Green Industry Geographies: Electricity Access and the Green Industry Firm Landscape

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Abstract (155 words)

Industry requires access to renewably-sourced electricity in order to both reduce the carbon footprint and produce climate- and environment-friendly goods and services. But the allocation of electricity as a limited resource hinges on institutional rules. In this article, we ask how the process of accessing clean energy impacts the establishment, growth, and geographic location of new green industry firms. We conduct an exploratory study in the context of Norway, a country with a well-functioning electricity grid sourced from renewable energy and clear political goals of electrifying industry, but whose electricity supply is in practice constrained by limited electricity supply but increasing industrial demand. We find that three characteristics of the process of accessing electricity in Norway shape the establishment, growth and geographical location of new green industry firms in Norway: regional variation in the absolute amount of available electricity; unclear rules for accessing the grid; and a length and potentially costly process for gaining access.

Key words: industry, electrification, renewable energy, green industry, institutions, geography

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Abstract

Access to clean electricity is fundamental for reducing the carbon footprint of industry, both for existing industrial operations and for producing new climate- and environmentally friendly goods and services. But the allocation of electricity as a limited resource hinges on institutional rules. In this article we examine how the process of electricity allocation impacts the establishment, growth and geographical location of new green industry firms. We examine how process impacts electricity access for green industrial firms in the context of Norway, a country with a seemingly well-functioning electricity grid sourced from renewable energy and clear political climate goals for greening industry. Through an exploratory study based on an extensive document review and in-depth qualitative interviews with key informants, we find that the management of the electrical grid, from the quantity of available electricity to the process by which firms access electricity, hinders green industry firms in accessing power. This is for three reasons: 1) regional variation in the absolute amount of available electricity; 2) unclear rules and queue systems for accessing the grid; and 3) a lengthy and potentially costly process for gaining access. These findings indicate that formal and informal rules determine the establishment of green industry firms in industrialized countries, and could hinder progress on climate goals.

Greening Industry: Opportunities and Challenges in Electricity Access for Norwegian Industry Firms

1. Introduction

Reducing the carbon footprint of industry is essential if industrialized societies are to make a low-carbon transition, whether by improving the environmental performance of existing industrial firms or by establishing new industries that use climate- and environment-friendly methods to produce green goods and/or services (Shapira et al 2014; UNIDO 2010; Altenburg and Assmann 2017). Greening industry is important not only for reducing emissions, but also for creating the basis for green economic growth in the form of new jobs and new sectors. As industry is a major greenhouse gas emitter (contributing about 21% of global greenhouse gas emissions, according to the United States Environmental Protection Agency[1]) but also a major part of advanced economies, green industry has an important role to play in achieving both global climate and economic goals (Anzolin and Lebdioui 2021). However, few studies have examined how access to renewably-sourced power influences the firm emergence and growth of firms in industrialized economies (Rodrik 2014). Electricity access negatively impacts company performance in low-income countries (see Fried and Lagakos 2020), but less is known about how industrial firms in high-income countries access cleanly-sourced power for their operations. This article contributes to filling this knowledge gap by examining the challenges and opportunities that industrial firms face in accessing clean energy from national electrical grids.

Though establishing and sustaining green industry may be desirable from economic, political, and environmental standpoints, bringing about change in industry requires enabling conditions and resources. There are also distributional implications, establishing green industrial firms in specific locations will benefit those locations over others. In this article, we examine how the process of, and premises for, accessing renewable electricity — a critical input for environment and climate-friendly industrial production — impacts the establishment, growth, and geographic location of new green industries and projects. We examine this question in the context of Norway, a country whose electricity is sourced 100% from renewable energy sources, namely hydropower (IEA 2022), but which faces supply and procedural constraints to ensuring full, equitable distribution of power to aspiring green industry firms and projects. In practice, variable

[1] See https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data

access to renewable electricity challenges the ability of green industries to emerge and sustain themselves in Norway, despite the government's push to electrify industry. This situation has become even more challenging with the government's decision to electrify more of Norway's offshore petroleum platforms to reduce emissions from extractive activities.

First, we review the relevant literatures on the geo-spatial determinants of industry location, on green industrial policy, on the role of electricity access in industry productivity and performance, and on energy justice. We then describe the methodology of our study, followed by an overview of the context of green industrialization and the process for accessing electricity in Norway. We find that three factors shape green industrial firms' access to electricity in Norway, with implications for the establishment, growth, and geographical location of new green industry firms in Norway for three reasons. First, there is regional variation in the availability and costs of electricity; second, there are unclear rules for accessing the electricity grid; and third, there is a lengthy and costly process for accessing electricity. We conclude with reflections on research gaps and the broader policy implications of clean energy for green industry development and growth in advanced industrial economies.

