a much more potent greenhouse gas. Research has shown that this is primarily a concern for large reservoirs in warmer climates. In colder climates as in Norway, this is less of an issue, among other things due to a much shorter and less intense growing season. The most important factor to consider when assessing a hydropower plant's potential for GHG emissions, is the impounded area. For a typical Norwegian small hydropower plant, the impounded area is a few hundred to some thousand square meters and

[1] https://www.nve.no/konsesjonssaker/konsesjonsbehandling-av-vannkraft/

thus the potential emissions from the reservoir are often negligible. In addition, since the impounded area for a typical small hydropower plant is mostly existing riverbed or existing lakes, the net impounded area with vegetation cover is normally very small.

There are ways to calculate the potential GHG emissions from a reservoir, for example with the G-res tool from the International Hydropower Association (https://www.hydropower.org/gres). It is, however, quite a significant undertaking to do these calculations. The added value of the results is also quite limited for small reservoirs, and the assessment is therefore not as crucial for most small hydropower plants, as they in general have no or small reservoirs. It is however our general view that the typical Norwegian small hydropower plant reservoir has a negligible if any negative impact on GHG emissions, hence a detailed GHG emissions calculation is deemed disproportionate for these small assets.

One of the key outputs from the G-res tool is power density. The power density describes the relation between the installed capacity of the power production and impounded area. Run- of- river facilities have very high power density of several thousand because of no or very small reservoirs. Even larger hydropower stations in Norway with reservoirs, typically have high power density due to high hydraulic head and/or a relatively small impounded area.

In 2017 the International Hydropower Association examined a large number of international hydropower plants with large reservoirs (no run-of-river plants included in the sample). For each plant the power density was calculated and the allocated greenhouse gas emission intensity. Figure 1 illustrates the relationship between power density and GHG emission intensity. In the sample no facilities with power density of >5 W/m^2 have emission intensity above 100 gCO_2e/kWh. Further it illustrates that facilities in colder climates have less emission intensities.

The threshold is in line with the overarching, technology-agnostic emissions threshold of 100 gCO_2e/kWh proposed for electricity generation in the EU Taxonomy.[2]

It is also in line with the Climate Bonds Initiative (CBI) mitigation component of 100 gCO_2e/kWh as presented in their consultation paper.

[2] http://europa.eu/rapid/press-release_IP-19-3034_en.htm

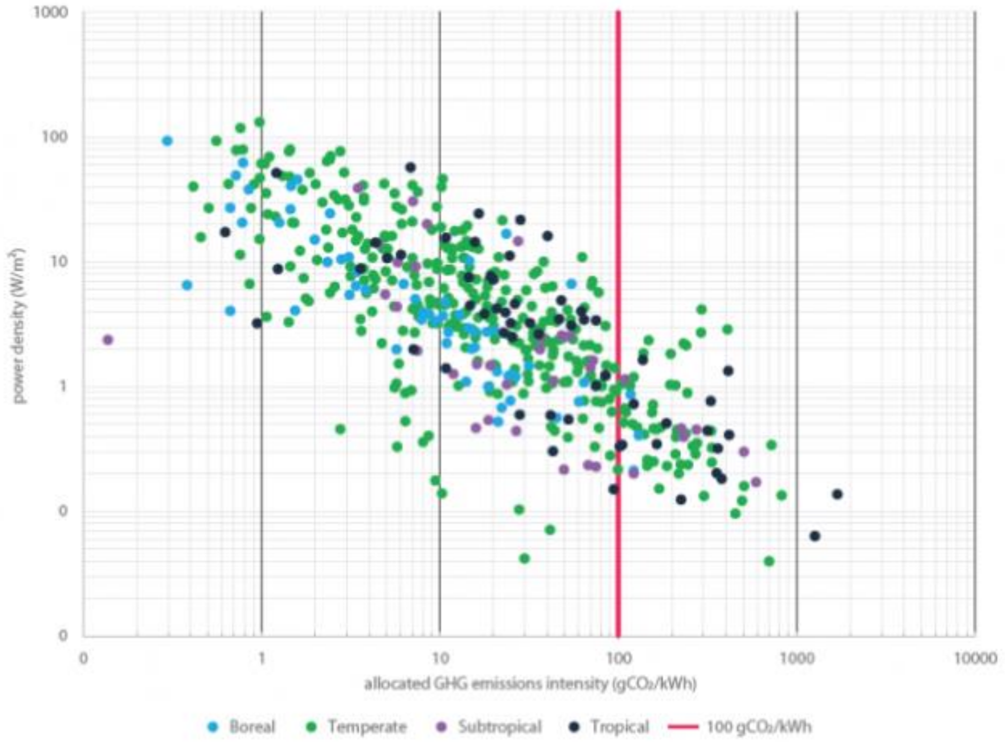

Figure 1 Relationship between GHG emissions intensity and power density of projects in IHA study including only plants with large reservoirs (International Hydropower Association[3])

