

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



*Photo: By & Havn / Ole Malling*

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**Public deliverable**  
**Confidential deliverable**



## **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.

## **Project Information**

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## List of Abbreviations

## Executive Summary

The delivery describes where we have installed measurements in the grid, 10 kV as well as 0.4 kV grid. It also describes the design of the 10 kV and 0.4 kV grid.

10 kV measurements are all placed in feeders in Primary Substation “Nyborggade Transformer station” (NGT).

The 0.4 kV measurement is placed in Secondary Substation 40086 “Århusgade Nord”.

All measurements in the grid, measure EnergyLab Nordhavn customers as well as customers outside the project. It is not possible to only measure ELN project customers in the grid, due to the fact, that it is very few customers in the ELN project compared to customers outside the ELN project.

## Version Control

Version	Date	Author	Description of Changes
2	19-12-2016	Ole Michael Pedersen	Measurements in 10 kV grid No measurements in 0.4 kV grid
3	03-04-2017	Ole Michael Pedersen	Measurements in 10 kV grid Measurements in 0.4 kV grid
4	16-06-2017	Ole Michael Pedersen	Measurements in 10 kV grid Measurements in 0.4 kV grid

## Quality Assurance

<b>Author</b>	<b>Reviewer</b>	<b>Approver</b>
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Approved	WPL group	<b>10-07-2017</b>

## 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.

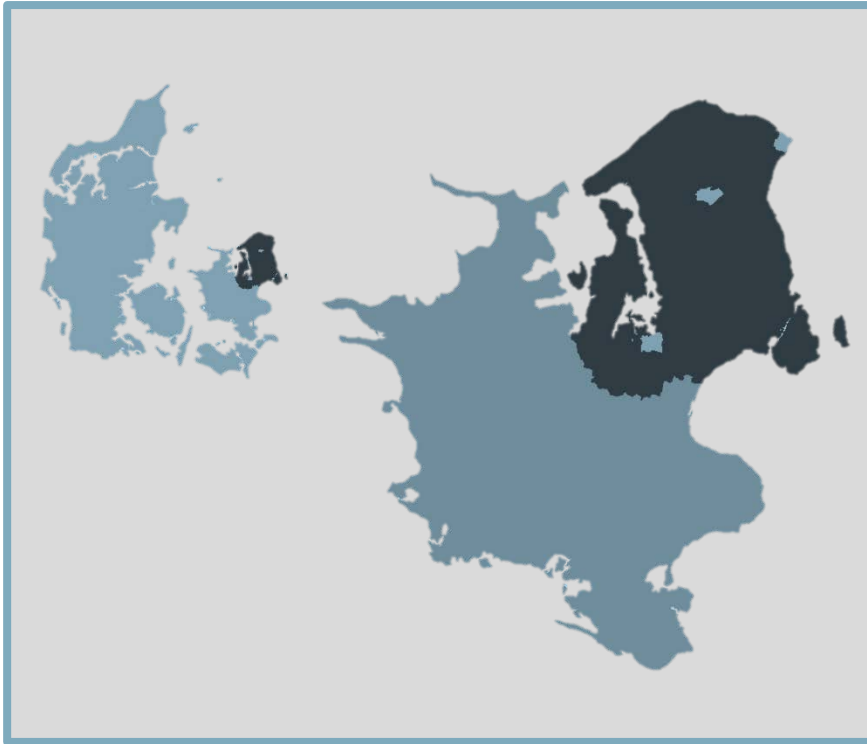


Figure 1 – Radius Elnet area of supply.

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.