2. Literature review

Here we focus on industrial firms that rely on renewable energy for production. Such "green industry firms" can also include companies that produce climate- and environment-friendly outputs. Greening industry has become increasingly important as countries around the world, particularly industrialized economies, seek to reduce their climate footprint while maintaining robust economies (Capasso et al 2019). In terms of ecological modernization (Mol and Sonnenfeld 2000), green economic growth hinges on sustainable industry, since industry is a primary motor of economic development and growth (Altenburg and Assmann 2017). Realizing this vision, however, requires a solid policy and institutional framework at the nexus of several policy arenas, including industrial, climate and environment, energy, labor, and education policies and regulations (Rodrik 2014). Major emitting countries and regions like the European Union and the USA have therefore developed policy approaches to support the development and expansion of green industry under their new green deals; and other major carbon-emitting countries like China are establishing suitable institutional frameworks (Chen et al 2016; Meckling 2016).

Here we examine the conditions under which green industrial firms in Norway access renewably-sourced electricity, and how this shapes the landscape or ecology of such firms. Norway represents a climate paradox: it has long been at the forefront of progressive global and national environmental politics, advocating internationally to combat climate change, channeling large amounts of foreign aid and climate financing towards developing nations for climate mitigation and adaptation purposes, and taking action domestically to reduce carbon emissions. Norway has some of the world's highest rates of electric car sales; and nearly all its electricity is supplied from renewable energy sources, primarily from hydropower, with wind power becoming increasingly important. However, Norway is also a contributor to climate change through its greenhouse gas emissions, a significant proportion of which come from the extraction of its offshore petroleum reserves, representing one-quarter of Norwegian emissions (NEA 2021). Industry is the largest consumer of energy in the country, consuming nearly 70 TWh in 2020—50 TWh of which come from the cleanly-sourced electrical grid.[2]

The Government of Norway is pushing for a "green shift" in order to achieve its goals of halving its climate emissions by 50% to 55% by 2030 and becoming a low-emissions society by 2050. These are the country's two core goals in its 2021– -2030 Climate Plan and are its key commitments under the UNFCCC Paris Agreement (Government of Norway 2020).[3] As the Climate Plan as well as the newly launched "Green Industry Lift" roadmap argue, Norwegian industry has an important role to play in the green shift, both by reducing its own emissions but also by producing materials, technologies, and other solutions that facilitate emissions reductions in other sectors, domestically and internationally, in order to maintain economic growth and revenues (Government of Norway 2022).[4] Electrification is thus an important factor shaping the ability of Norwegian industry to reduce its emissions – also as regards to the country's offshore oil platforms.

Norway is a pertinent case- country for study firms' access to renewably-sourced electricity. The government is actively trying to achieve both international climate and national economic goals, and the country normally benefits from a plentiful supply of cheap hydropower. Studies of the relationship between electricity access and firm productivity – focused on the Global South, where electricity availability is variable, show that a reliable supply of electricity

[2] See https://energifaktanorge.no/en/norsk-energibruk/energibruken-i-ulike-sektorer/
[3] https://www.regjeringen.no/no/tema/klima-og-miljo/innsiktsartikler-klima-miljo/det-gronne-skiftet/id2879075/
[4] Examples of green outputs include production of batteries and hydrogen.

affects both the establishment and productivity of industrial firms (cf. Fried and Lagakos 2020; Arlet 2017; Geginat and Ramalho 2015; Poczter 2017). Thus, we should expect to find that firms in Norway have easy access to the electricity grid where power is plentiful, readily available, and cheapest, based on basic cost-benefit considerations.

However, access to electricity depends not only on the availability of such power, but also on the rules and regulations—the process— for accessing electricity from power providers. Access to the electricity grid is not a simple a binary variable: several factors must be considered in explaining the characteristics of its availability, and how firms gain access to electricity to power their operations. The emergence of firms depends on geographical factors like industrial policy, political and economic institutions, actor networks, natural resources and environmental conditions, the quality of human capital, and—not least— infrastructural and material assets and services such as electricity. Research on the emergence and location of green industry firms has focused on the roles of green industrial policy and state intervention, the influence of geographic regions and industrial clusters, and the availability (or degree of lock-in) of assets for old versus new economic activities (Todtling et al. 2020; Trippl et al. 2020; Allan et al. 2021).

We argue that electric utilities should be viewed as institutions, with rules and norms governing their operation and actors playing a critical role in shaping the distribution of electricity. Thus, access to electricity is best understood as a process where firms must negotiate rules, procedures, and relationships over time and space in order to articulate and realize their demands for renewable power, and where electricity providers must make decisions about who and where to allocate renewable power, as renewable electricity is a limited resource. This institutional context— with institutions defined as the "rules of the game" (North 1990)— is critical in determining which firms are able to access electricity and where. Moreover, informal institutions like unwritten norms, rules, relationships, shared expectations, and codes of behavior also influence patterns of organizational behavior (Lauth 2000; Helmke and Levitsky 2004).

