DATA FOUNDATION FOR SCALING ENERGY EFFICIENT MORTGAGES IN DENMARK, NORWAY AND SWEDEN

NEEM HUB

Nordic Energy Efficient Mortgage Hub

8 December 2021

PUBLICATION INFORMATION

The Nordic Energy Efficient Mortgage Hub aims to scale-up lending to energy renovations in the Nordics and will publish a blueprint on how to accomplish this which will be implementable in other regions of Europe and, indeed, the world. In striving to increase energy renovations, the NEEM Hub will help achieve the targets of the European Green Deal and contribute to addressing ambitious national climate targets.

The NEEM Hub will be comprised of a long list of institutions from the financial sector, behavioural scientists, mortgage specialists and authorities, and digital technologies communities from across the Nordics, all guided by leading European Economics Consultancy, Copenhagen Economics.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 101032653.

NEEM HUB
Nordic Energy Efficient Mortgage Hub

Table of contents

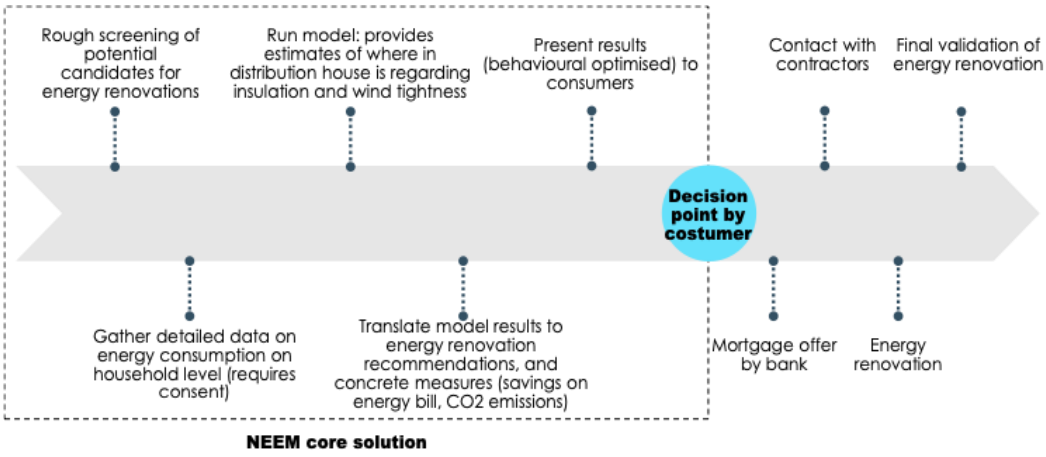
LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Scaling the necessary financing for energy-efficient retrofits, via energy-efficient mortgages or other financial products, calls for a value chain of inputs. This value chain starts with a foundation of data about energy, real estate and weather, data which must be translated into finance-relevant insights for banks and other financial service institutions engaged in the asset class of real-estate. The NEEM project works along this value chain with several pilot banks and focuses on residential real estate limited to single-family privately owned homes. This paper outlines the current state of the supply of digital data available to banks in Sweden, Norway, and Denmark for the purpose of scaling energy-efficient mortgages.

Figure 1
NEEM solution process



Source: Illustration by NEEM consortium

For each of those three countries, the paper develops a data supply profile by describing data available to banks across the four main data categories of 1) energy consumption data; 2) energy production or energy source data; 3) building parameter data; and 4) weather data. It highlights data quality issues or gaps about which a bank must be aware when leveraging a particular data set in a particular country. The paper also looks at the frequency with which data is updated and data resolution in terms of how granular a data set is. It looks mainly at the availability and readiness of data to be deployed by banks for two of the specific NEEM core solutions displayed on the infographic. The first solution is use of data for initial screening of potential candidates in a mortgage portfolio for energy renovations. The second solution is remote identification of the causes of energy inefficiencies (including lack of air tightness, insulation, or behaviours) which are insights to guide design of a renovation package for financing. The latter use case requires dynamic data harvested via smart technology directly from the asset at high frequency (hourly or quarterly). It also requires data on the size

of the house either from the bank loan book or from the real estate registry. Local weather data is also needed.

The reason for focusing on the data foundation for a dynamic approach to real estate screening is because once the low-hanging fruits have been harvested, energy retrofit advice will need to increasingly shift from looking at only one element (e.g., changing the energy source) to screening of the entire building to determine causes of energy inefficiency in order to design cost efficient and scalable energy retrofit packages and financing options. Moving into a flexible energy system, retrofit advice also must include elements of how to leverage the thermal characteristics of the house (for example, using the storage capabilities of walls for energy storage) to ensure retrofit advice is future proof. This requires a dynamic data foundation.

