

Delivery no.: 2.2.a and 2.2.b Design specification



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Preface

EnergyLab Nordhavn – New Urban Energy Infrastructures is an exciting project, which will continue until the year of 2019. The project will use Copenhagen's Nordhavn as a full-scale smart city energy lab, which main purpose is to do research and to develop and demonstrate future energy solutions of renewable energy.

The goal is to identify the most cost-effective smart energy system, which can help counteract the climate challenges the world are facing.

Budget: The project has a total budget of DKK 143 m (€ 19 m), of this DKK84 m (€ 11 m) funded in two rounds by the Danish Energy Technology Development and Demonstration Programme (EUDP).

Forord

EnergyLab Nordhavn er et spændende projekt der løber til og med 2019. Projektet vil foregå i Københavns Nordhavn, og vil fungere som et fuldskala storbylaboratorium, der skal undersøge, udvikle og demonstrere løsninger for fremtidens energisystem.

Målet er at finde fremtidens mest omkostningseffektive energisystem, der desuden kan bidrage til en løsning på de store klimaudfordringer verden står overfor nu og i fremtiden.

Budget: Projektets totale budget er DKK 143 mio. (EUR 19 mio.), hvoraf DKK 84 mio. (EUR 11 mio.) er blevet finansieret af Energiteknologisk Udviklings- og Demonstrationsprogram, EUDP.

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1. Introduction

Radius Elnet has the responsibility of ensuring [delivery](#) of [electric power](#) to approximately 960.000 homes and businesses in the Copenhagen area, Frederiksberg and Northern Zealand, as illustrated by the dark area in Figure 1.

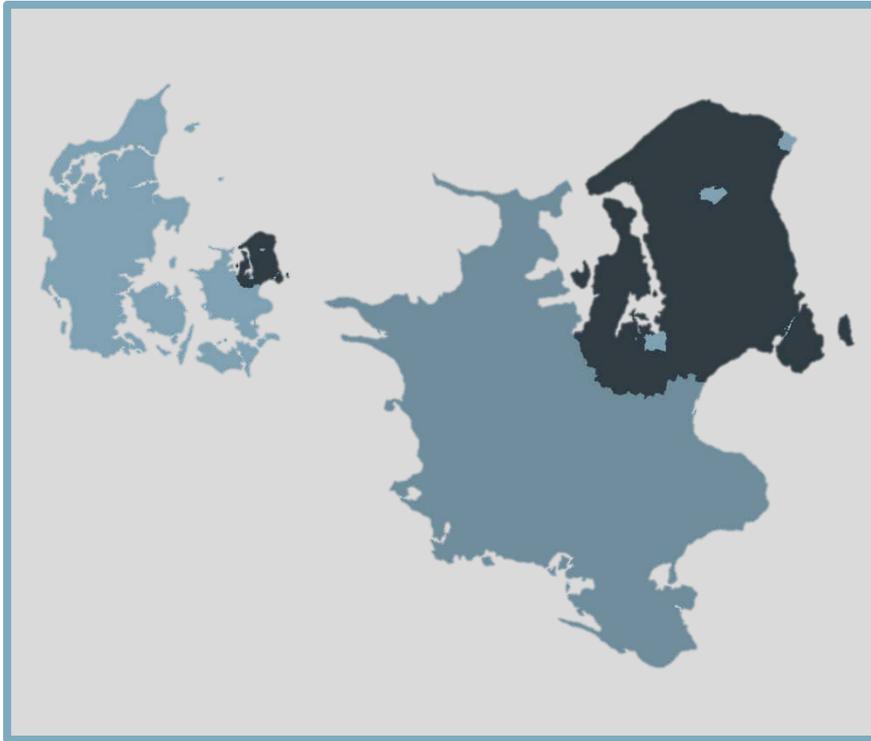


Figure 1 – Radius Elnet area of supply.

To facilitate a high level of security of supply, Radius Elnet is continuously improving the grid, which entails that monitoring, maintaining, and expanding the grid is an ongoing process.

In urban areas, expanding and establishing electric infrastructure can be extremely expensive, which entails that an accurate dimensioning of the grid is an imperative requirement for a cost-efficient operation.

2. Energy Lab Nordhavn (ELN) customers

ELN customers are located in Århusgade area, Sundkaj area and Levantkaj Vest area. In these areas, Energy Lab Nordhavn customers and partners are in the construction areas 1.07, 1.11, 1.13, 1.15, 1.16, 1.17, 1.30, 4.01, 5.03, 5.10, 5.18 all shown in figure 2. These construction areas furthermore include customers outside the ELN project. Apartments with ELN customers are mixed in the buildings with apartments with customers outside the ELN project.