Further, scant attention has been paid to distributional and procedural justice in explaining which firms access power and with what consequences. *Distributional* justice concerns the degree to which resources and benefits as well as costs are equally distributed in society (Jenkins et al 2016). *Procedural* justice, which refers to the perceived fairness of a process that allocates resources (McCauley et al. 2019; Jenkins et al. 2016), requires inclusion, neutrality, and transparency in decision-making processes to achieve equitable outcomes (Dolan et al. 2007).

Processes that lack these characteristics are likely to result in certain actors (in our case, firms) receiving privileged access to resources over others— an inequitable outcome that does not necessarily reflect the best allocation of resources for the best possible uses. In terms of energy transitions and green industrialization, sub-optimal distribution of goods represents a market failure: an inefficient distribution of resources (here: clean electricity) that results in a sub-optimal outcome: sub-par numbers of green industry firms and products.

We investigate how the availability as well as the process of, and rules for, accessing renewably-sourced electricity shapes which firms are able to start and sustain operations in Norway. Few studies have examined how the availability of clean electricity, and how that power is accessed, influence the emergence and sustainability of green industry firms (Lema et al. 2022; Philibert 2017; IRENA 2015). Our study offers empirical evidence of the challenges firms face in accessing renewably-sourced electricity.

3. Methodology

We employed a qualitative methodological approach in conducting an exploratory study, which allowed us to deductively investigate the plausibility of our hypotheses, and inductively generate further insights into the relationship between the power system as an institution and the green industry landscape for testing in future research. We focus on the case of Norway, where electricity is generated almost exclusively through renewable sources (~90 % hydropower) (Energifakta Norge, 2022). Like other industrialized countries trying to meet international climate goals and reduce their emissions, the Government of Norway has developed and follows a set of clear policy goals of electrifying industry and achieving a green economic shift (c.f. Government of Norway 2022); moreover, the country seems to have a well-functioning electricity grid. Norway is therefore a good case in which to collect exploratory evidence about the process whereby firms access renewably sourced electricity that is plentiful in theory, but is constrained in practice.

Our data collection was carried out in 2021, prior to the Ukraine – Russia crisis and its impact on electricity prices throughout Europe. Data collection involved document analysis and qualitative, semi-structured interviews. First, we collected and analyzed relevant, publicly available documents from the government and government agencies. Documents were deemed relevant if they explicitly discussed the energy transition, new/green industry and/or the process

of gaining access to electricity (see Table SI 1). One important source of documentary evidence for our study is the publicly available input from various actors to the Electricity Grid Commission ("Strømnettutvalget," or the "Nakstad Commission"), as well as the report that the Commission delivered in June 2022.[5] This Commission was established in 2021 by the Ministry of Petroleum and Energy to examine the further development of Norway's electricity grid. The aims of the Commission are to examine measures for reducing the time needed for developing and expanding the grid, and to develop principles for accessing power. In addition to serving as additional evidence to support the interview data, these documents were used to map out the green industry projects and associated industry actors and business associations relevant this study. We extracted further relevant information on the projects from homepages, published news, news articles and other secondary sources.

Second, to gain in-depth understanding of the perceptions and opinions on the topic, we conducted in-depth, semi-structured, qualitative interviews. Respondents were selected from the electricity sector, green industry firms and industry hubs, industry and electricity associations, and government officials. Interviews were semi-structured, where the respondents answered preset open-ended questions, and were based on a semi-structured interview guide (Table SI2). The eight interviews were conducted with individuals or with a group, 12 interviewees all together, and lasted for 30 min to one hour (See Supplementary Information for an anonymized list of interviewees). We identified interviewees through our document analysis by drawing up an initial list of power producers, industrial firms, relevant business and industry associations, and government actors, and aimed to interview persons representing each of the five price areas (Fig. 1). All interviewees were asked about their knowledge of, and experience with, the process of accessing the electricity grid for green industry projects, and the factors shaping company establishment. Interviews were conducted online with video, recorded and transcribed; and then coded for themes related to the process of accessing the electricity grid. There were some preconceived themes that we expected to find reflected in the data, however, we also allowed the addition of further categories to make the categorization more useful and accurate. (See overview of the categories in Table SI3). We recorded all the data in the appropriate categories; NVivo helped to speed up the process here. The collected data were examined to find patterns and draw inferences concerning our research question.

[5] https://stromnettutvalget.no/

3.1 Context: Norway's electricity system

The overall production and use of electrical power in Norway is coordinated and operated by the government agency Statnett. The electricity grid is divided into five price-related geographic regions (Fig. 1), with several different utility companies (grid owners) operating in each region and responsible for generating and distributing electricity from the grid within their respective price region. These price areas formed our five cases. These price areas reflect structural bottlenecks, where the grid limits the ability to transfer power from one area to another (Statnett, 2021). The main difference in price is between the northern area (NO 4) and the southern areas (NO 1,2,3 and 5) (Statnett, 2022a) The power grid is a natural monopoly and the grid companies are strictly regulated. The grid companies are responsible for planning and implementing necessary investments in their grid, while Statnett is responsible for the system and controls the overall physical management and control of the power system. Electricity distribution companies purchase the generated power from the utility companies through an open market and provide power to households and other consumers.