The content of this paper has been generated via web searches, research of technical and API specification documents, literature review, and interviews with private data vendors and hosts of public databases as well as national statistical offices. We would like to specifically extend thanks to Jens Mathiesen of the Norwegian Statistical Office; the team at the Norwegian Elhub; Norwegian Kartverket; Anders Skjøtt and Renato Ezban of the Danish Building Hub; Joel Torkelsson, CEO of Metry.io; Mark Sanctuary, Vice Director of Sustainable Finance Lab Sweden; Tor Brekke, Senior Advisor at Enova; Inger Andreasen, Professor in Integrated Energy Design in the Department of Architecture and Technology at Norwegian University of Science and Technology (NTNU); Trine Engnestangen, Seniorrådgiver Segmentansvarlig Eiendom Kartverket; Stig Frode Opsvik, CEO at Proptech Innovation Norway; Prof. Henrik Madsen, DTU Compute; Rea Parashar, Head of Innovation NCE Finance Innovation; the team at Läntmateriet; Martin Verhage, Data Management Statistics Sweden, EDIEL in Sweden; and Øsedunds Kräft, Vattenfall.

EXECUTIVE SUMMARY

Across the three Nordic countries which are the subject of this paper, the governments and regulators have given the transmission system operators (TSOs) the responsibility to develop and operate data hubs. Today, energy data hubs are up and running in Denmark and Norway and under development in Sweden, with a scheduled start in 2022/2023[1] depending on legislation. However, in Denmark, the Datahub, that country's centralized platform for electricity data and information exchange, only offers centralized access to electricity consumption data, not to data about heating which accounts for the largest part of total energy consumption. These data hubs are not explicitly designed for the use case of scaling finance for energy-efficient mortgages. They are partly a response to the requirements of the Electricity Market Directive (2019/944/EU), which stipulates that validated historical consumption data shall be made available to end customers on request, easily and securely and at no additional cost. These energy consumption data sets are available from both the Norwegian and Danish data hubs via third-party agreements. However, because the Danish Datahub (as noted above) only hosts electricity consumption data, it cannot currently offer the full energy consumption profile of a house to a prospective bank or other financier. Therefore, in Denmark as well as in Sweden access to full consumption data requires several agreements. Below is a brief summary of the main state of data supply in each of the three countries, focused on data needed to deliver on the two NEEM solutions referenced earlier.

Denmark: Real estate data is available for a modelled approach that can be used for a rough screening to identify potential low energy efficiency performing assets within a mortgage portfolio. Real estate parameter data can be accessed via an Application Programming Interface (API) to the national real estate register (the BBR). Statistics on the distribution of Energy Performance Certificates (EPC) per historical build period can be retrieved from the EPC database as input to build a model to roughly estimate EPC across a portfolio. Banks can access EPC data through the EPC database either via address searches or leveraging the EPC calculator of the Energy Authority (Energistyrelsen) to generate an EPC estimation. Another approach to rough screening using BBR data can be to identify households with a fossil fuel-based energy source. Rough screening based on measured energy consumption data directly from the dwelling can give a more accurate energy efficiency estimation, but this approach is currently only possible in limited geographical areas of the country (those areas covered by the Center Denmark and the real estate data lake). A rough screening model could be verified by assessing the modelled results against similar house categories covered by the real consumption data captured in the data lakes.

For the second core NEEM solution of screening individual dwellings, data is most readily available via the data lake. In order to screen real estate in other

[1] (2020) Implementation of Data Hubs in the Nordic Countries. NordReg, Nordic Energy Regulators.

parts of the country, a bank will need to sign data agreements with heating utilities covering a given set of addresses, and also sign a third-party data agreement with the Datahub, Denmark's central platform for electricity data and information exchange. Access to real estate parameter data in Denmark can be obtained via an API to the BBR real estate register which includes data on floor size of the house, heating source, and in some cases also includes information on retrofits undertaken. The BBR register does have data quality concerns, as its frequency of update is low and often the actual retrofits are not properly registered.