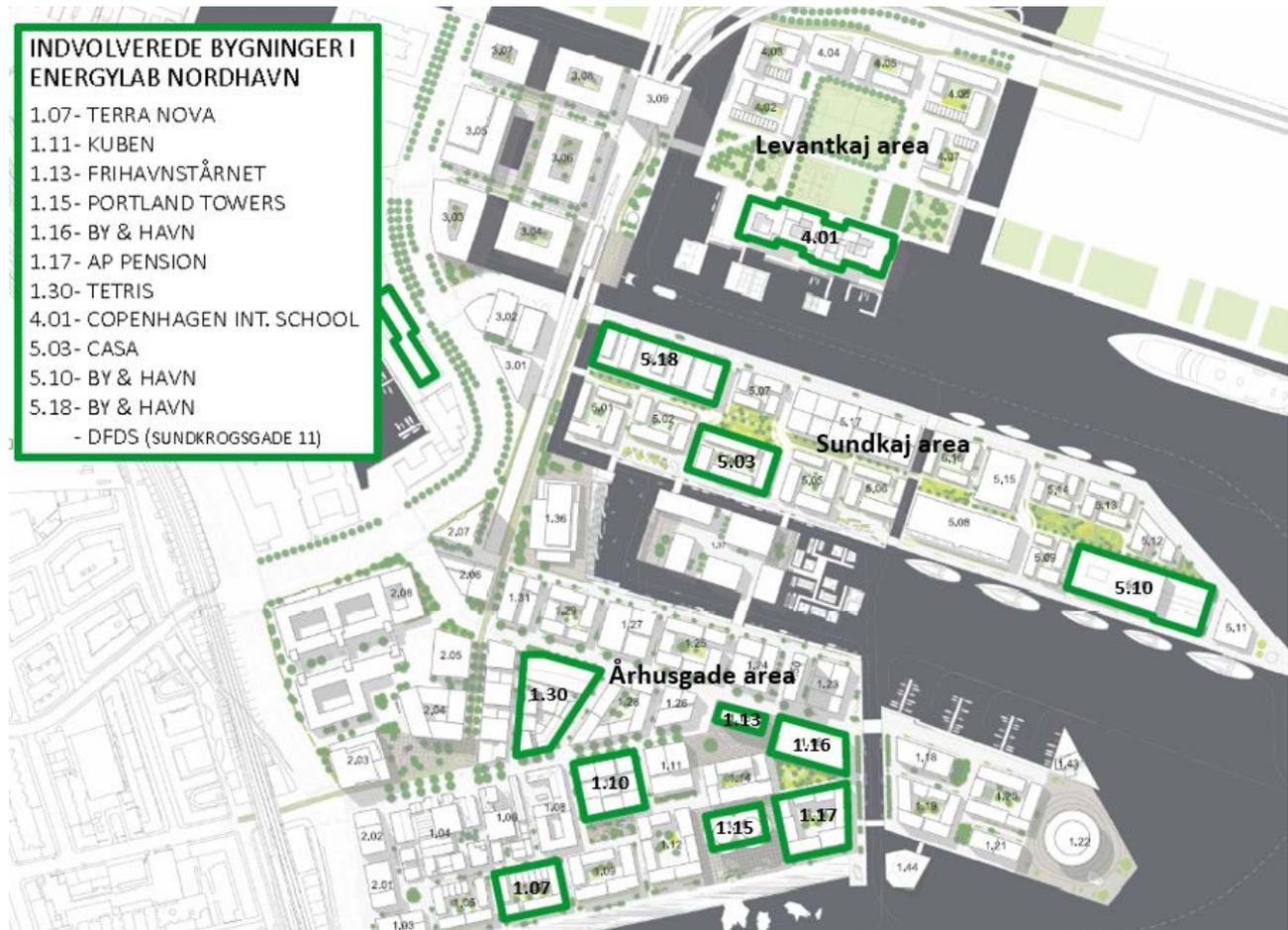


Figure 2

3. 10 kV grid in general

The 10 kV grid feeding Nordhavn is schematic build as shown in figure 3. Each feeder is named starting with the primary substations initials followed by a number, e.g. "NGT 65" for "Nyborggade transformer station". In chapter four is listed the specific feeders feeding ELN customers in the Nordhavn area.

10 kV busbars in primary
secondary substation
Nyborggade (NGT)

