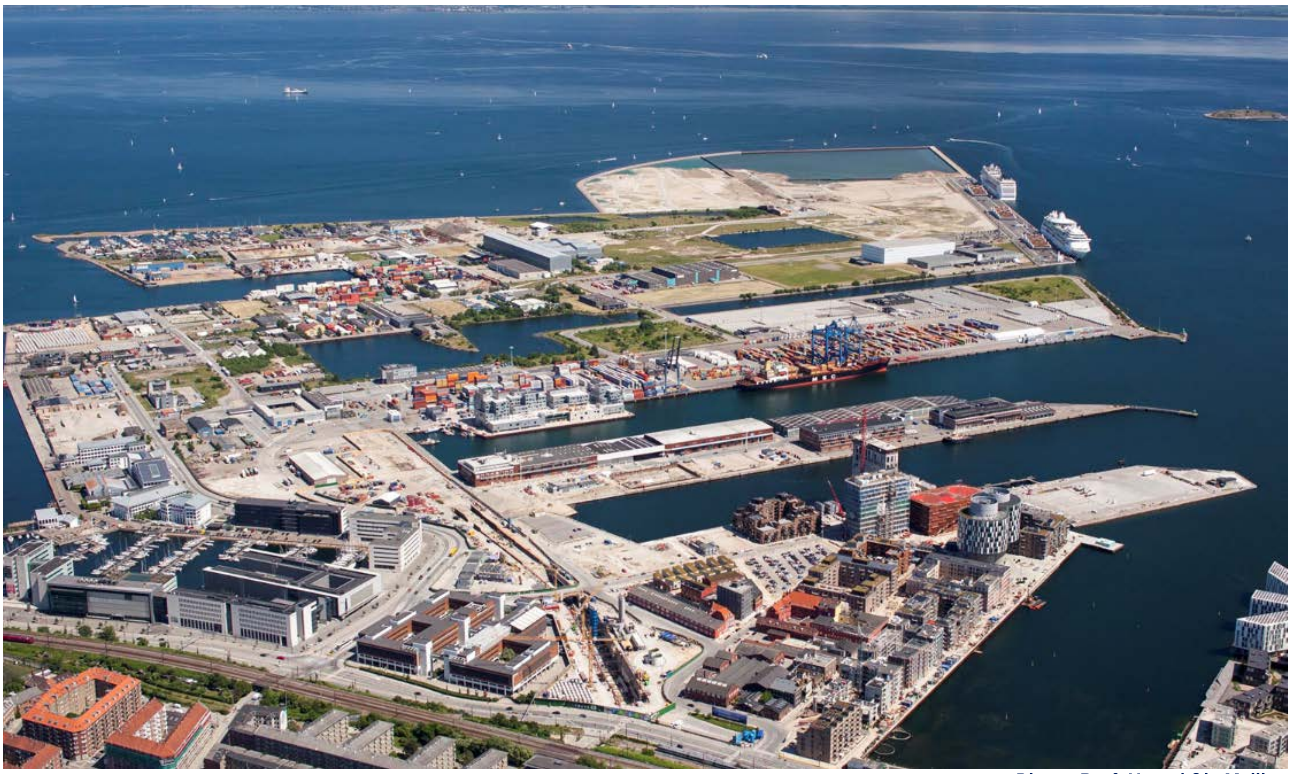
Deliverable D8.4a
International experience on energy prices and tariffs



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DTU-CEE & HOFOR
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September 13th, 2019

Public deliverable ☒
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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 contribute to the major 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 demonstrerer 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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2	29. October, 2018	Kristian Honoré	Comments & clarifications
3	09. November, 2018	Lesia Mitridati	Comments & clarifications
4	24. November, 2018	Edoardo Bosco	Additions/comments
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1. INTRODUCTION

1.1 The energy system

The objective of the EnergyLab Nordhavn project is to develop new methods and solutions for design and operation of the future cost-effective integrated energy system.

During the last couple of years, many projects and activities have been focusing on smart grid and smart energy systems, however most of them were mainly focused on the electricity system.

In this report, we have collected relevant projects and results from both smart grid and smart energy systems focusing not only on the electricity sector, but with relevance also to the heating sector for inspiration and usage in Task 8.4.

Nowadays, integrated energy systems involving integration of the electricity system and the district heating system throughout the whole value chain from production to consumption are not common across Europe, with only minor exceptions in the Nordic countries.

However, several technologies such as combined heat and power plants (CHP´s) and heat pumps are good examples of integrating technologies that can drive the integration within electricity and district heating systems, and provide socio economic benefit and with the proper tariff and price schemes also be positive from a private economic point of view.

Nevertheless, the electricity system and the district heating systems differ in many ways. The electricity system is typically large in terms of volume and market participants (international scale) and liberalized, while the district heating systems is on a more local scale and typically run only by a few market participants, and in a market like Denmark even operated by non-profit companies according to the Danish Heat Supply Act.