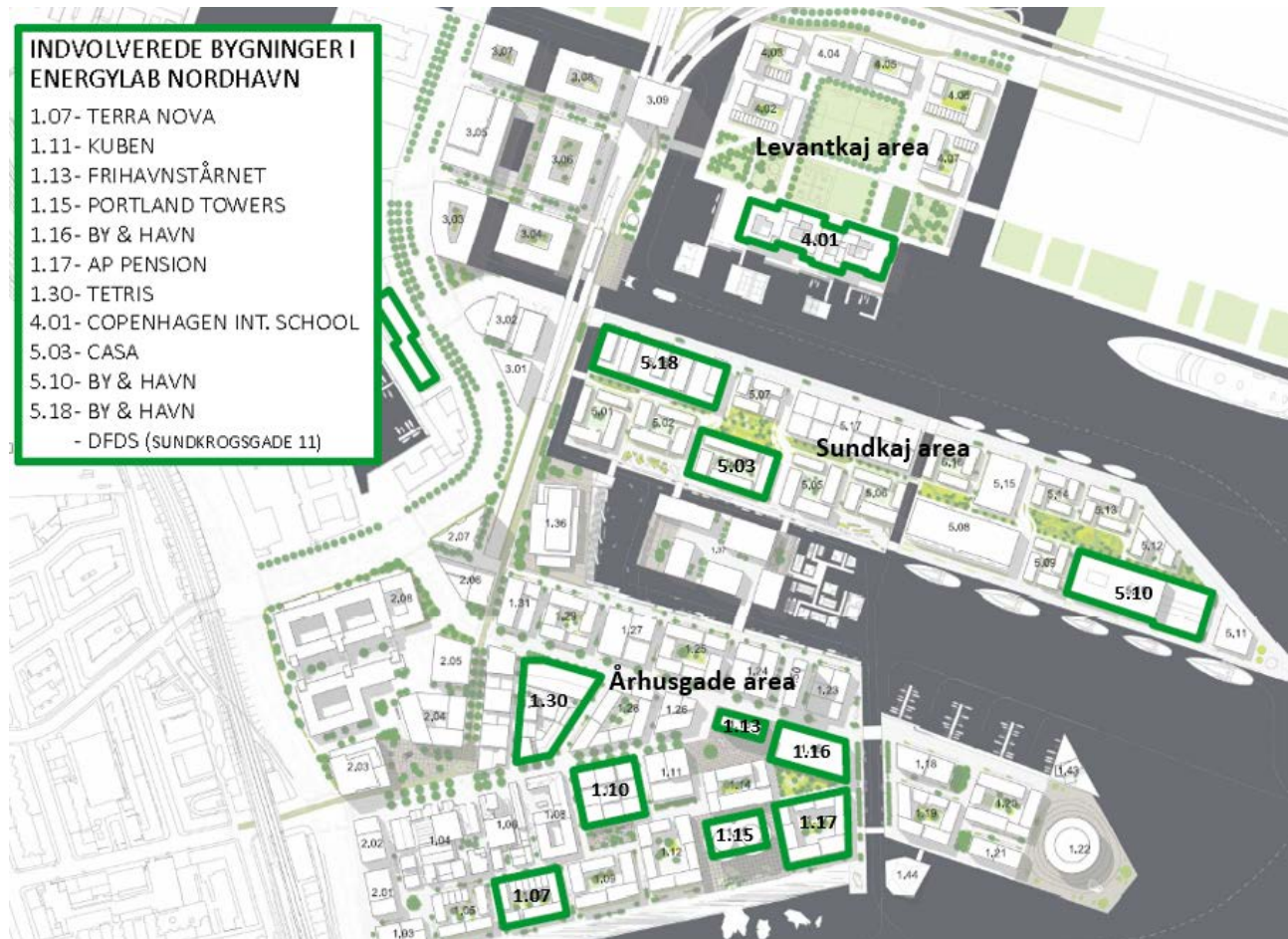


Figure 2



### 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)

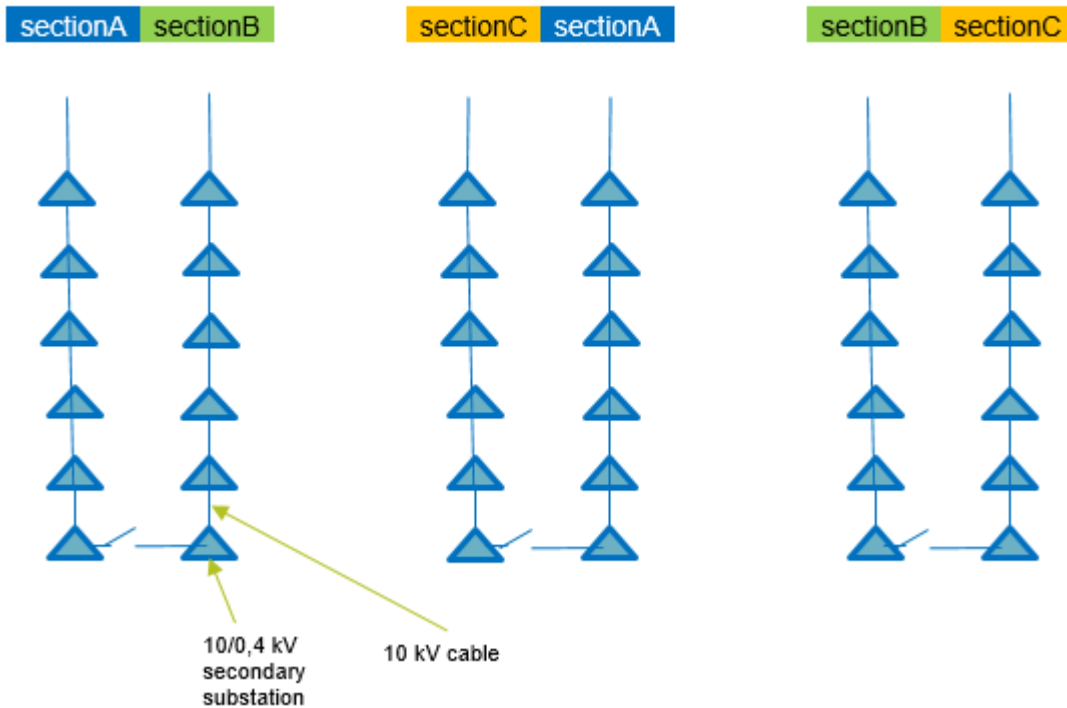