In addition to reservoir emissions the GHG emission contribution from a hydropower plant is, as for other types of constructions, related to the emissions caused by production and transportation of building materials such as steel and concrete and emissions during the construction process.

The Association of Issuing Bodies (AIB)[4] uses an emission factor of 6 gCO_2e/kWh for all European hydropower in calculations of the European residual mix. The value is based on a life-cycle analysis where all upstream and downstream effects in the whole value chain for power production are included.

The average GHG emission intensity in Norwegian hydropower (all categories) has been calculated, using LCA, to 3.33 gCO_2e/kWh. (Østfoldforskning, 2019[5])

All small hydropower assets with small reservoirs and run-of-river assets in Norway have negligible negative impact on GHG emissions.
Hydropower in Norway with large reservoirs have little, or significantly lower negative impact on GHG emissions than the threshold proposed for electricity generation in the EU Taxonomy, the proposed CBI criteria's mitigation component and the projected European production mix in the assets lifetime of 136 gCO_2e/kWh (see chapter 7).

[3] https://www.hydropower.org/resources/factsheets/greenhouse-gas-emissions
[4] AIB is responsible for developing and promoting the European Energy Certificate System - "EECS"
[5] https://norsus.no/wp-content/uploads/AR-01.19-The-inventory-and-life-cycle-data-for-Norwegian-hydroelectricity.pdf

4.2 Environmental, Social and Governance

Hydropower development may have more or less environmental and social impact affecting the sustainability of the development. The International Hydropower Association has developed a comprehensible tool, The Hydropower Sustainability Environmental, Social and Governance Gap Analysis Tool (HESG Tool), applicable also for assessing eligibility in a green bond framework. Using the tool ensures focus on potential gaps related to the following main topics:

- Environmental and Social Assessment and Management
- Labour and Working Conditions
- Downstream Flows, Sedimentation, and Water Quality
- Project-affected Communities and Livelihoods
- Resettlement
- Biodiversity and Invasive Species
- Indigenous Peoples
- Cultural Heritage
- Infrastructure Safety
- Climate Change Mitigation and Resilience
- Communications and Consultations
- Governance and Procurement

The prevailing requirements to be fulfilled before acquiring a licence from NVE to build and operate a hydropower plant in Norway encompass investigations and potential need for mitigation related to all these topics. The rigid processing of applications prior to licencing, including public hearing, and subsequent follow up by NVE, is set up to ensure that gaps are closed, and all promised mitigation actions are completed.

Due to rigid requirements regarding environmental and social impact of hydropower developments in Norway, all Norwegian hydropower assets conform with very high standards regarding environmental and social impact.

5 Eligibility

The main eligibility criteria are in line with the CBI criteria & the EU Taxonomy. For Norwegian hydropower these criteria are easily fulfilled and most assets overperform radically.

- All run-of-river power stations have no or negligible negative impact on GHG emissions.
- Due to the cold climate and high power density of Norwegian hydropower, Norwegian reservoirs are not exposed to significant cyclic revegetation of impoundment and hence the negative impacts on GHG emissions from these reservoirs are very small.

Eligibility criteria:
Hydropower plants with power density > 5 W/m^2 or emission intensity below 100 gCO_2/kWh are eligible for green bonds.

Climate Bonds Initiative (CBI) have published hydropower eligibility criteria for public consultation[6]. These criteria have a mitigation component and an adaptation and resilience component.

The mitigation component requires power density > 5 W/m^2 or emission intensity < 100 gCO_2/kWh.

The adaptation and resilience component, addressing ESG, is in the Norwegian context covered by the rigid relevant requirements in the Norwegian regulation of hydropower.