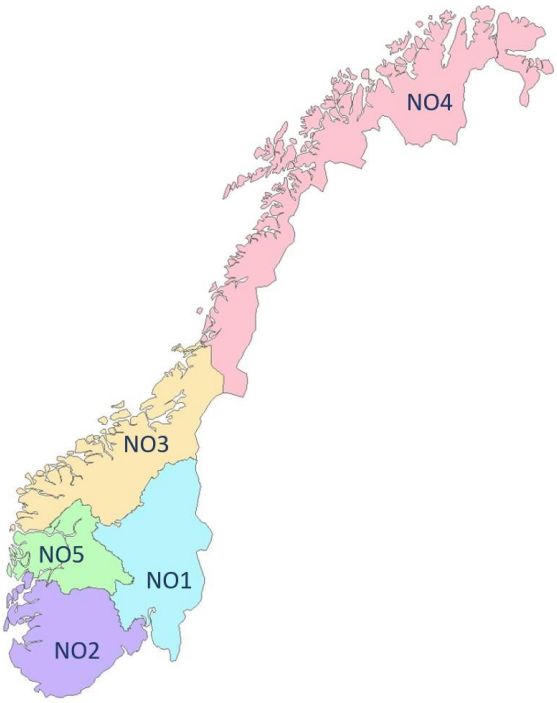

Figure 1: Map showing the different price areas.
Source: Modified from Statnett, 2023

Industrial consumers access the electrical grid either by contacting the relevant regional utility (for smaller projects, under 1 MW), or Statnett directly for larger projects. Statnett or the local utility decides whether a project is mature enough to access power, or if it requires guidance first; there is also a queuing system for accessing the grid. Once a project is considered ready to access the electrical grid, the Norwegian Energy Directorate (NVE) determines, on behalf of Statnett whether it is operationally sound as well as the available grid capacity, a process that can take many months. Industrial consumers may reserve grid capacity for a time period agreed upon with Statnett, and this capacity can remain reserved so long as the customer demonstrates

progress in the project.[6] If sufficient grid capacity does not exist, the customer must provide funding to expand the grid. Expansion is often necessary because most of today's grid was built between 1950 and 1980, and significant additional investments are now needed to reduce imbalances and to secure energy supply (NHO, 2021).

4. Results and discussions

Our findings indicate that electricity access shapes the geographic distribution of green industry firms in Norway. The choice of location is affected by three obstacles that firms may face in accessing the electricity grid: i) increased competition for available electricity ii) a non-transparent and discretionary process of gaining access to the grid iii) and the length of time and potential for added costs in gaining access. We now examine each of these three issues and how they affect the geographical distribution of green industry firm landscape.

4.1 Increased industrial competition for available electricity

The Government of Norway's 2022 "Roadmap for a Green Industry Lift" cites access to electricity in general as the first challenge to green industrialization, due to the significant increase in demand for access to the electricity grid since 2018. Demand for grid access rose by as much as 10% after 2018, corresponding to nearly half of the total production capacity in the existing power supply in Norway in 2021 (NHO, 2021). Growth in consumption has been highest in coastal areas, where many industrial clusters are located (Statnett, 2021).

We find that the overall availability of electricity shapes the establishment of firms: it is easier to access electricity in areas where there is a surplus of electricity as well as where industry already exists and has access to the grid (Interviews #4 and #8; Skjelvik & Olaisen, 2021). Unsurprisingly, new green industry firms are attracted to geographic areas with reasonably secure and reliable electricity supplies, and at lower cost; as one industry group representative explained, "existing electricity access at a reasonable cost is extremely important for power-intensive

[6] https://www.statnett.no/en/for-stakeholders-in-the-power-industry/the-grid-connection-process/the-steps-in-the-grid-connection-process/

industries" (Interview #4). Conversely, challenges to electricity access may halt the development and implementation of new ideas and projects.

The northernmost part of Norway (Area NO4, Fig. 1) has a general year-round power surplus and lower electricity prices (Interview #1). As a result, several industrial clusters are located in this region, and power intensive industry accounts for approximately 80 % of electrical energy consumption in the area (Helgeland Kraft Nett, 2020). As security of supply in the region is considered good, and there are usually no problems in meeting the demand for energy, several green industry projects are currently in the pipeline. (Gen2Energy, n.d;Skjelvik & Olaisen, 2021). However, change is underway: one utility representative described the current power situation in this area as being

> "a wild battle for the available capacity… There is not enough capacity for everyone who knocks on the door. We have seen an increase in inquiries from customers during the past years, and it is likely that lower electricity prices are affecting this. We also have a low and competitive grid access fee. As a result, the available capacity is constantly being eaten up" (Interview #1).

The neighbouring area NO3 is experiencing a deficit of access to electrical power, and imports from area NO4 are required to maintain supply. There are several proposed industrial projects for this area which will put pressure on grid capacity. This includes land-based fish farms, data centers, electrification of ferry connections, and expansion of existing land-based power-intensive industries (Interview #2). If no new measures are taken to expand the grid in NO3, the bottleneck through central Norway will worsen.