Norway: Data to undertake rough screening to identify the most energy inefficient parts of a bank portfolio will need to take a modelled approach in Norway. This is because of the data gaps in floor-size data in the real estate registry and because it is currently not possible to access large, anonymised datasets of energy consumption data from the Elhub. These data gaps inhibit a dynamic and more building-specific approach to screening. Instead, a bank can leverage data from the EPC label database, using statistical data on the distribution of EPC per building code for single family homes as input to design a modelling approach. This model could for instance be built by assessing the energy use per square meter allowed per building code and screening the bank portfolio for building code distribution and converting to estimated EPCs. Or it can be done by using the EPC database statistics to develop a classification of estimated EPC per building code. The EPC database offers access to data (although not yet via an API, which will only be available next year), so banks can order data delivered in pdf files or directly via searches in the EPC open statistics on the EVONA website.

For the second NEEM use case of building-specific screening and identification of the causes of energy inefficiencies, data from the Elhub can be leveraged except for buildings in areas with district heating. It is high frequency data of hourly consumption values. It is a single aggregate energy consumption value, not split as to how much is spent on heating versus general electricity use. Combined with floor-size data from the real estate register, hosted by Kartverket via Matrikkelen API, it is possible to identify main energy inefficiency causes. It is not a regulatory requirement in Norway to register the floor size of a building so this data point may be missing for older houses in the Matrikkel API. For these buildings the bank can either use its own data if available, ask the customer to input the data, or estimate the floor size using map data from the Norwegian statistical office and street view maps. The more time- and labor-intensive nature of the latter option will generate transaction costs.

Sweden: A rough screening model for a bank real estate portfolio in Sweden can leverage the EPC API to develop a distribution of energy labels of single-family homes per build year as data input to design a screening model. Another approach can be to leverage scientific literature or other knowledge products to identify parts of the housing stock with high likelihood of low energy performance. According to the Individual Building Renovation Roadmap for Sweden 2.2 million (44 percent of total residential buildings) in Sweden are single family

houses.[2] Around 715,000 single-family dwellings were constructed between 1961 and 1980. The average energy use of those houses is approximately 40 percent higher compared to houses constructed between 2011 and 2013. To screen a portfolio for mortgage clients with houses built in this period between 1961 and 2980 a bank can leverage the Byggnad API of Boverket. According to the Swedish Energy Agency the total number of single-family houses with an oil heating source was in 2020 estimated at 57,000 homes, but it is not possible to get addresses or other building identification on these.

The data foundation in Sweden for the second NEEM use case of building-specific screening is more fragmented because of the absence of a datahub. Here banks need to sign agreements with the grid operator and get a Letter of Attorney to access hourly energy consumption data.

[2] https://epbd-ca.eu/wp-content/uploads/2018/08/CA-EPBD-IV-Sweden-2018.pdf

DATA FOUNDATION IN DENMARK

The data foundation in Denmark is characterised by easy access to real estate data through the BBR register, which does have data quality issues due to low update frequency and user-generated inputs. However, compared to real estate registries in the two other countries, the number of open data points (including energy source, floor size, etc.) is higher and highly relevant to the NEEM use cases. Banks in Denmark also have access to high frequency electricity consumption data via the Datahub, but access to energy use for heating and water is more decentralised and fragmented. For that information, the bank will need to enter into data agreements via the district heating companies in various areas of the country.

Table 1
Data sources in Denmark

	CONSUMPTION DATA	REAL ESTATE DATA	METEOROLOGICAL DATA	EPC-DATA
Description	Datahub database with hourly metering data from all households.	Real estate data from Bolig- og Bygningsregisterets open API (DAWA).	Weather data from DMI Open Data API.	Energistyrelsens complete database of EPCs. requires contact to ENS.
Link to database access	https://energinet.dk/El/DataHub or https://www.centerden-mark.com/da/dataplatformen/kob-adgang-til-dataplatform/	https://dawadocs.dataforsyningen.dk/dok/bbr or https://www.centerden-mark.com/da/dataplatformen/kob-adgang-til-dataplatform/	https://confluence.govcloud.dk/display/FDAPI or https://www.centerden-mark.com/da/dataplatformen/kob-adgang-til-dataplatform/	https://sparenergi.dk/forbruger/vaerktoejer/find-dit-energimaerke or https://www.centerden-mark.com/da/dataplatformen/kob-adgang-til-dataplatform/

ENERGY PERFORMANCE CERTIFICATE LABEL DATA

In Denmark there is an EPC database with a search function allowing searches of EPC labels and reports on addresses. Out of a total of 1,582,000 single-family detached homes in Denmark, approximately 1,000,000, or 63 percent, have EPC labels. Each year approximately 70,000 homes in this category gets an EPC. The number of EPCs that expire each year is unknown, but since 2016 the total number of active EPCs has risen from approx. 700,000 to 1,000,000. All EPCs are publicly available. The connected API is free of charge and access is possible via the Danish Energy Agency.