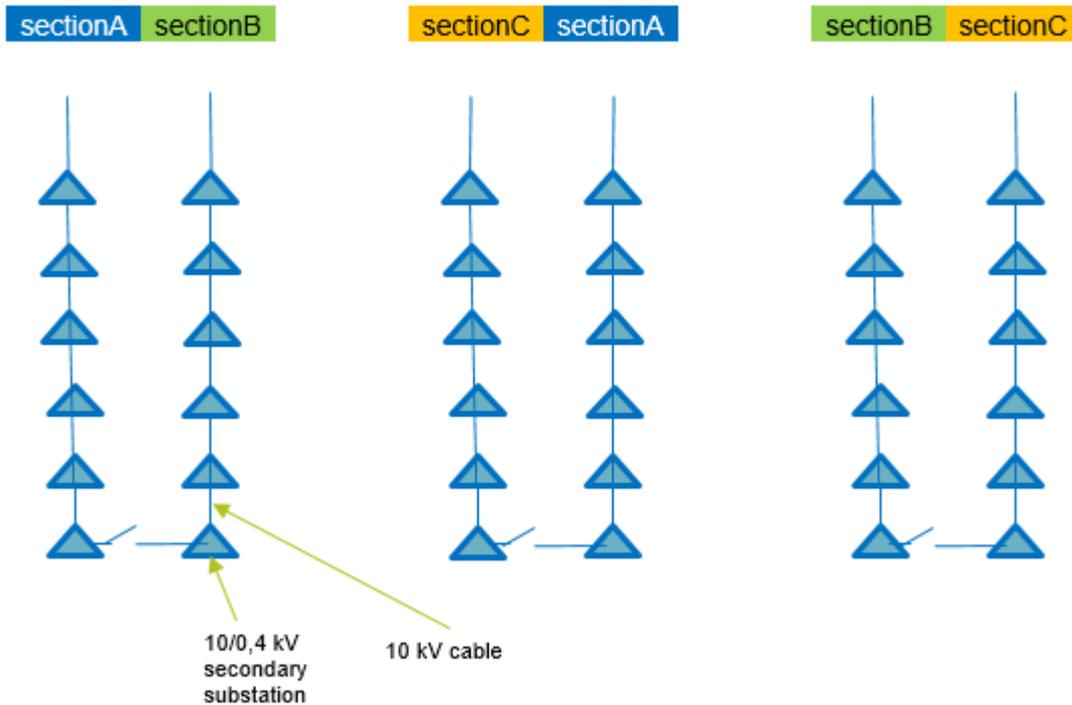


Figure 3

4. 10 kV grid measurement in Nordhavn

In order to get the Battery Energy Storage System (BESS) to do peak shaving, the algorithm needs load information from the 10 kV loop feeding BESS (NGT 08 and NGT 65, figure 4). We therefore establish measurements in these 10 kV feeders. In addition to these two measurements, we plan to measure all 10 kV feeders feeding Nordhavn areas containing ELN customers (areas mentioned in chapter 2). All 10 kV measurements are installed in the Primary Substation Nyborggade (NGT). This gives us measurements in the following feeders:

10 kV feeders in Århusgade area (figure 4):

NGT 16 supplying TETRIS, PORTLAND TOWERS, TERRA NOVA, FRIHAVNSTÅRNET, KUBEN

NGT 08 supplying only customers outside ELN project. Measurement used for peak shaving.

NGT 65 supplying AP PENSION, BESS. Measurement used for peak shaving.

NGT 56 supplying only customers outside ELN project.

Feeder in Sundkaj area (figure 5):

NGT 15 supplying CASA

Feeder in Levantkaj area (figure 6)

NGT 57 supplying COPENHAGEN INTERNATIONAL SCHOOL

All feeders mentioned will have ELN customers as well as not ELN customers. These data are now accessible for the DTU data warehouse. Resolution and communication interface is given in table 2 in chapter 7.

The measurements are only measured as current. For the BESS algorithm, we must calculate the power/energy via the equation: $U \times I \times \sqrt{3}$. It is therefore not possible to get the direction of the energy. As we see it, the direction always will be outgoing from the primary substation towards the grid. The local energy production is too low, compared with the load to make the power & energy to flow from the grid towards the primary secondary substation. Furthermore, we only inject energy into the grid, when NGT load is bigger than set point for peak shaving.

The 10 kV grid schematic topology and geographic placement of the 10/0, 4 kV secondary substations in Århusgade area

The top of the figure shows the three loops with its specific 10/0.4 kV secondary substations feeding Århusgade area. The loops are colored

GREEN (NGT 16 – NGT 59)

BLUE (NGT 08 – NGT 65)

YELLOW (NGT 56 – NGT 39)

The loops have each an open circuit breaker (x) which divides each loop into 2 feeders, e.g. GREEN (NGT 16 – NGT 59) is in normal operation two independent feeders NGT 16 and NGT 59.

The secondary substations are also showed where they are placed geographical, and have the color responding to the 10-kV loop from which they are fed.

Furthermore, the figure has a little scheme, telling the number of customers that are fed from each feeder. These customers are ELN customers as well as customers outside the ELN project.

The 10-kV grid schematic topology and geographic placement of the 10/0, 4 kV secondary substations in the Sundkaj area

The top of the figure 5 shows the loop schematically with its specific 10/0.4 kV secondary substations feeding the Sundkaj area. The loop are colored PURPLE (NGT 15 – NGT 55)

The loop has an open circuit breaker (x) which divides the loop into 2 feeders.

The geographical location of the secondary substations is also shown, and is colored purple corresponding to the 10-kV loop from which it is fed.

Furthermore, figure 5 have a little scheme, telling the number of customers that are fed from each feeder, e.g. 88 from NGT 15 and 138 customers from NGT 55 respectively. These customers are ELN customers as well as customers outside the ELN project.