The situation in area NO5 is more mixed, with several surplus and deficit areas in close geographic proximity to each other. Consumption is highest along the coast, linked to power-intensive industry, as well as to the petroleum industry and Bergen city (NHO, 2021). There is normally a large surplus of electricity in the northernmost part of this area, which has facilitated a good deal of new industrial production in recent years. In contrast, bottlenecks are increasingly occurring in the transmission network in the southern part of the area— a situation that may well worsen, given the various industrial project proposals that would significantly increase electricity consumption along the coast, including electrification of offshore platforms and operations. Total

electricity demand in the area for new green industry initiatives is about 2600 MW (Fig. 2), while industry consumption today is about 700 MW (Statnett, 2020).

Area NO2 is expected to see growth in power-intensive industry, due largely to the available electricity supply (Statnett, 2021). In the western part of this area, more than 400 MW of wind power has been put into operation or is under construction, and additional ongoing wind projects represent a potential of over 350 MW. After Statnett was licensed to build a new transmission cable to supply the region with new green energy (Statnett, n.d.), several green industrial initiatives announced their interest in the region (Grøndal, 2021). Planned initiatives are for hydrogen production, battery factories, and data centers. The eastern part of NO2 it is expected a growth in power-intensive industry from 400 MW in 2020 to about 2200 MW in 2030 (Statnett, 2021). One of the battery factories will require power capacity up to 100 MW (Viseth, 2021). After more than three dozen sites in southern Norway were evaluated, it was access to electricity that became decisive when selecting the location in 2020 (Interviews #4 and #6). However, a complicating factor is that Google has reserved the ability to access to electricity for a data center in this same grid area, with an estimated power requirement of 400 MW; this blocks access for other new projects in the region as Google's application technically preceded these other new projects (ibid.).

Finally, several new industrial projects are proposed for area NO1, but almost no new electricity production. The area is attractive for the establishment of data centers, battery factories and other major industries given its proximity to large towns and cities as well as the main airport (Statnett, 2021). Approx. 1000 MW will be needed for new consumption in the area, but only 200 MW have been given reserved capacity while the remainder must await further measures (Statnett, 2022b). Limitations in transmission capacity into the area will make this area an isolated high-price area if there is considerable new consumption (Statnett, 2022b).

Interviewees from all areas consistently noted the issues of increased competition and capacity constraints as determining factors for new firms and projects. For instance, one business association representative told us that at one of the industry parks in their region, 76 % of all new planned investment for the energy transition (approx. NOK 24 billion by 2025) concerns power-intensive industry (Interview #5). Moreover, "if you don't have power, you don't have a chance". Although this region happens to have the greatest production of electricity, at ca. 1600 MW, the local distribution grid is not currently able to handle massive growth in consumption. Thus,

increased competition for access to power represents the major bottleneck and highest risk for the energy transition in the area (Økland, 2021; Hovland, 2020). One utility company representative told us that a company that wished to establish several data centers decided to place them outside the utility company's grid area specifically because of the growing competition and thus lack of sufficient grid capacity for these centers (Interview #2). We find that available electricity supply has influenced the establishment and localization of green industry firms in all five price regions, and that the competition for access to the grid has increased. Indeed, several proposed projects have since had to be put on hold or re-located, as growing demand for access to the grid has exceeded the available supply in several areas, and the capacity to power all these projects does not exist currently. As the CEO of one regional grid company told a local media outlet in November 2021, "by 2030, the need for electricity will probably be more than twice as great as previously expected, and 70 per cent of this need was reported only last year" (Økland, 2021).

The current model of expanding grid capacity requires the companies to fund a portion of the cost in advance of starting operations (Interviews #1, #2, #3, #4, #6). This added cost and time for building the grid makes it more likely for companies to "locate their operations where they can get access to the grid rather than wait for an extension to be built" (Interview #6). The added cost affects the competition between actors as it is a barrier for smaller companies in particular. This was emphasized by one industry association representative: "It's not realistic for a small or medium- sized company to fund the building of grid capacity, which is ironic since the grid needs to be enhanced in order for business activity to continue" (Interview #3).

Moreover, the electrification of Norway's offshore petroleum platforms increases the competition and creates additional constraints on available power supply for green industry firms and projects. From area NO5, located on the west coast and containing several large industrial parks, it is a short distance to some of the major producing oil fields at the continental shelf (Fig. 2). According to the CEO of one industrial park after the electrification of the offshore platforms, "there was actually nothing left" in terms of electricity supply. Furthermore, "electrification of the oil platforms is a hot potato issue since the platforms are using electricity from a region where demand is already very high" (Interview #7).

