REPORT

SR-Bank Green Hydropower portfolio

CLIENT

SpareBank 1 SR-Bank ASA

SUBJECT

Hydropower

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REPORT

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1 Introduction

On assignment from SR-Bank, 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 SR-Bank

The Green loan portfolio of SR-Bank consists of hydropower plants that meet the criteria as formulated below.

2.1 Eligible hydropower assets

Multiconsult has investigated a sample of SR-Bank's portfolio and can confirm that the assets, both planned and in operation have low to negligible GHG-emissions related to construction and operation.

About 60 % of power produced by power stations in the portfolio are in stations with capacities in the range of 0.1- 25 MW. These are all run-of-river plants with no or very small reservoirs and hence very high power density of several thousand W/m^2 (ratio between capacity and impounded area).

The remaining 40 % of power produced by power stations in the portfolio is related to one medium sized existing run-of –river power station (40 MW) in an existing waterway that has been in operation for more than 100 years. Power density is even for this stations very large due to no reservoir.

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

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 have also provide essential data on the assets. Some of the hydropower producers have several assets and several sources of financing, and the bank will provide historical power production figures, where available, and planned production in not yet commissioned plants. The bank will also provide its share of financing or related power production 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 95 % of the national power production.

3.2 Licencing

All hydropower developments in Norway are subject to licencing and 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. 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 projects 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 on different kind of projects[1].

The plants will not be given 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, given the right 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-hydro plant the impounded area is a few hundred to some thousand square meters and thus the potential emissions from the reservoir are quite negligible. In addition, since the impounded area for a typical small hydro plant is mostly existing river bed and 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

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

however quite a significant undertaking doing these calculations. The value of the results is also quite limited for small reservoirs that apply to most small-hydro plants. Further, the calculations are not able to be performed for the plants we are considering here. It is however our general view that the typical Norwegian small-hydropower plant reservoir has a negligible if any negative impact on GHG emissions.

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 hydropower stations in Norway with reservoirs have high power density due to high hydraulic head and/or 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 proposed CBI criteria's mitigation component of 100 gCO_2e/kWh.

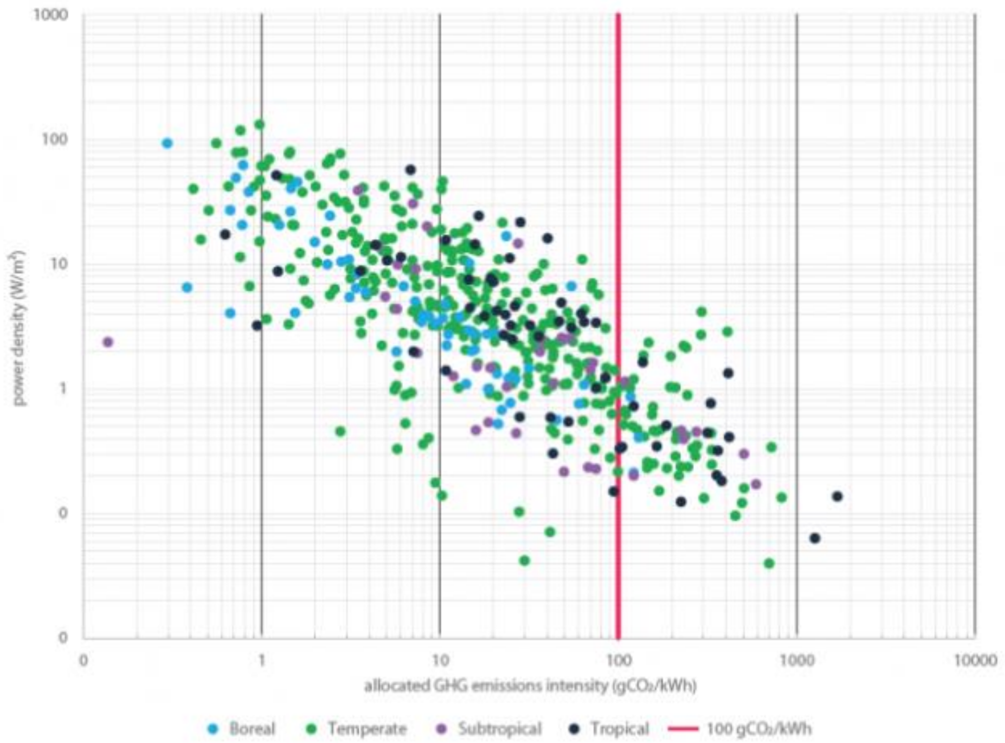

Figure 1 Relationship between GHG emissions intensity and power density of projects in IHA study including only plants with large reservoirs (International Hydropower Association[3])

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

[3] https://www.hydropower.org/news/study-shows-hydropower%E2%80%99s-carbon-footprint

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 2.39 gCO_2e/kWh. (Østfoldforskning, 2015[5])

All small hydropower assets with small reservoirs and run-of-river assets in Norway have negligible if any 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).

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

[4] AIB is responsible for developing and promoting the European Energy Certificate System - "EECS"
[5] https://www.ostfoldforskning.no/media/1056/734-1.pdf

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 regarded 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 eligibility criteria is formulated in line with 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 climate, Norwegian reservoirs are not exposed to 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.