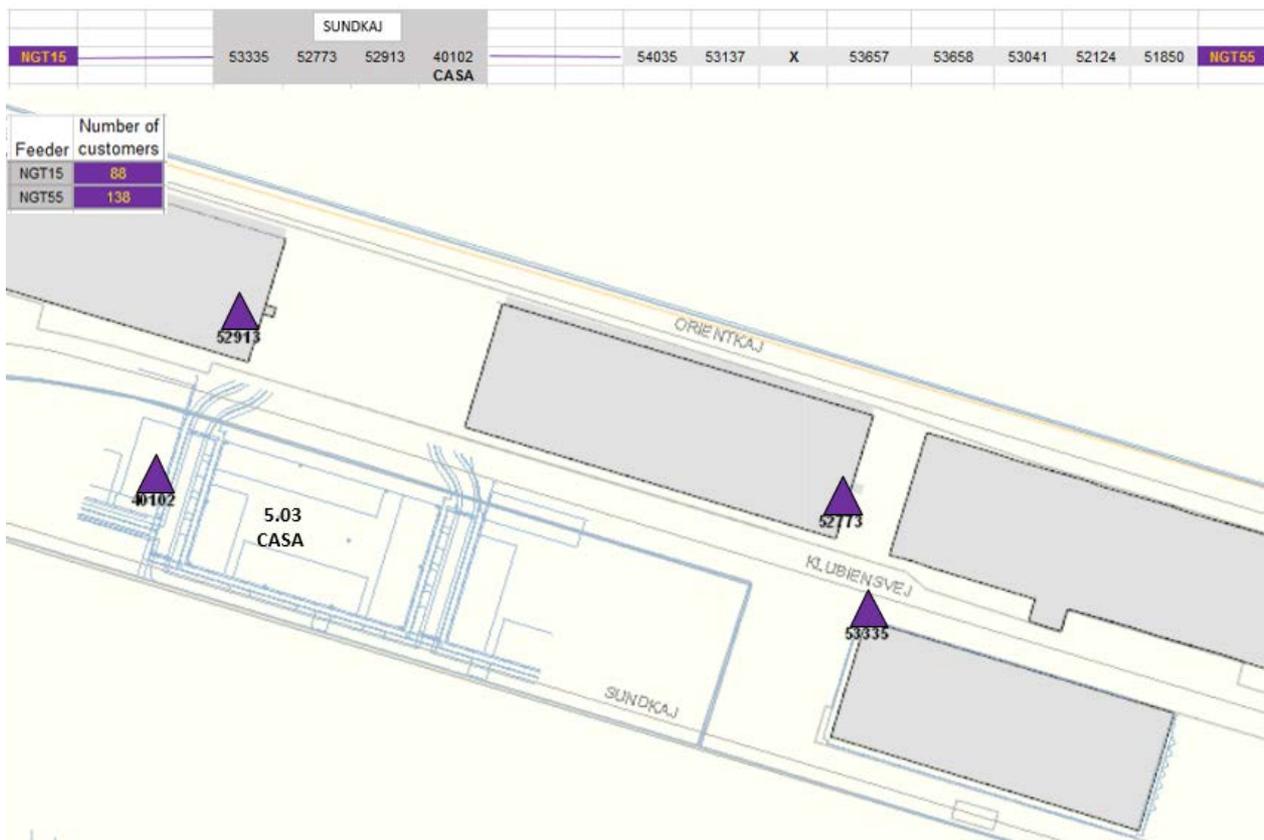


Figure 5

The 10-kV grid schematic topology and geographic placement of the 10/0, 4 kV secondary substations in the Levantkaj area

The top of figure 6 shows the loop with its specific 10/0.4 kV secondary substations feeding Levantkaj area. The loop are colored ORANGE (NGT 57 – NGT 26)

The loop has an open circuit breaker (x) which divides the loop into 2 independent feeders.

The geographical location of the secondary substations is also shown and has the color corresponding to the 10-kV loop from which it is fed.

Furthermore, figure 6 has a little scheme, telling the number of customers that are fed from each feeder. These customers are ELN customers as well as customers outside the ELN project.