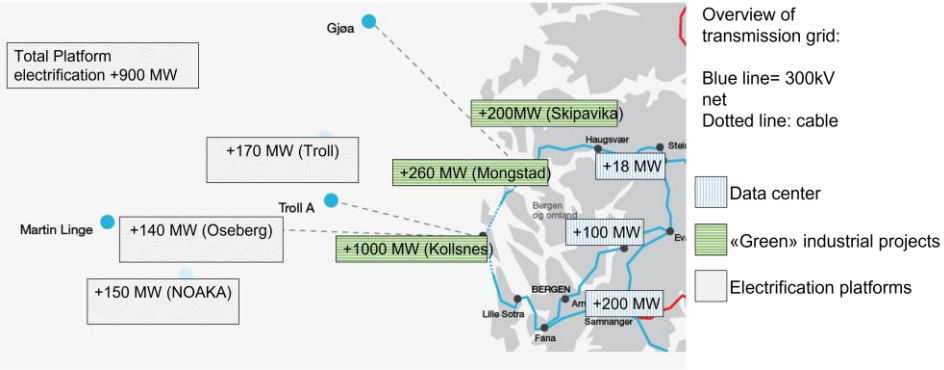

Figure 2: Overview of expected consumption growth in the Western region. Source: Modified from Statnett, 2020 and BKK Nett, 2020a.

4.2 Accessing the electricity grid

A second obstacle to the emergence and growth of green industry in Norway is the process involved in accessing the electricity grid, a process that many of our interviewees viewed as being overly discretionary (on the part of Statnett in particular) and non-transparent. The Electricity Grid Commission report from June 2022 notes the unpredictable, lengthy, and discretionary process as a major problem in the current system for accessing the grid (Government of Norway, 2022). The report further points out that there is no official overview of available grid capacity, and that it takes too long for potential customers to get information regarding capacity and where their application stands in the handling process. Additionally, informal rules surrounding the process make it difficult for investors to navigate access to the grid, heightening perceptions of procedural injustice.

Two partly contradictory principles guide the allocation process: "first come first serve," and project maturity. Under the former principle, allocation of electricity from the grid should follow a temporal process, with applicants being granted access according to the order in which when they apply. In contrast, the project maturity principle implies that the point in time an application is delivered is not as important as the ability to implement a given project and its power requirements.

Formally, if grid capacity exists for a proposed project, the principle of "first come first served" technically applies. According to the Statnett webpage, grid owners must treat all customers equally and provide a connection to the grid in the order in which they apply. However, in reality, determining available capacity depends on (and is a function of) evaluating the maturity and realism of a proposed project. This more qualitative evaluation of a proposed project means that utility companies and/or Statnett may prioritize certain customers or customer groups over others, rather than following a temporally-based queuing system. Such consideration is supposed to be based on guidelines provided by the authorities, but no such guidelines currently exist (Interview #8). Thus, evaluating maturity and realism is largely subjective, and varies across utility companies. Statnett describes the evaluation of maturity as follows: "To assess how likely it is that individual actors will establish themselves, the utilities have chosen to emphasize the degree of maturity of the individual projects. This involves an assessment of how far the actors have come in the project development, in any government processes and in the grid connection process" (Statnett, 2020). Further, Statnett stresses the importance of complete information about the project and about the actors supporting it, as well as whether the plans involve mature or immature technology —yet nowhere are the concepts of "mature" or "immature technology" defined.

As described by Statnett's communication manager to a media outlet in November 2021 "We have a queueing system, based on current regulations. It is not entirely first-come first serve, as we monitor the maturation and development of the projects so that they are actually realized" (Økland, 2021). As the demand and number of applications for grid access have increased, the utilities have become increasingly concerned with ensuring the maturity and realism of the projects: thus, the utility company's evaluation of a project's maturity becomes critical for the applicants. As one regional utility representative told us, "You cannot come with unrealistic plans and think that you'll be able to reserve capacity. Then you will be put at the back of the queue. There must be some realism in this" (Interview #1).

In regions where the struggle for capacity was until recently less intense, as for example in area NO3, immature projects and non-serious actors have not yet been a major problem for the

utility companies,[7] which had been primarily applying the principle of first come first serve to the queuing system. One utility representative felt increasingly that "one must insist that [grid access] is for serious actors who actually intend to build something or access new consumption within the timeframe they say. So that is kind of an assessment of seriousness" (Interview #2). This particular utility has forwarded every inquiry received for projects demanding more than 1 MW to Statnett; our interviewee explained, "what we have received from inquiries are, after all, serious things, which are so specific that we report them". This informant added that the proposer must provide grid construction funding and must also pay for the assessment of an application.