EU is in its Taxonomy including hydropower, however, this is also work in progress. The eligibility criteria mentioned above are central also in the taxonomy. In the current available documents, most *do no significant harm* (DNSH) requirements are covered by current national regulation of hydropower, however, with exemptions. The current proposal on requirements regarding documentation of eligibility are not addressed in this assessment.

[6] https://www.climatebonds.net/2019/06/we-want-hear-you-first-three-things-you-should-know-about-cbi%E2%80%99s-hydro-criteria

6 Power production estimates

The power plants in SpareBank 1 Østlandet's portfolio are quite varied in age and a large portion of younger plants add uncertainty to the future power production. Actual or planned power production has been provided by the bank.

For small hydropower plants it is important to understand that stated power production given in the concession documents do not necessarily represent what can realistically be expected from the plant over time. For one the hydrology is uncertain, and unfortunately often overestimated in early project phases. Also, production figures normally do not account for planned and unplanned production stops, due to accidents, maintenance etc. Research on small hydropower has shown that actual production often is more than 20 % lower than the concession/pre-construction figures. There is no equivalent evidence to claim the same mismatch for large hydropower.

7 Impact assessment

7.1 Electricity production mix

In 2019, the Norwegian power production was 98 % renewable (NVE[7]).

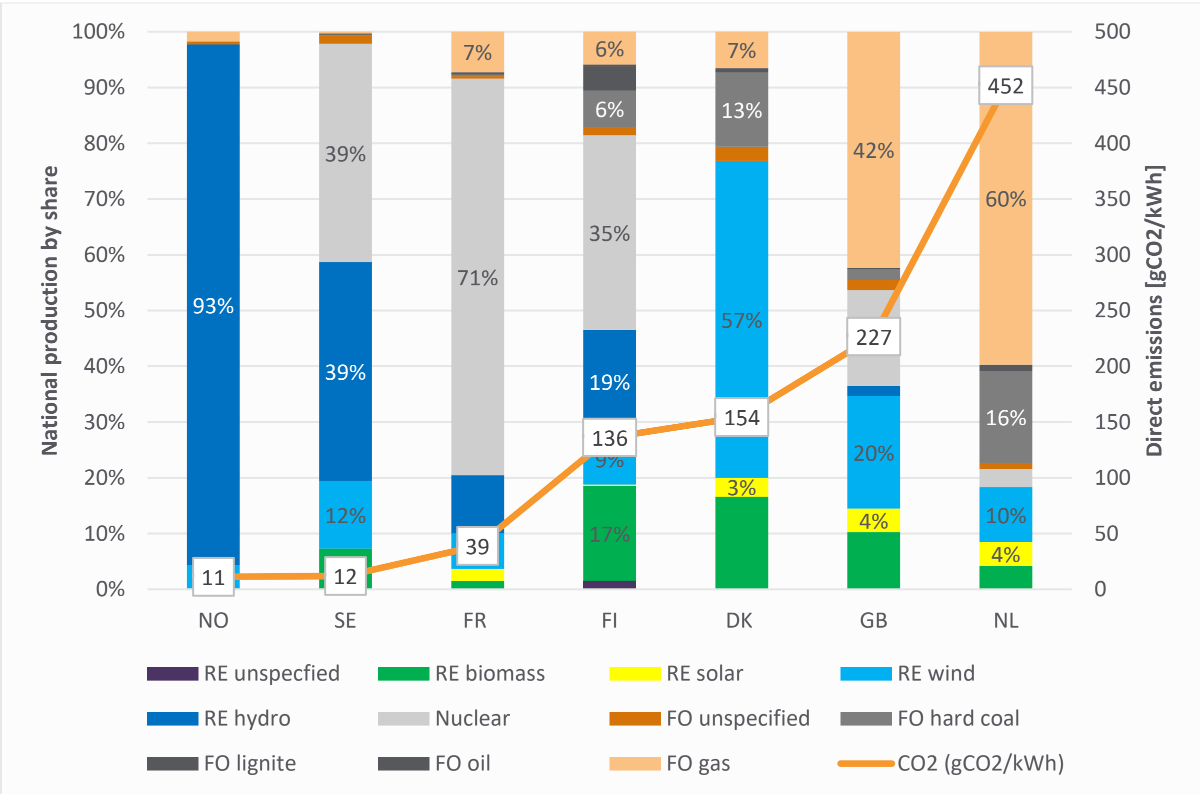

Figure 2 National electricity production mix in some relevant countries (European Residual Mixes 2019, Association of Issuing Bodies[8])

As shown in figure 2, the Norwegian production mix in 2019 resulted in emissions of 11 gCO_2/kWh. The production mix for other selected European states is also included in the figure for illustration.