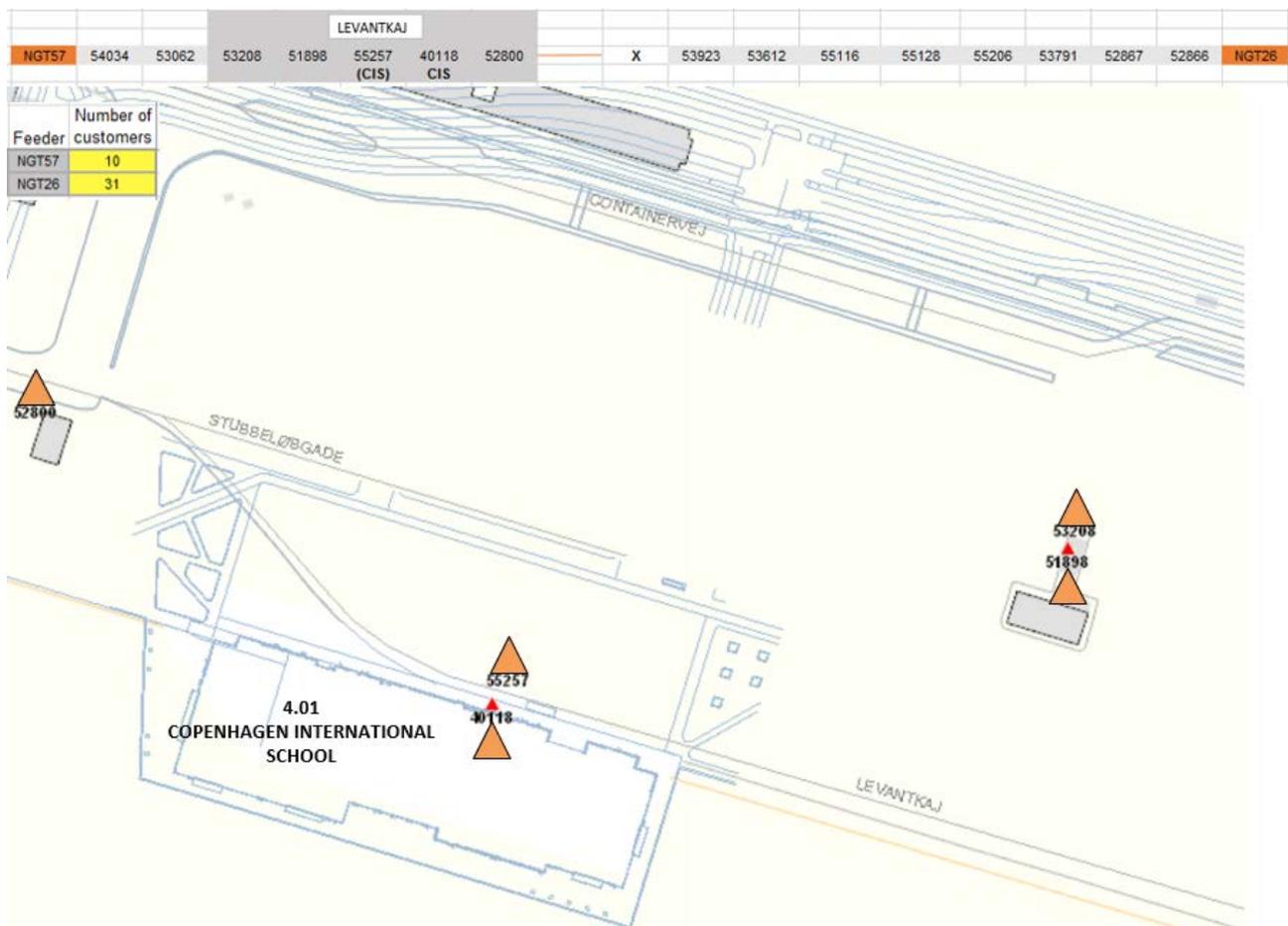


Figure 6

5. 0.4 kV grid in general

The 0.4 kV grid feeding Nordhavn is schematic build as shown in figure 7.

Each cable box is fed from several 0.4 kV cables. Customers are fed via “stikledninger” (cable branch) connected in the small cable boxes, Kabelskab type 2, shown in figure 7 or in the 0.4 kV busbar inside the secondary substation. The big cable boxes, Forsyningskab type 1, in figure 7 are for making the right topology, and have normally no customers connected. Households in the ELN project are fed from DIN cable boxes which also feeds households outside the ELN project.

Due to the 0.4 kV topology and that customers in the ELN project and outside the ELN project are fed through common cables, it will not be possible to get the load picture of individual ELN customers via measurements in the 0.4 kV grid.