In addition to assessing the maturity of projects, several interviewees told us that there must be a certain development in the project once it is placed in the queue, merging the two seemingly contradictory principles. For instance, interviewees from a regional utility company told us that "…something must have happened in relation to milestones as well, which the actors have decided when they reserved the capacity. There must be a development over the time that they are allowed to reserve the capacity…in relation to some milestones we set up" (Interview #1). There are no set rules from the relevant government authority (the Norwegian Water and Energy Directorate, NVE) for how often the utility companies must follow up their customers to evaluate developments in a project, nor do any guidelines exist for how the utilities can define a project's "appropriate" progression for retaining its place in the queue. The regional utility we interviewed (Interview #1) stated that they follow up their customers in the queue once every half year, and then according to the deadlines that the utility has set for the project. "But we'd have liked to have seen even better rules and management around [the queueing process], so that everyone [utilities] did the same" (Interview #1).

Further adding to the feeling that the process of accessing the electricity grid is overly discretionary, several people we spoke with noted that when grid capacity is a scarce resource and competition is high, it can be advantageous for a customer to know the application process well. Not understanding the application process can result in lengthy periods spent figuring out the process and the rules. As one interviewee who had spent two years on the application process

[7] An example of a non-serious actor is what our interviewees labeled "strawmen", who travel around to look for and try to get access to the electricity grid at a lower cost, which they then plan to trade onwards in the future. This is possible to do in a place like Balsfjord, where there is still some spare capacity and a customer can get access to electricity at a lower price due to its geographical proximity to the main electricity grid (Interview #1).

explained: “It was challenging to know who the right addressee for our power needs should actually be. One moment we were directed to the regional utility company, then in the next to the transmission grid owner. And we also experienced a period where NVE thought they were the right addressee…” (Interview #7). Other applicants with prior experience and better knowledge of the process secured spots in the queue early on, becoming frontrunners in getting grid access contracts: “...like real estate agents who wanted to increase the value of their property, or data centers with international owners...They foresaw the potential bottlenecks as they had experience from other places. And such a contract for access to electricity became a type of ‘security’ and increased the value of the property and project” (Interview #5).

According to several interviewees, there is a big difference in the approach between new and old industry when they apply for grid access (Interviews #1 and #4). Green industry firms are those that most often fall into the “new” industry category. As compared to already established industrial firms, new green industry firms “have very different levels of knowledge and approach” in the application process (Interview #1). This is perhaps not surprising, as older, more established firms are likely to have greater familiarity with the process of applying for access to the electricity grid, as well as personal connections they can leverage. The consortium behind the “Common Energy and Industry Policy Platform,” which includes the Confederation of Norwegian Enterprises and the Norwegian Confederation of Trade Unions, acknowledges weaknesses in the exchange of information between new industrial initiatives and grid operators (NHO, 2021), and highlights the importance of good anchoring processes and transparent information exchange to avoid delayed connections and lost business opportunities.

Adding to the discretionary nature of the application process is the fact that some of the proposed green initiatives are partly owned by, or have the same owners, as the power utilities. That is perceived as a potential conflict of interest with power utilities sitting on both sides of the table; such cases mainly concern initiatives for producing green hydrogen. According to our informants, this might be a competitive advantage as regards the process of actually getting a place in the queue: the utilities are familiar with the process, which could save them time. Additionally, some interviewees felt that there was too much of a conflict of interest around electrification of the oil platforms, and too much discretionary authority on the part of the Ministry of Petroleum and Energy (OED) as the former main shareholder of Equinor in deciding that the petroleum platforms should be electrified ahead of other projects. As one business

association representative put it, “because OED owns Equinor, then the process in reality is ‘first Equinor, then everyone else’” (Interview #5).

Finally, interviewees noted the lack of transparency. One company with plans to build a factory in area NO2 expressed concern over the lack of transparency and the considerable discretion involved in gaining access to the electricity grid. This company requires additional electricity to implement their project, which is energy-intensive. The company has applied for grid access to the local utility company and are now awaiting feedback on their application. In this region, there is an ongoing process, whereby Statnett determines how much more capacity the network in the region can request given the new proposed projects. The next step is for the regional utility company to evaluate the maturity of all its projects and allocate capacity to actors in the queue. However, the company representative we spoke with stated, “we don’t really have insight on where we are in the queue” (Interview #7), and further felt that it would have been an advantage if the process were more clear and transparent— a point also made in the Electricity Grid Commission report of June 2022 (Government of Norway 2022). “Because it is very difficult to know how all this really goes, it is not clear to anyone. And that can itself be daunting. There is no such thing as 100% predictability, either in time or process, and then there may be some reason to consider other locations then” (Interview #7).

4.3 Timeline: Lengthy process in securing reliable power

Having a place in the queue does not necessarily provide access to the electricity grid. Until the customer actually holds an access license, there is a risk of not being allowed to access the grid. Critical for the establishment of new industry is the difference in timing between the investment cycle and the grid access cycle. The investment cycle— from starting to evaluate a project until the project should be operative— is normally 3 to 4 years (Interview #5). But accessing the electricity grid can take between 5 to 10 years, or even longer, creating insecurity and lack of predictability for investors (Økland, 2021). “The bottlenecks are in motion,” said a regional grid manager, “but the lack of materials and components in the world market is a growing challenge. Capacity and competence as well. And we’re dependent on goodwill, as power development often encounter opposition from locals, politicians and others” (Interview #2).