ENERGY CONSUMPTION DATA

The energy consumption of Danish buildings is predominantly heating, which primarily consists of district heating (64 percent) and natural gas (16 percent). The rest is a mix of various heating sources. The Danish Energy Agency decreed in 2013 that all electricity meters in Denmark had to be replaced by smart meters. By 2020 the installation was complete for all measuring points in Denmark. To reap the benefits of smart meter monitoring of electricity consumption, Energinet.dk was put in charge of establishing the Datahub which, as noted above, is an electricity data hub and a centralized information exchange system for the electricity retail market. The Datahub contains data on consumption and production of electricity (energy source) and different market processes from all readable electricity metering points in Denmark. The Datahub contains hourly data on consumption and production from all metering points in Denmark and the hourly data is sent from the distribution network companies to the Datahub once per day. The Datahub functions as a hub for the automatic exchange of information between power grid companies and power suppliers, and all these companies are digitally connected to Datahub 24 hours a day. Data access is free for all market actors including third parties. Third parties must have written permission to access customer data from the Datahub.

Datahub has power consumption metering points for all consumers and energy production metering points (summationsmålere) for consumers who produce their own energy via solar power. Energy production data is only available from the summationsmålere. This is only if the house can use a local energy source such as solar cells, where a combined meter can grant access to data about the quantity of local energy produced. Metering points have location data either as coordinates or addresses. All data must be available with intervals of maximum 15 minutes. For an institution to access Datahub data via a third-party agreement the following requirements must be fulfilled: 1) The company must document its corporate purpose, as well as the purpose of collecting data; 2) The company must be a broker, energy advisor, service provider, or have authorization for data collection; 3) It must register via valid NemID company signature; 4) Have its own webpage, and 5) Be VAT-registered in Denmark or another EU country. Read more here.

Denmark has two data lakes intended to become one-stop shops or platforms for a full real estate data profile with energy consumption, production and building parameter data. Both data lakes are in their early stages of establishment and development. The first is the Center Denmark data lake which offers data on household energy consumption in addition to real estate data from the BBR via one platform for 150,00 households both as anonymized and non-anonymized data. The API to the data lake provides near real-time consumption data updated every 1-2 minutes directly from smart meters, with some of the formal and stable data points being updated once per day. The data is already available through the Center Denmark Data Lake for a few geographical areas. The Real Estate Hub (bygningshubben) is a project which intends to have data on energy consumption (not real-time) and real estate parameter as well. Currently there are only plans to cover the geographical location of Aarhus municipality, defined by the 62,000 customers of the local district heating company AffaldVarme Aarhus. The building hub is expected to be accessible sometime in 2022.

METEOROLOGICAL DATA

The Danish Meteorological Institute's (DMI) official data sources are freely available to the public for use, dissemination and further processing. DMI's raw data derives from measuring instruments, surface stations, aircraft measurement, radiosondes, ships, buoys, weather radar and satellites, and is used in a three-dimensional variational data assimilation. DMI has an API which is freely accessible via their confluence site. The data is available free of charge for everyone provided no changes are made to the data. Weather-related raw data derives directly from weather stations, and is updated every ten minutes for measured temperature, wind direction, wind speed, and radiation mean intensity. The weather forecasts are updated every hour, for the coming 48 hours. This weather data is also available through the Center Denmark Data Lake which already has a connection to the DMI API correlating energy data with weather data. There is a potential to enable access to localized weather data through a combination of data from meteorological data and data from local measuring stations and forecast services. During the NEEM project, the Center Denmark Data Lake will add the needed data points for the NEEM use cases. The building hub is also working on correlating weather, building and energy data.

REAL ESTATE DATA

The Danish Bygnings- og Boligregistret (BBR) contains real estate data for all households in Denmark, including construction year, geolocation, heating source, size of property, total floor areas, number of rooms, and several other data (such as water supply, secondary buildings, construction materials and roof type). The responsibility of updating the register is divided between the municipality and the owner. The municipality has the formal responsibility but can issue fines for up to 5,000 DKK if the registered data is wrong. In terms of quality of data, the following parameters are of very high quality: 1) construction year; 2) geolocation; 3)

size of property; 4) total floor area; and 5) number of rooms (and number of floors).