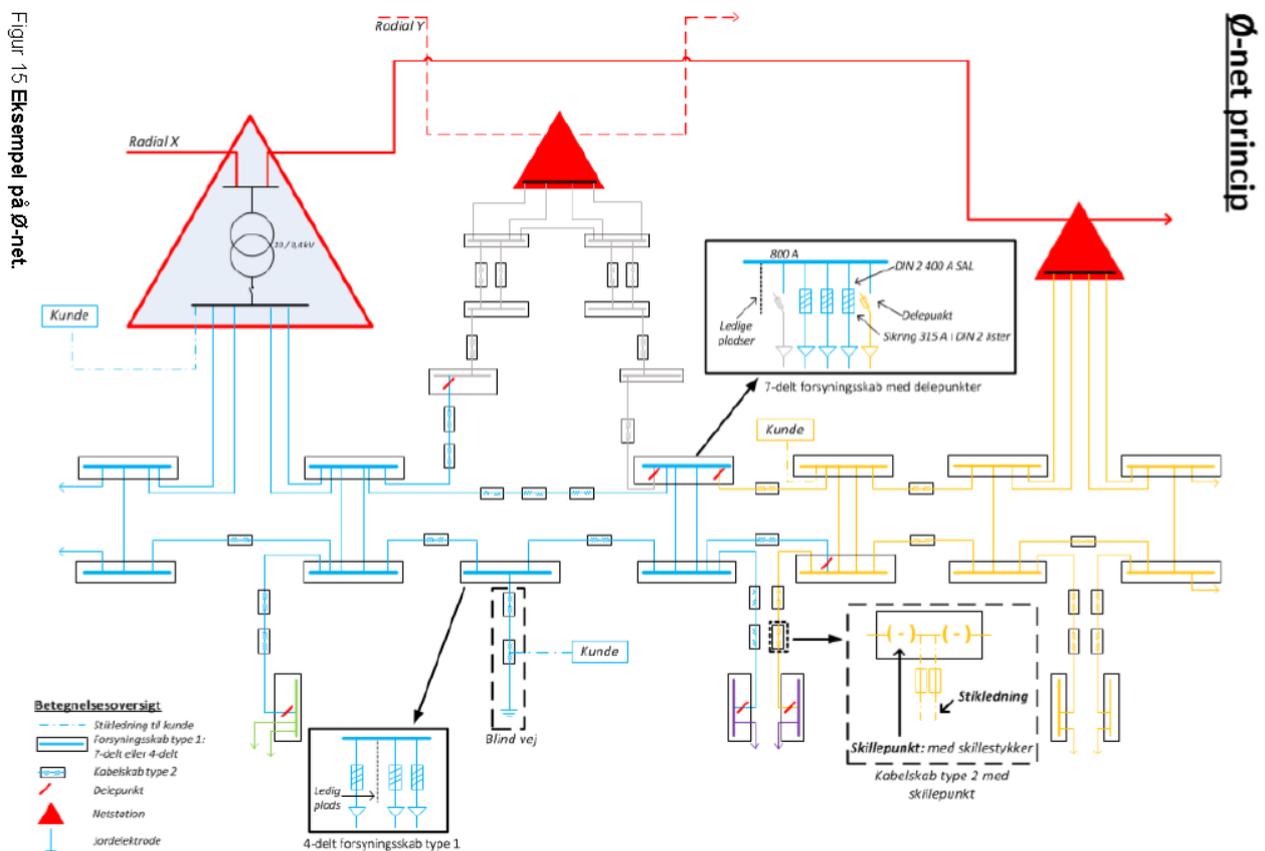


Figure 7

6. 0.4 kV grid measurement in Nordhavn

In addition to our proposed approach in section 5, we have decided to install measurements in secondary substation 40086 Århusgade Nord. These measurements will give us load from customers outside as well as inside the ELN project. This is due to the topology of the 0.4 kV grid, as described in section 5. It is simply not possible to measure only the customers in the ELN project via measurements in the grid.

The secondary substation 40086 Århusgade Nord feeds the customers shown in the table 1. Customers outside the ELN project are grey, customers in the ELN project are yellow, green and orange. The measurements will give us the total load for all customers.

Table 1. List of customers connected to 40086 Århusgade substation.