6 Power production estimates

The power plants in SR-Bank'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 attained by the bank from their clients, covering 72 % of the power production portfolio.

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

For small hydropower 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. There is, however, also the fact that the 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 2018, the Norwegian power production was 98 % renewable (NVE[7]).

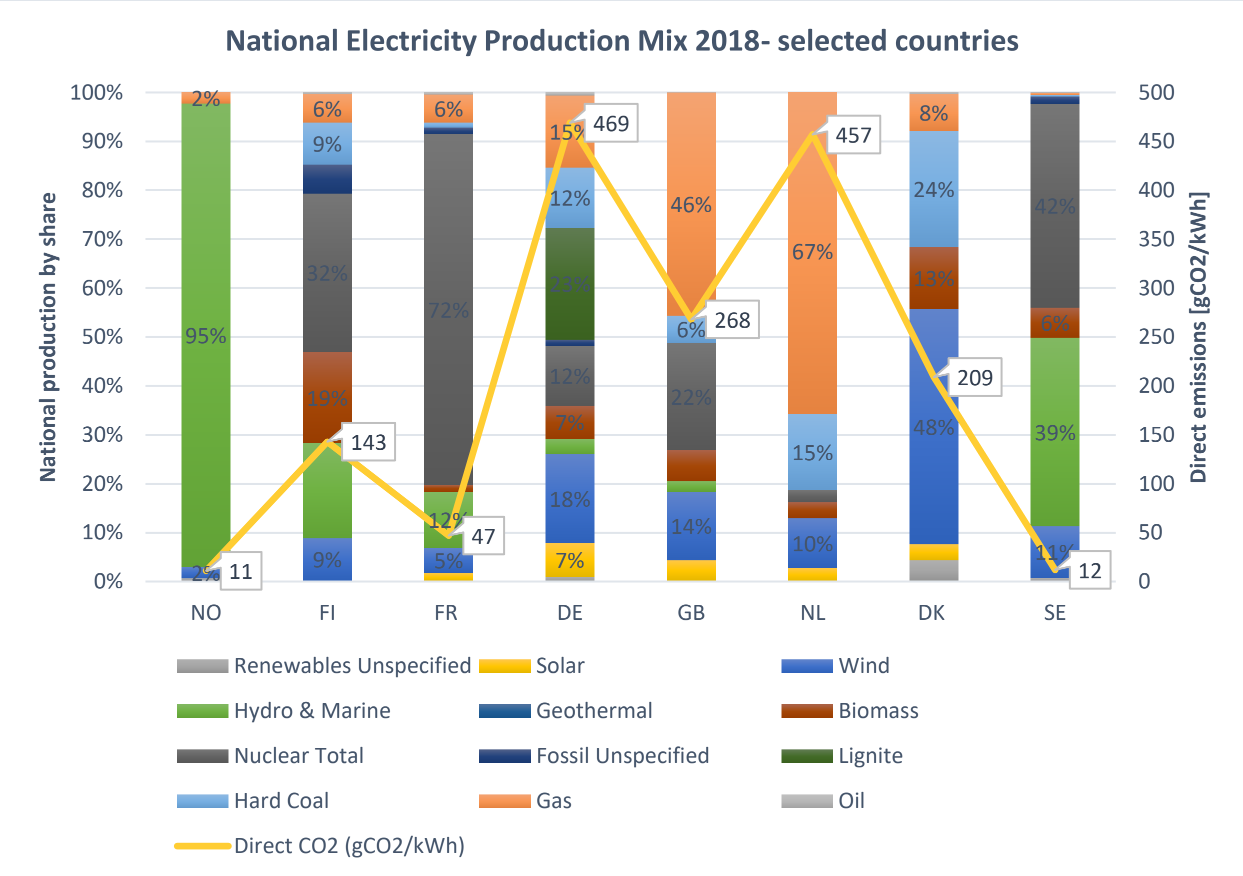

Figure 2 National electricity production mix in some relevant countries (European Residual Mixes 2018, Association of Issuing Bodies[8])

As shown in figure 2, the Norwegian production mix in 2018 (95 % hydropower) results in emissions of 11 gCO_2/kWh. The production mix is also included in the figure for other selected European states for illustration.

[7] https://www.nve.no/energy-market-and-regulation/retail-market/electricity-disclosure-2018/
[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 is more relevant than national production. Using a life-cycle analysis, the Norwegian Standard NS 3720:2018 “Method for greenhouse gas calculations for buildings” take into account international electricity trade and that the consumption is not necessarily equal to domestic production. The grid factor, as average in the lifetime of an asset, 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 for the next 60 years, a lifetime also relevant for hydropower assets, according to two scenarios as described in table 1.

Scenario	CO_2- factor (g/kWh)
European (EU28+ Norway) consumption 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 apply the European mix in table 1. This is in line with Nordic Public Sector Issuers: Position Paper on Green Bonds Impact Reporting (January 2019)[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 have 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 SR-Bank 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 SR-Bank’s portfolio is 130 gCO_2/kWh compared to the baseline of 136 gCO_2/kWh.

[9] https://www.kommunalbanken.no/media/545579/npsi_position_paper_2019_final.pdf