The following relevant data is of lesser quality, due to deficient data entries from district heating companies and owners: 1) Heating source; and 2) Energy consumption (only available for some properties). Detailed information of regulations and limitations to alterations of properties is described in local plans and easements (servitutter) as well as the general rules of Building Regulations (bygningsreglementet (BR-18)). BBR has an open API called Danmarks Adressers Web API (DAWA), which is accessible to anyone if the use of data complies with GDPR.

DATA FOUNDATION READINESS FOR TWO NEEM USE CASES IN DENMARK

Rough screening of potential candidates for energy renovations: A bank can mirror the EPC calculator on their website in Denmark offering clients to estimate EPC of their home. Banks can also use the BBR register to identify the addresses in their loan book with a fossil fuel energy source as a first identification of energy efficiency financing needs. In addition, banks can use the EPC estimator to arrive at a rough distribution of energy labels across the loan portfolio. Center Denmark can deliver anonymised data sets for the households in the data lake, making it possible for a bank to conduct an EPC estimation via dynamic data inputs on actual energy consumption. This could be compared with the results of the rough modelling as a means of verification.

Gather detailed data on energy consumption on household level: For the use case of screening an individual single-family house to help the client assess causes of energy inefficiency, the necessary data is most readily available in Denmark via one of the two energy data lakes. For real estate mortgage clients in other parts of the country, a bank will need to sign a third-party data agreement with one of the two data lake solutions, however, this will only enable screening on a limited part of the mortgages in the portfolio. In addition, a digital consent must be secured from the energy users.

DATA FOUNDATION IN NORWAY

The data foundation in Norway is characterised by easy access to high frequency energy consumption data via one centralised database. Because Norwegian single-family homes are mainly powered by electrified heating, the data from the centralised Elhub captures the total energy consumption per piece of real estate via smart meters. The real estate registry data is less complete in terms of data points for the relevant NEEM use cases, chiefly because key data points (e.g., floor size) are not mandatory to report to the real estate register.

Table 2
Data sources in Norway

	CONSUMPTION DATA	REAL ESTATE DATA	METEOROLOGICAL DATA	EPC-DATA
Description	Elhub database with hourly metering data from all households	Lantmäteriet Byggna direkt API	Weather data from Open API	National EPC-database hosted by Enova at
Link to database access	https://elhub.no/en/	https://www.lantmateriet.se/sv/Kartor-och-geografisk-information/geodataprodukter/produktlista/byggnad-direkt/	https://api.met.no/	https://www.energimerking.no/

Norway has a national EPC database which currently does not offer an API but meteorological datasets are available through the MET open API version 3.0.

ENERGY PERFORMANCE CERTIFICATE LABEL DATA

Out of a total of 1,838,000 single-family homes in Norway, 662,000 or 36 percent, have an Energy Performance Certificate. Each year approximately 50,000 homes in this category get an EPC, usually when they are put on the market for sale. Currently regulations are under revision and once this is finished in 2022 the EPCs labels will most probably be publicly available.

Norway has a national EPC database managed by Enova, which is an entity owned by the Norwegian Ministry of Climate and Environment responsible for operation and development of the EPC system. Enova offers third-party access to

data from the energy label programme for use that is in line with the programme's purpose. A bank wanting to use the data for energy efficient mortgages is considered aligned with the purpose and can therefore access data from the national EPC database without cost. Currently the EPC system is being further developed, and an API will be made available in 2022. Until then, a monthly file containing EPC data (limited to the central indicators) can be made available to banks upon application. Most banks in Norway issue green loans based on these data according to the Enova interview conducted as part of this mapping. The Enova EPC database has a searchable statistical function, where it is possible to retrieve data on distribution of EPC labels per building code for different categories including single-family houses.

ENERGY CONSUMPTION DATA

The share of fossil fuel is very low and declining.[3] The fuel mix in Norwegian district heating production in 2019 included only 5 percent from fossil fuels (oil and gas). In 2019, the Norwegian power production was 98 percent renewable (NVE3). The Norwegian Water Resources and Energy Directorate (NVE) decreed on the 24th of June 2011 that all electricity meters in Norway had to be replaced by smart meters. By the beginning of 2019 the installation was complete for 97 percent of all measuring points in Norway.[4] To reap the benefits of smart meter monitoring of electricity consumption, Statnett was put in charge of establishing a data hub (Elhub). Like Denmark's Datahub, the Norwegian Elhub is an electricity data hub and a centralized information exchange system for the electricity retail market. It contains data on consumption and production of electricity (energy source), but does not cover real estate in Norway with district heating.