10kV Radial	Netstation	Udlevering, LV-stærkning, skab	Skabnr	Conn. Obj. ID	Device Location UID	Fuse size	Cable dimension	Installation Number	Point of delivery ID	Business Partner	Name /Last Name	Address Line 1	Street	House Number
NGT16	40086	4	56758	61775090	61665918	160	2X4X105 AL	027701438468	571313161170182090	602254450	KPC København A/S	Bibaugade 8X	Bibaugade	8X
NGT16	40086	4	Not assigned	61665917	61665918	160	2X4X105 AL	027701573060	571313161100054602	602342538	Grundejerforeningen Friksværret	Århusgade 131	Århusgade	131
NGT16	40086	4	Not assigned	61665917	61665922	160	2X4X105 AL	027701573060	57131316100054010	602242339	Ljefloreningen Det Grønne Rigtme	Århusgade 131	Århusgade	131
NGT16	40086	12653-3-35000-3	9150	61145584	61174889	63	4X18 CU	02720507238	5713131610507238	602245974	Udviklingskøbel By & Havn IS	Gliucksdalsvej 4	Gliucksdalsvej	4
NGT16	40086	12653-3-35000-3	Not assigned	61064554	61613185	60	4X95 CU	02720497936	57131316104079307	602229203	Udviklingskøbel By & Havn IS	Billevde 8	Billevde	8
NGT16	40086	12653-3-35000-3	Not assigned	61064554	61617122	60	4X95 CU	02720497937	57131316104079374	602343952	UDVKLINGSKØBEL BY & HAVN IS	Billevde 8	Billevde	8
NGT16	40086	12653-3-35000-3	Not assigned	61064554	61620056	60	4X95 CU	02720497992	57131316104079922	602212532	Udviklingskøbel By & Havn IS	Billevde 8	Billevde	8
NGT16	40086	12653-3-35000-3	Not assigned	61064554	61620082	60	4X95 CU	02720497993	57131316104079939	602378715	Udviklingskøbel By & Havn IS	Billevde 8	Billevde	8
NGT16	40086	12653-3-35000-3	Not assigned	61064554	61620080	60	4X95 CU	02720497995	57131316104079954	602252446	HOV Administration A/S	Billevde 8	Billevde	8
NGT16	40086	12653-3-35000-3	Not assigned	61140464	61196932	Not assigned	Not assigned	02720507880	571313161105078805	602282806	Udviklingskøbel By & Havn IS	Southamptongade 2	Southamptongade	2
NGT16	40086	12653-3-35000-3	Not assigned	61140464	61229645	Not assigned	Not assigned	0272054967	57131316110549677	601077512	Udviklingskøbel By & Havn IS	Southamptongade 2	Southamptongade	2
NGT16	40086	12653-3-35000-3	Not assigned	61145621	61277399	Not assigned	Not assigned	02720545893	571313161105458939	602374280	Udviklingskøbel By & Havn IS	Southamptongade 2	Southamptongade	2
NGT16	40086	12653-3-35000-3	Not assigned	61145621	61489411	Not assigned	Not assigned	02720473350	571313161104733501	602352893	Forward Capital A/S	Southamptongade 2	Southamptongade	2
NGT16	40086	12653-3-35000-3	Not assigned	61149073	61514030	Not assigned	Not assigned	02720473343	571313161104733430	602210095	Brødr. Jørgensen A/S	Århusgade 127	Århusgade	127
NGT16	40086	12653-3-35000-3	Not assigned	61149081	61191638	Not assigned	Not assigned	02720514023	571313161105140230	602252477	Plasser Scand. (Plasser Scand. AG)	Dansk FLAT Plasser Scand. Ltd Eich	Århusgade	130
NGT16	40086	12653-3-35000-3	Not assigned	61149881	61513158	Not assigned	Not assigned	02720497935	57131316110497935	601087821	Sea Ranch ApS	Henrik Aas	Århusgade	130
NGT16	40086	12653-3-35000-3	Not assigned	6157568	61514848	Not assigned	Not assigned	02720473344	571313161104733440	602210890	Udviklingskøbel By & Havn IS	Rosencgade 7	Rosencgade	7
NGT16	40086	34542-1-34565-7	54039	61092109	61092109	25	4X8 CU	027701550902	571313161170301904	602174933	Annette Daa Gvarter	Morten Upetberg	Kølgade	7
NGT16	40086	34542-1-34565-7	54039	61051187	61051188	25	4X8 CU	027701550904	571313161170301871	602175035	Peter Threl Jessen	Torje Bergholm Vestby	Kølgade	9
NGT16	40086	34542-1-34565-7	54039	61051189	61051190	25	4X8 CU	027701550908	571313161170301796	602358304	Pung Vo	Kølgade 11	Kølgade	11
NGT16	40086	34542-1-34565-7	54039	61051291	61051292	25	4X8 CU	027701550907	571313161170302062	602164603	Signe Jensen	Jonas Green	Helmskigade	8F
NGT16	40086	34542-1-34565-7	54039	61051293	61051294	25	4X8 CU	027701550909	571313161170302113	602164095	Daniel Cortes	Helmskigade 8G	Helmskigade	8G
NGT16	40086	34542-1-34565-7	54039	61051330	61051331	25	4X10 CU	027701550929	571313161170302120	602291061	Ulrik Graff	Juulie Wickowski	Kølgade	5
NGT16	40086	34542-1-34565-7	54039	61051332	61051333	25	4X8 CU	027701550931	571313161170302137	602291059	Rune Helby Koek	Siri Helby Koek	Kølgade	4
NGT16	40086	34542-1-34565-7	54039	61051337	61051338	25	4X8 CU	027701550936	571313161170302089	602291057	Knit Jessen	Hanne Kriplund	Kølgade	6
NGT16	40086	34542-1-34565-7	54039	61051341	61051342	25	4X8 CU	027701550940	571313161170302076	602291056	Per Stengade	Helle Høng	Kølgade	6
NGT16	40086	34542-1-34565-7	54039	61051350	61051351	25	4X8 CU	027701550949	571313161170302151	602291037	Klaus Frandsen	Susanne Leth	Kølgade	10
NGT16	40086	34542-1-35000-1	54038	61051278	61051279	25	4X8 CU	027701550973	571313161170301956	602184440	Charlotte Damboe Løse	Heino Jacobsen	Helmskigade	6A
NGT16	40086	34542-1-35000-1	54038	61051280	61051281	25	4X8 CU	027701550975	571313161170301963	602184502	Peter Pohani	Peter Pohani	Helmskigade	6B
NGT16	40086	34542-1-35000-1	54038	61051283	61051284	25	4X8 CU	027701550979	571313161170301963	602184594	Helle Jensen	Jesper Termandsen	Helmskigade	6C
NGT16	40086	34542-1-35000-1	54038	61051285	61051286	25	4X8 CU	027701550981	571313161170302106	602184597	And Dines Dalgaard Hansen	Karen Agathe Hari	Helmskigade	8D
NGT16	40086	34542-1-35000-1	54038	61051289	61051290	25	4X8 CU	027701550985	571313161170301987	602184599	Anders Ødegaard Christiansen	Jane Greve	Helmskigade	8E
NGT16	40086	34542-1-35000-1	54038	61067802	61067803	25	4X8 CU	027701573952	57131316100066677	602300111	TDC A/S	Helmskigade 6	Helmskigade	6
NGT16	40086	34565-1-35000-5	54037	61052920	#	63	4X10 CU	027701478419	571313161170220337	602242031	Rasmus Friis A/S	Århusgade 133, Y MGD	Århusgade	133
NGT16	40086	34565-1-35000-5	54037	61051179	61051180	25	4X8 CU	027701550978	571313161170301833	602175008	Marcus Jacobsen	Cornelia Jacobsen	Kølgade	1
NGT16	40086	34565-1-35000-5	54037	61051181	61051182	25	4X8 CU	027701550978	571313161170301840	602175008	Michael Aggaard	Mia Dunneose Jensen	Kølgade	3
NGT16	40086	34565-1-35000-5	54037	61051183	61051184	25	4X8 CU	027701550980	571313161170301857	602175010	Morten Christian Erichsen	Dorte Bjerrmand Erichsen	Kølgade	5
NGT16	40086	34565-1-35000-5	54037	61051288	61051289	25	4X8 CU	027701550985	571313161170302090	#	#	#	#	#