As noted by both an industry- group representative and a green industry firm representative, the failure to deliver sufficient electricity at the right time and place results in lost

investment (Interviews #4 and #8). A business association representative we spoke with felt that this was the entirely wrong way to go about getting green industry up and running: "First there's the proposal, then the plan, then building the grid. It's like a 5-year Soviet planning model! But that's not how things work in business— we have to build the grid based on the basis of speculation. This requires public funding and means that the government must take the risk, although business can be asked to contribute funding through taxes. Given the [level of] demand for clean electricity, there is a very low risk of our building the grid too much or too fast" (Interview #5). As a representative of a green industry firm explained, this lack of current capacity means that Norway risks losing investment in green industry altogether: "The system we've had until now does not work for today's needs. And investors don't the patience to wait ten years for electricity access. For Norway to be attractive for investment in green energy, we have to compete with other locations and countries— we need a faster and more efficient process for accessing power" (Interview #8).

4.4 Consequences for the green industry landscape

Due to the uncertainty and lengthy process involved in securing reliable power access, several industrial clusters claim to have lost customers, and local municipalities to have lost jobs. "The main argument [of these lost customers] was precisely the uncertainty related to power. It was impossible for them [the investors] to relate to," one business association representative told us (Interview #5). "We have registered them as lost...companies we have talked to for many months who suddenly withdraw their interest" (Interview #5). In addition, the industrial parks have had to reject several actors due to the long waiting period for electricity access: "Since the summer I have said 'no' to 2400 potential jobs" due to the long time involved in getting access (Interview #5). According to the CEO of another industrial park, with unlimited access to electricity he could have landed five or six green establishments in one to two years (Økland, 2021).

On the eastern coast, a lengthy process for accessing power has also caused several industrial initiatives to relocate. Some are planning to shift their location closer to the central grid in –land, especially for battery factories. "What we see is that these [three battery factories] are now trying to locate themselves as close as possible to the central grid so that at all of them can get access more quickly. No one has time to wait for them to build [transmission] lines, as there

is no reasonable time schedule, and they need access to power *now*", a business association representative told us (Interview #6).

One industrial company we spoke with had announced its plans for a new factory for production of battery materials in 2020. After considering some 30 locations, they chose to locate the factory at an industrial park in southern Norway (NO2). One main reason for choosing this park was that the other areas evaluated did not have enough power at the right time (Hovland, 2020). However, due to the sudden increased competition for access, there is no longer available electricity access at this particular park, and this company is reconsidering the location, as are other industrial initiatives. For instance, two out of three actors in a collaboration for initiating the production of green ammonia in the same industrial park. recently announced their intention to withdraw from the project (Lea & Ghaderi, 2022). As demand for capacity generally exceeds supply most of the projects will be rejected: "We must trust that our project is the one that deserve to get access. Because if it is ten years to next time, our full-scale factory will not be located at the park. We can probably say that for sure" (Interview #8). When the available capacity is allocated, the grid will need to be developed for further industrial activities at the park, which may take over a decade to complete.

In summary, the often unclear, lengthy process of accessing the grid means that green industry firms are inclined to search for geographic locations with pre-existing electricity access. Otherwise, these firms may well choose not to invest in Norway at all, — and Norway risks losing a competitive edge and momentum in its green shift. As one industry park executive pointed out: "We cannot, with all this important new green industry, do things in the old way where it takes 5, 8, or 15 years to get access to electricity. The state needs to put in money and invest in the infrastructure. If not, green industry is going to go elsewhere in Europe, and we are going to lose the leadership we have now in certain areas like carbon capture storage" (Interview #8). Shorter-lead times from planning to development will be crucial for achieving Norway's climate goals and industrial ambitions (NHO, 2021).

5 Conclusion

Access to clean electricity is a key input for green industry, whether greening existing industry or supporting the development of new industries producing environmentally-friendly outputs using environmentally-friendly inputs. This should be easy to achieve in a country like Norway, with

plentiful sources of clean electricity. However, our analysis shows that the management of the electrical grid— from the quantity of available electricity, to how firms can access electricity— hinders green industry firms from accessing power, as well as affecting the establishment, growth and geographical location of green industry. In other words, the formal and informal rules for accessing electricity determine the establishment and operations of green industry firms. Ultimately, this could hinder Norway's progress on its climate goals, as industry is a major producer of greenhouse gas emissions and green industry outputs are important for helping society at large to reduce emissions.

Our exploratory study raises several pertinent questions for future research, within the Norwegian context and beyond. First, Norway's Electricity Grid Commission has now delivered its report, and whether and how its recommendations are taken up by the government should be followed up. Second, comparative studies of other countries should be conducted, to explain how the institutional features of electrical grids shape green industrial company landscapes cross-nationally. Third, we need a better understanding of how access to electricity shapes the perceptions and actions of investors and firms regarding project development and implementation.

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Commented [ML1]: Referenced in Appendix

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