Elhub contains hourly data on consumption from all metering points in Norway. The Elhub receives and processes approximately 70–80 million-meter readings and 150,000 market messages daily. In 2023 the Elhub will meet the requirement for a 15-minute interval in the power market. Data access is associated with a third-party annual fee and an additional user fee. The current fee levels were established at the start of 2019 and run until end 2022. Third-party users pay a fixed fee of 4,500 Norwegian kroner (NKR) per month. An additional fee is collected the last week of every month per meter point data. This is a differentiated fee structure and third-party data users pay the lowest fee of 0.28 NKR per month per metering point.[5] Houses can have multiple meters reporting to Elhub, a main meter and sub-meters.

Most metering points have location data either as coordinates or addresses, but this is currently not mandatory data, so data gaps can occur. Currently, about one-third of metering points have GPS location. For an institution to get access to Elhub data via a third-party agreement a Norwegian registration number is

---

3 (2021) Norwegian Energy Efficient residential Buildings, Multiconsult.

4 https://ec.europa.eu/eurostat/cros/system/files/admin_wp6_2018_no.pdf

5 Electricity fee structure. Original titel: "Elhub gebyrer, version 2.0, gjeldende fra 01.01.2020".

required. It is also possible to test in the Elhub test environment with a Norwegian registration number. The test environment does not offer real consumption data sets but simulated data.

METEOROLOGICAL DATA

The Norwegian Norwegian Meteorological Institute's (MET) official data sources and products are freely available via open APIs. Customised data incurs a start-up charge and an annual management charge, but the information itself is still free. Guaranteed deliveries are priced to cover the cost of monitoring and a share of the infrastructure used to maintain a stable supply. MET's raw data derives from its own measuring instruments, visual observations, and quality assured data from third-party measurements. Large parts of MET's data and products are available from MET's self-service download services such as the weather API which is available for use under a Creative Commons license. These weather data points are also available for sourcing from the EU Copernicus database.

REAL ESTATE DATA

Data on building parameters can be sourced from the national property register (Matrikkelen). The register is under the jurisdiction of the Land Department of the National Cartographic Authority of Norway (Kartverket). Local cadastral services are under the jurisdiction of municipalities which are responsible for data entry in the cadastre. In its turn, the National Cartographic Authority coordinating the work of municipalities in this area summarizes information and maintains the register. A unique cadastral number is assigned to each property.

Kartverket provides companies with electronic access to information from both Matrikkelen and the Cadastre database via an API. This API access does not require a Norwegian registration number. Access allows for searching, viewing, and downloading all or part of the contents of the databases. Access is granted on standard terms set by the Kartverket for entities that have the authority to process the information in accordance with set regulations. Banks are among the types of enterprises allowed electronic access via an API to all information, but this does require an application via email to Kartverkets.

Not all buildings in the API contain data on floor size of building, which is a key dataset to enable banks to calculate current energy efficiency, generate automated retrofit advice, and calculate the potential savings from retrofit investments. It is not required by law to enter the floor size (bruksareal) of a building into the registries, and the largest data gaps on building floor size is found in the older housing stock. In order to estimate floor size of houses where that data field is missing from the real estate register, it is possible to acquire roof sizes from the statistical offices and then use satellite photos and street view photos to estimate number of stories in the house and thereby estimate floor size.

DATA FOUNDATION READINESS FOR TWO EEM USE CASES IN NORWAY

Rough screening of potential candidates for energy renovations: Data to undertake rough screening to identify the most energy inefficient parts of a bank portfolio will need to take a modelled approach in Norway. This is due to the data gaps in building floor size in the real estate registry as well as the fact that it is currently not possible to access large anonymised datasets of energy consumption data from the Elhub. These data gaps inhibit a dynamic and more building-specific approach to portfolio screening. Instead a bank can leverage data from the EPC label database using statistical data on the distribution of EPC per building code for single-family homes as input to design a modelled approach. This can either be done by assessing the energy use per square meter allowed per building code and then screening the bank portfolio for building code distribution in order to convert building code distribution into estimated EPC distribution. Another method could be to use the EPC database statistics to develop a classification of estimated EPC per building code.