Figure 3

#### 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.

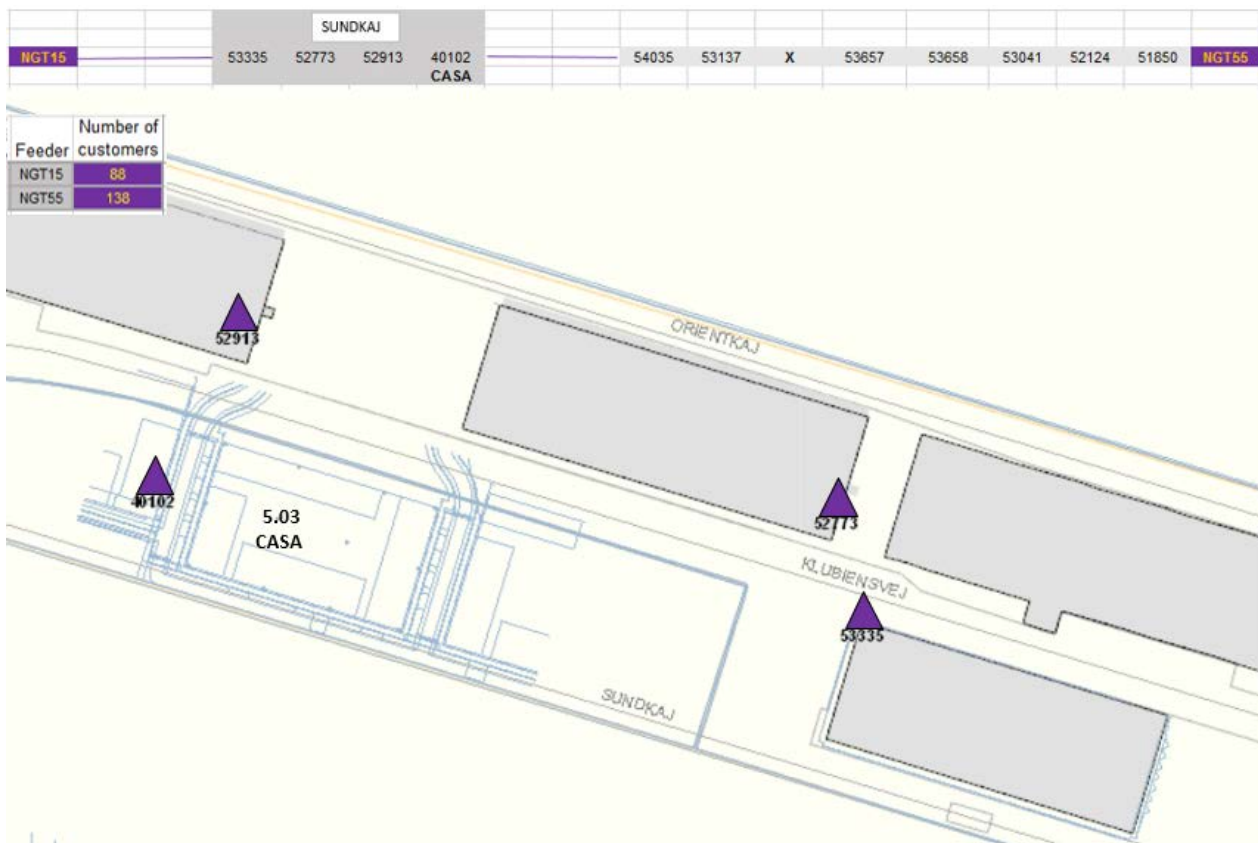


Figure 5

**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.