We believe, that in addition to the measurements we have from each customer, via RPM (Remote Power Meters) measurements it will be possible to generate useful information regarding the influence from the ELN initiatives.

7. Field measurements design

As described, ELN customers are mixed with customers outside the ELN project, on 10 kV level as well as on 0.4 kV level.

Due to this, it is not possible to establish measurements in the grid, which measures only ELN customers.

However we have

- established 10 kV measurements in all 10 kV feeders with ELN customers as described in section 4
- established 0.4 kV measurement in one secondary substation, feeding some ELN customers, as described in section 6

In addition to the mentioned measurements, we suggest looking into RPM's in the households. To obtain measurements for each building, it is possible to summarize measurements from individual customers. The data can be obtained through Radius' RPM meters with hourly resolution from all households in the Nordhavn area, or through KNX based bi-meter with 1 sec resolution for the buildings and apartments, which participate in the ELN project and have installed KNX system. Balslev have registered customers that have installed the KNX system.

Radius Elnet have by now installed RPM in all households in Nordhavn area. Households, who act only as consumers, will be Kamstrup meters. Households that also generate power, e.g. with PV's installed, are not Kamstrup meters. This will complicate our set up, but it will be possible to do one of following:

1. The data from Radius meters will end in a Meter Data Management MDM (please write in full the first time)-system as active power (kWh) with 1-hour time resolution. If we get the addresses from costumers we want to analyze this, values can be provided in a spreadsheet with a few days' delay, to DTU. The meters that are not Kamstrup meters (installations with power generation), can also be send as values in an xlsx spreadsheet with a few days' delay to DTU.
2. In Kamstrup meters, a dongle could be placed in a separate port in the meter. The meter can be programmed to store selected values with an optional time resolution (how fine, seconds or better?). Communication system to DTU Data warehouse must be installed at customer's site. To this, we need customers' acceptance. When this setup is in operation, it is possible to get close to real time measurements. The meters which are not Kamstrup (installations with power generation), will be send as values in an xlsx spreadsheet with a few days' delay to DTU.

Table 2. Measurements in the 10 kV and 0.4 kV grid as well as at customer's site that can register/measure load in the grid

Technology	Data available	Customer type	Responsible	Resolution	Data warehouse feed	Comment
RPM via MDM database	kWh	Household	Radius	1 hour	Auto in packages Manual via xlsx	
RPM via MDM database	kWh	Commercial	Radius	1 hour	Auto in packages Manual via xlsx	
RPM online via Panda	kWh	PV	Radius	Online	Manual via xlsx	
KNX meters	kWh	ELN participants	ABB	Real time	Auto	
10 kV RTU from ABB	A	all	Radius	Real time	Auto	Accessible via BESS
0.4 kV Smart Grid Unit from Thiim	U, I, cos phi, active and reactive power, all by each phase	all	Radius	Real time	Auto	Accessible via secondary substation 40086 Århusgade Nord

Abbreviations

RPM = Remote Power Meter

MDM = Meter Data Management

HES = Head End System

Panda = Combination of MDM and HES

RTU = Remote Terminal Unit