Norway has Europe's highest share of renewable energy in power production. By 2019, some 1.4 million electric heat pump units had been sold in Norway according to the European Heat Pump Association. Today 60 percent of single-family homes have heat pumps. Norway's rapid adoption of heat pumps was spurred by a series of cold winters, an increase in electricity prices, grants, and bans on old boilers. Still retrofitting is needed because despite the country's significant amount of clean hydropower, the capacity is not sufficient to cover the need for electrification of the transport and industry sectors as Norwegians consume more energy per household than other countries in the Nordic region.[6] Energy renovation of existing buildings will be a cost-effective way to 'free up' electricity for use in other sectors where it will replace the use of fossil fuels. Research shows that in the post-war period, many single-family homes were built that today need an energy efficiency upgrade. Looking at typical houses constructed between the 1960s and the 1980s, research points to the following priority upgrade measures: 1) improved airtightness of the building envelope; 2) improved insulation of the building envelope; and 3) installing balanced ventilation with heat recovery.[7] Identifying those houses that are built in this period or earlier can be done via data from the statistical office or the real estate register.

Gather detailed data on energy consumption on household level: For this use case a Letter of Attorney is needed from the customer to pull energy consumption data from the Elhub and combine this with floor size data from the real estate database via the Metriklen API. This data will need to be combined with local weather data from the MET open API. If the floor size data field is empty in Metriklen, then the bank can either get roof sizes from matrikel styrelsen or get floor size form the customer directly. Using roof size as a proxy for floor size can

6 https://spabol.sparebank1.no/2016/norwegian-environmental-housing

7 Insights from an interview with NTNU.

be challenging as there is still the need to determine the number of floors in the house. This data is currently not available in the public registries and, as noted above, would require using Google street view or other satellite-based data points to estimate[8] the height of the house, then estimate the number of storeys based on that height, and then further estimate floor size based on that estimated number of storeys.

[8] https://blogg.sintef.no/sintefenergy-nb/utslippsfrie-nabolag-i-norge-kan-endre-det-europeiske-kraftmarkedet/

DATA FOUNDATION IN SWEDEN

The data foundation in Sweden is characterised by a higher degree of fragmentation than the other two Nordic countries. This is mainly due to the decentralised structure of the energy consumption data infrastructure, which means that energy consumption data will need to be obtained from the grid companies with end users' permission (obtained via digital signature).

Table 3
Data sources in Sweden

	CONSUMPTION DATA	REAL ESTATE DATA	METEOROLOGICAL DATA	EPC-DATA
Description	Need agreements with the grid operator in the area of Sweden	Lantmäteriet Byggnad API	SMHI Open Data	National Board of Housing, Building and Planning's API to the EPC database (Boverket)
Link to database access	https://natomraden.se/	https://www.lantmateriet.se/sv/Kartor-och-geografisk-information/geodataprodukter/api-portalen/	http://opendata-catalog.smhi.se/explore/	https://www.boverket.se/sv/om-boverket/publicerat-av-boverket/oppna-data/publikt-api-for-energideklarationer/

ENERGY PERFORMANCE CERTIFICATE LABEL DATA

The Energy Performance Certificate system is run by Boverket, which is responsible for the supervision, control and management of the national EPC database. Boverket offers an EPC API. Through the API it is possible to access the basic information in an energy declaration. The API is only available to companies and to gain access, companies must apply via the Boverket website. The API only gives access to basic EPC information including: the building's energy performance, energy class, energy declaration ID, property designation, municipality, address and date of energy declaration, and whether mandatory checks have been performed of the ventilation system and to measure radon. This basic information accessed via the API is provided free of charge. Berverket publishes statistics on EPC labels as total numbers but not in terms of distribution, which is almost 700,000 to date. To develop a distribution of EPC labels according to build year, there is a need to link the building ID from the EPC database to the API in Boverket. The

EPC API does have a number of limitations including a maximum of 1500 calls per day for data access, 40,000 kilobytes limit per day, and 10 calls per second.

To access the API a company must complete and submit a standard application form to Boverket but as noted earlier, API access is free of charge for approved uses. A company is not allowed to use the data from the API for direct marketing and may not provide access to, transfer or otherwise disseminate the information to an external party. There will also be restrictions on the number of downloads. The Sustainable Finance Lab Sweden is currently undertaking research to develop a tool for assessing EPC distribution in Sweden. The ambition is to offer full coverage of all Swedish buildings, including residential buildings. The tool is under development and a beta version will be ready for testing later in 2022.[9]

ENERGY CONSUMPTION DATA

Currently there is no centralized data hub in Sweden to host smart data on household energy consumption. The Swedish kraftnät and the Swedish Energy Markets Inspectorate (Energimarknadsinspektionen, Ei) have been assigned by the Swedish Government to establish a data hub that will encompass all metering data for the electricity market. The board at Svenska kraftnät decided on the 22nd of September 2020 to put the project working with the development of the Elmarknadshubb on hold due to delays in the legislation. The government will return with a bill on proposals for regulation of the Electricity Market Hub, after which it will be handled by the Riksdag before it can become law. Svenska kraftnät's assessment is that the entire process will take at least two years, and that the initial necessary legislation is unlikely to be adopted earlier than the second half of 2022.