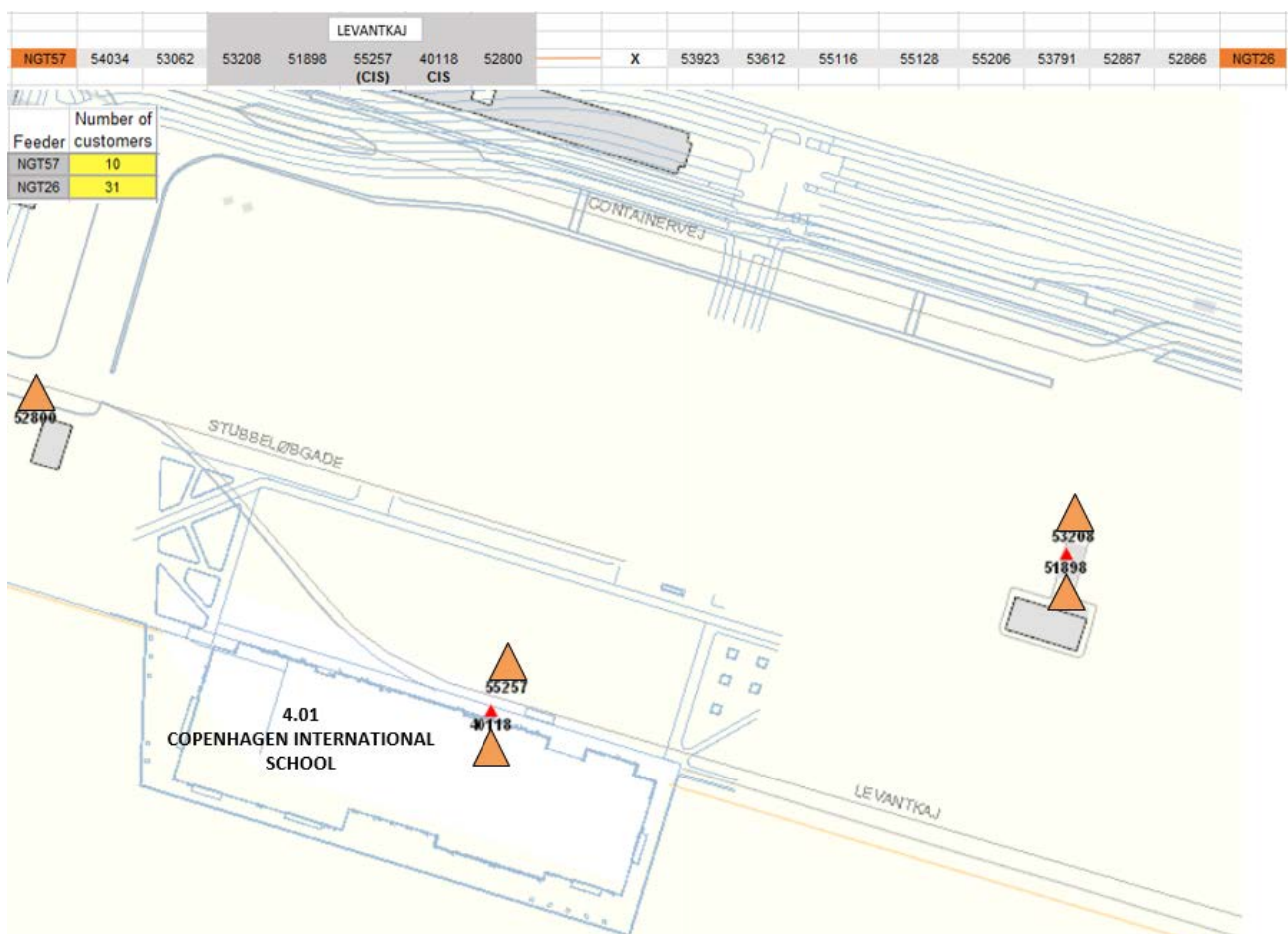


Figure 6



## 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.

Figur 15 Eksempel på Ø-net.