[7] https://www.nve.no/nytt-fra-nve/nyheter-energi/varedeklarasjon-for-stromleverandorer-2019/
[8] https://www.aib-net.org/facts/european-residual-mix

7.2 CO_2- emissions related to electricity demand

Power is traded internationally in an ever more interconnected European electricity grid. For impact calculations the regional or European production mix therefore is more relevant than national production. Using a life-cycle analysis, the Norwegian Standard NS 3720:2018 “Method for greenhouse gas calculations for buildings” takes into account international electricity trade and that the consumption is not necessarily equal to domestic production. The grid factor, as average over the lifetime of an energy consumer as a building, is based on a trajectory from the current grid factor to a close to zero emission factor in 2050 and steady until the end of the lifetime.

The mentioned standard calculates, on a life-cycle basis, the average CO_2- factor from the European and Norwegian grid over the next 60 years. These two scenarios are presented in table 1. The same lifetime of assets is also relevant for hydropower projects.

Scenario	CO_2- factor (g/kWh)
European (EU27 + UK + Norway) production mix	136
Norwegian consumption mix	18

Table 1 Electricity production greenhouse gas factors (CO_2- equivalents) for two scenarios (source: NS 3020:2018, Table A.1)

The impact calculations in this report apply the European mix in table 1. Using a European mix instead of a national production mix is in line with Nordic Public Sector Issuers: Position Paper on Green Bonds Impact Reporting (February 2020)[9]. 136 gCO_2/kWh constitute the GHG emission intensity baseline for power production with a long economic life.

7.3 CO_2- emissions impact of hydropower production in Norway

All power production has more or less negative impact on GHG emissions. Instead of calculating the impact on GHG emissions for all, and most of them rather small facilities in the SpareBank 1 Østlandet portfolio, e.g. by using the earlier mentioned G-res tool, we refer to The Association of Issuing Bodies (AIB). AIB is responsible for developing and promoting the European Energy Certificate System - "EECS".

AIB uses an emission factor of 6 gCO_2/kWh for hydropower in their calculations of the European residual mix. The value is based on a life-cycle analysis where all upstream and downstream effects in the whole value chain for power production are included.

For the type of assets in the portfolio, run-of-river and small hydropower, the AIB emission factor is regarded as conservative in an impact assessment setting. The positive impact of the hydropower assets in SpareBank 1 Østlandet’s portfolio is 130 gCO_2/kWh compared to the baseline of 136 gCO_2/kWh.

[9] https://www.kbn.com/globalassets/dokumenter/npsi_position_paper_2020_final_ii.pdf

7.4 SpareBank 1 Østlandet's criterion - New or existing Norwegian hydropower plants

The eligible plants in SpareBank 1 Østlandet's portfolio is estimated to have the capacity to produce about 140 GWh per year. The available data from the bank and in open sources include:

- Type of plant (run-of-river/reservoir)
- Installed capacity
- Estimated or recorded production
- Age

To cross check the data, a sample of the planned power production for the assets has been attained from the Norwegian Water Resources and Energy Directorate's hydropower database[10] or licencing documents. Due to the often overestimated annual production in small hydropower, the impact is conservatively calculated for estimated production reduced by 20%.

	Capacity [MW]	# of plants	Total capacity [MW]	Estimated production [GWh/yr]	Expected production [GWh/yr]
Small run- of - river	0.04 – 4.8	8	18.7	69.2	55.3
Small reservoir HPP	2.2 – 10	5	21.3	70.5	56.4
Sum		13	40	139.7	111.7

Table 2 Capacity and annual production of eligible hydropower plants (HPP), estimated and expected production (reduced for common errors)

The table below summarises the renewable energy produced by the eligible assets in the portfolio in an average year, and the avoided CO_2-emissions the energy production results in.

	Produced power	Reduced CO_2-emissions compared to baseline
Eligible hydropower plants in portfolio	**111.7 GWh/year**	**14,526 tons CO_2/year**

Table 3 Annual power production and estimated positive impact on GHG-emissions

[10] https://www.nve.no/energiforsyning/kraftproduksjon/vannkraft/vannkraftdatabase/