Hence, Sweden currently has a decentralised system, where energy consumption data requires agreements with grid operators and explicit permission from the end user. For dwellings using district heating, data is accessible via the heating utilities upon purchase of a file or via customer log-in. This relatively fragmented energy consumption data market has resulted in a number of platforms offering integrated data solutions such as the Metry.io solution, which currently offers energy consumption data for commercial real estate.

METEOROLOGICAL DATA

Weather data can be accessed via an open API through the SMHI (Swedish Meteorological and Hydrological Institute) under the Ministry of the Environment. SMHI's observation stations collect large quantities of data, including hourly temperature data, precipitation, wind speed, air pressure, lightning, solar radiation and ozone. Data is presented continuously on smhi.se and used in SMHI's various weather services. In the Explorer SMHI´s data is available with open access (in Swedish). For more information and to use the SMHI´s open data, please

[9] https://www.svk.se/utveckling-av-kraftsystemet/systemansvar--elmarknad/elmarknadshub-ben/

see the Open data API Documentation. As previously highlighted, it is possible to obtain location-specific weather data through a combination of weather data sources.

REAL ESTATE DATA

Lantmäteriet (the Swedish mapping, cadastral and land registration authority) maps the country, demarcates boundaries and helps guarantee secure ownership of Sweden's real property. Access to building parameter data for single-family dwellings requires an application to Lantmäteriet for access to the "Byggnad API."[10] The API supports property-specific searches via the address or building ID. Available data includes build year, time of latest construction work, any building remark Information, description of the building's constituent parts (e.g., roofing material type, facade etc.) as well as list of changes to the building including changes to building size.

DATA FOUNDATION READINESS FOR TWO EEM USE CASES IN SWEDEN

Rough screening of potential candidates for energy renovations: A rough screening model for a bank's real estate portfolio in Sweden can leverage the EPC API to develop a distribution of energy labels of single-family homes per build year as data input to the design of a screening model. Another approach can be to leverage scientific literature or other knowledge products to identify parts of the housing stock with high likelihood of low energy performance. According to the Individual Building Renovation Roadmap for Sweden, 2.2 million (44 percent of total residential buildings) in Sweden are single-family houses.[11] Around 715,000 single-family dwellings were constructed between 1961 and 1980. As in other countries, the average energy use of these older Swedish houses is approximately 40 percent higher than the corresponding energy used in houses constructed between 2011 and 2013. To screen a portfolio for mortgage clients with houses built in this period a bank can leverage the Byggnad API of Boverket.

Gather detailed data on energy consumption on household level: Electricity is the most common energy source for heating in houses in Sweden, followed by biofuels and district heating.[12] Fossil fuels have largely been phased out.[13] Because, as noted earlier, there is currently no centralized data hub in Sweden, access to hourly meter data requires an agreement with a grid operator and a Letter of Attorney.

---

10 https://www.lantmateriet.se/sv/Kartor-och-geografisk-information/geodataprodukter/produktlista/byggnad-direkt/#steg=3
11 https://epbd-ca.eu/wp-content/uploads/2018/08/CA-EPBD-IV-Sweden-2018.pdf
12 https://energimyndigheten.a-w2m.se/Home.mvc?ResourceId=198022
13 https://www.sciencedirect.com/science/article/pii/S0301421520304080

CONCLUDING REMARKS

The data foundation across all three countries is defined by different degrees of fragmentation, with Sweden having the lowest degree of data foundation readiness for the two NEEM core use cases. In Denmark the geographical areas covered by the two data lakes are most ready for both NEEM core use cases, even though this will not result in a nationwide sample of the bank mortgage portfolios. In Norway the data infrastructure is ready for testing of both NEEM core solutions although there will be specific data challenges to overcome if the data about floor size proves to be missing for a high percentage of the mortgage sample. The magnitude of that data challenge can only be assessed against the specific Norwegian address sample. Alternatively, the project can buy data from the Norwegian Statistical Office for municipalities that have few data gaps on single-family home floor sizes. As the least ready for testing of the two NEEM core solutions, Sweden will need identification from the bank mortgage portfolios of targeted municipalities for testing and then discussions with the grid providers or adoption of an approach where end users themselves enter data into a user interface.