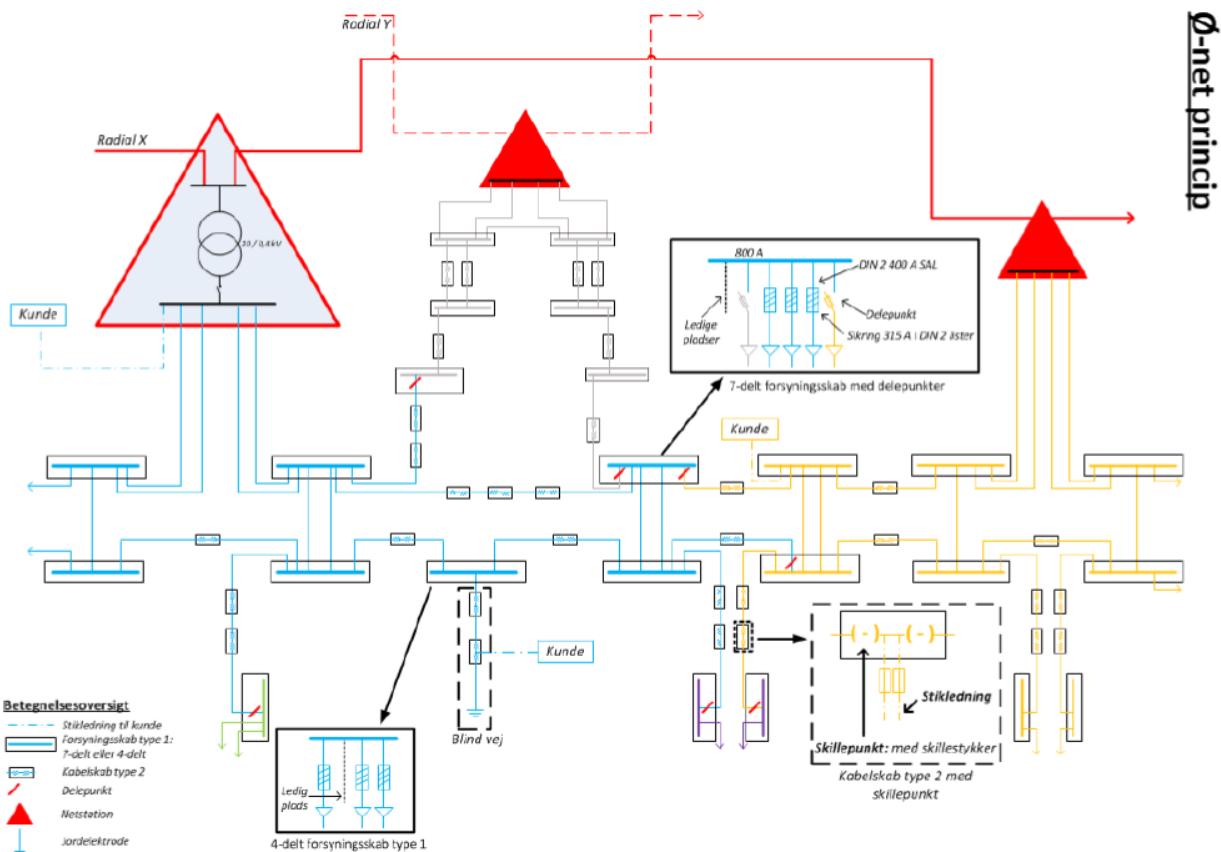


Figure 7



## 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 Radar	Metstation	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 Friksværteret	Århusgade 131	Århusgade	131	
NGT16	40086	4	Not assigned	61665917	61665922	160	2X4X105 AL	027701573060	57131316100054010	602242339	Lieferforeningen Det Grønne Hjørne	Århusgade 131	Århusgade	131	
NGT16	40086	12653-3-35000-3	9150	61145584	61174889	63	4X18 CU	02720507238	5713131610507238	602245974	Udviklingskøbelet By & Havn IS	Glücksbølvej 4	Glücksbølvej	4	
NGT16	40086	12653-3-35000-3	Not assigned	61064554	61613185	60	4X95 CU	02720497936	57131316104079307	602229203	Udviklingskøbelet By & Havn IS	Billevde 8	Billevde	8	
NGT16	40086	12653-3-35000-3	Not assigned	61064554	61617122	60	4X95 CU	02720497937	57131316104079374	602343952	UDVKLINGSØSSELKABET BY & HAVN IS	Billevde 8	Billevde	8	
NGT16	40086	12653-3-35000-3	Not assigned	61064554	61620056	60	4X95 CU	02720497692	57131316104076922	602212532	Udviklingskøbelet By & Havn IS	Billevde 8	Billevde	8	
NGT16	40086	12653-3-35000-3	Not assigned	61064554	61620082	60	4X95 CU	02720497693	57131316104076939	602378715	Udviklingskøbelet By & Havn IS	Billevde 8	Billevde	8	
NGT16	40086	12653-3-35000-3	Not assigned	61064554	61620080	60	4X95 CU	02720497695	57131316104076953	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	602262806	Udviklingskøbelet By & Havn IS	Southamptongade 2	Southamptongade	2	
NGT16	40086	12653-3-35000-3	Not assigned	61140464	61229645	Not assigned	Not assigned	0272054967	57131316110549677	601077512	Udviklingskøbelet By & Havn IS	Southamptongade 2	Southamptongade	2	
NGT16	40086	12653-3-35000-3	Not assigned	61145621	61277399	Not assigned	Not assigned	02720545893	571313161105458939	602374280	Udviklingskøbelet 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	61149873	61514030	Not assigned	Not assigned	02720473443	571313161104734433	602210095	Brødr. Jørgensen A/S	Århusgade 127	Århusgade	127	
NGT16	40086	12653-3-35000-3	Not assigned	61149881	61191638	Not assigned	Not assigned	02720514023	571313161105140230	602252477	Plasser Scand. (Plasser Scand. AG)	Dansk FLAT Plasser Scand. Ltd Scti	Århusgade	130	
NGT16	40086	12653-3-35000-3	Not assigned	61149881	61513158	Not assigned	Not assigned	02720497935	571313161104979355	601087821	Sea Ranch ApS	Henrik Aas	Århusgade	130	
NGT16	40086	12653-3-35000-3	Not assigned	6157568	61614848	Not assigned	Not assigned	02720473344	571313161104733440	602210890	Udviklingskøbelet By & Havn IS	Rosencgade 7	Rosencgade	7	
NGT16	40086	34542-1-34565-7	54039	61092109	61092109	25	4X8 CU	027701550902	571313161170301904	602174033	Annette Daa Gvarter	Morten Upetberg	Kølgade	7	
NGT16	40086	34542-1-34565-7	54039	61092109	61092109	25	4X8 CU	027701550904	571313161170301904	602174033	Peter Threl Jessen	Torje Bergholm Vestby	Kølgade	9	
NGT16	40086	34542-1-34565-7	54039	61092109	61092109	25	4X8 CU	027701550906	571313161170301906	602358301	Pung Vio	Kølgade 11	Kølgade	11	
NGT16	40086	34542-1-34565-7	54039	61092109	61092109	25	4X8 CU	027701550907	571313161170302062	602164603	Signe Jensen	Jonas Gress	Helmskigade	8F	
NGT16	40086	34542-1-34565-7	54039	61092109	61092109	25	4X8 CU	027701550909	571313161170302113	602164095	Daniel Cortes	Helmskigade 8G	Helmskigade	8G	
NGT16	40086	34542-1-34565-7	54039	61092109	61092109	25	4X8 CU	027701550912	571313161170302120	602291061	Ulrik Graff	Helmskigade 8H	Kølgade	5	
NGT16	40086	34542-1-34565-7	54039	61092109	61092109	25	4X8 CU	027701550913	571313161170302137	602291059	Rune Helby Knok	Helmskigade 8I	Kølgade	4	
NGT16	40086	34542-1-34565-7	54039	61092109	61092109	25	4X8 CU	027701550916	571313161170302069	602291057	Knit Jessen	Hanne Kriplund	Kølgade	6	
NGT16	40086	34542-1-34565-7	54039	61092109	61092109	25	4X8 CU	027701550919	571313161170302076	602291056	Per Stengade	Helle Høng	Kølgade	6	
NGT16	40086	34542-1-34565-7	54039	61092109	61092109	25	4X8 CU	027701550940	571313161170302151	602291037	Klaus Frandsen	Susanne Leth	Kølgade	10	
NGT16	40086	34542-1-35000-1	54638	61092109	61092109	25	4X8 CU	027701550973	571313161170301956	602164440	Charlotte Damboe Løse	Helmskigade 6A	Helmskigade	6A	
NGT16	40086	34542-1-35000-1	54638	61092109	61092109	25	4X8 CU	027701550975	571313161170301963	602164502	Peter Pohani	Peter Pohani	Helmskigade 6B	Helmskigade	6B
NGT16	40086	34542-1-35000-1	54038	61092109	61092109	25	4X8 CU	027701550979	571313161170301963	602164594	Helle Jensen	Jesper Termandsen	Helmskigade 6C	Helmskigade	6C
NGT16	40086	34542-1-35000-1	54038	61092109	61092109	25	4X8 CU	027701550981	571313161170302106	602184597	And Dines Dalgaard Hansen	Karen Agathe Hari	Helmskigade 6D	Helmskigade	6D
NGT16	40086	34542-1-35000-1	54638	61092109	61092109	25	4X8 CU	027701550985	571313161170301987	602164599	Anders Ødegaard Christiansen	Jane Grøve	Helmskigade 6E	Helmskigade	6E
NGT16	40086	34542-1-35000-1	54038	61092109	61092109	25	4X8 CU	027701573652	57131316100066677	602300111	TDC A/S	Helmskigade 6	Helmskigade	6	
NGT16	40086	34565-1-35000-5	54039	61092109	61092109	25	4X8 CU	027701478419	571313161170220337	602242031	Rasmus Friis A/S	Århusgade 133, Y MGD	Århusgade	133	
NGT16	40086	34565-1-35000-5	54037	61092109	61092109	25	4X8 CU	027701550978	571313161170301833	602175008	Marcus Jacobsen	Helmskigade	Helmskigade	1	
NGT16	40086	34565-1-35000-5	54037	61092109	61092109	25	4X8 CU	027701550978	571313161170301840	602175008	Michael Aggaard	Helmskigade	Helmskigade	3	
NGT16	40086	34565-1-35000-5	54037	61092109	61092109	25	4X8 CU	027701550980	571313161170301907	602175010	Morten Christian Erichsen	Dorte Bjerrmand Erichsen	Kølgade	5	
NGT16	40086	34565-1-35000-5	54037	61092109	61092109	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