Due to these differences, challenges and opportunities it is important to identify and learn from the most recent and on-going projects in order to build a future reliable and competitive integrated energy system.

1.2 Challenges for the future integrated energy system

In 2011 the Danish government set the target of being fully independent from fossil fuel sources by 2050 [1].

In this perspective, district heating will play a key role. Denmark has a long tradition for using district heating for supplying heating to dense populated areas within both the commercial and residential sectors, and today, more than 60 % of the total heating demand is supplied by district heating, with very high peaks in urban areas like Aarhus and Copenhagen [2].

Consequently, establishing an efficient district heating market based on renewable energy is one of the key targets to reach the sustainability goals set by the Danish government. In addition, due to the growing interactions between heat and electricity sectors in the Danish energy system a well-structured district heating market will also facilitate the integration of renewable energies in the electricity market [3].

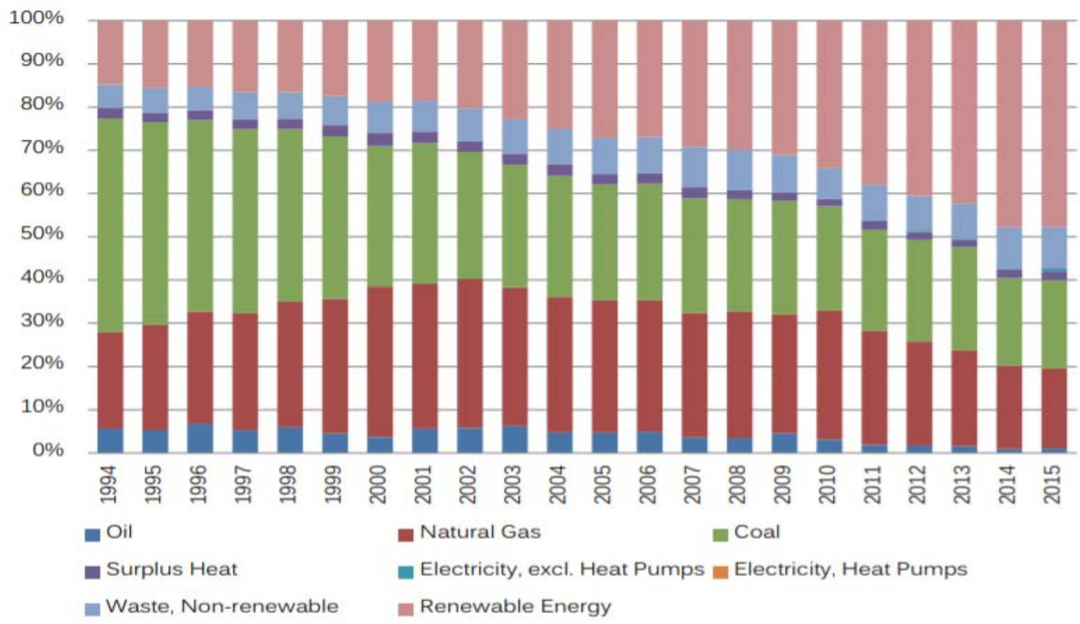

Figure 1: Fuel composition for Danish district heating, percentage of distribution 1990-2015. Image adapted from [2]

Furthermore renewable electricity, typically from the wind turbines and solar will play a more significant role in the near future.

Green and affordable electricity from wind turbines and solar can be utilized for heating purposes both in small and large scale applications as well as in different ways like in an electric boiler or a heat pump.

In today's energy system having mainly large centralized production plants there is a lot of flexibility at the production side due to the nature of a CHP-plant being able to prioritize between heating and power.

In the future de-centralized energy system, most of the energy is coming from renewables like wind and solar, and then there is no flexibility in the production as it is based on whether the wind is blowing or the sun is shining.

Therefore it will be important to identify and utilize the flexibility downstream in the energy system, and here among other the district heating network and the connected buildings/customers could provide a large amount of the required short term flexibility needed for balancing the future integrated energy system.

However there is today very little incentives in the legal framework on energy prices and tariffs on end-user/customer level driving the development in this direction, and this will be needed if the common goals of becoming fossil free is to be reached at the lowest possible cost on heating and electricity.

2. GENERAL CONCEPTS

2.1 District heating cost structure

The production cost is defined as the cost of the producers for supplying the overall heating demand.

However, the bill payed by end consumers typically consists of 4 different components:

1. Fixed Component (FXC)
2. Load Demand Component (LDC)
3. Energy Demand Component (EDC)
4. Flow Demand Component (FDC)

FXC represents the cost that a consumer needs to pay for staying in the network and is generally related to the consumers estimated/measured peak load demand.

LDC is used to cover the DH companies' costs to maintain a certain level of capacity for peak load. It usually also covers investment costs for new facilities and depreciation of existing infrastructures.

EDC reflects the DH production costs.

Some of DH companies also charge to the end user a FDC, based on the volume of hot water needed to deliver the energy to the user, and it covers pumping costs and heat losses. However, this components typically represents only 1-2 % of the overall end user's cost.

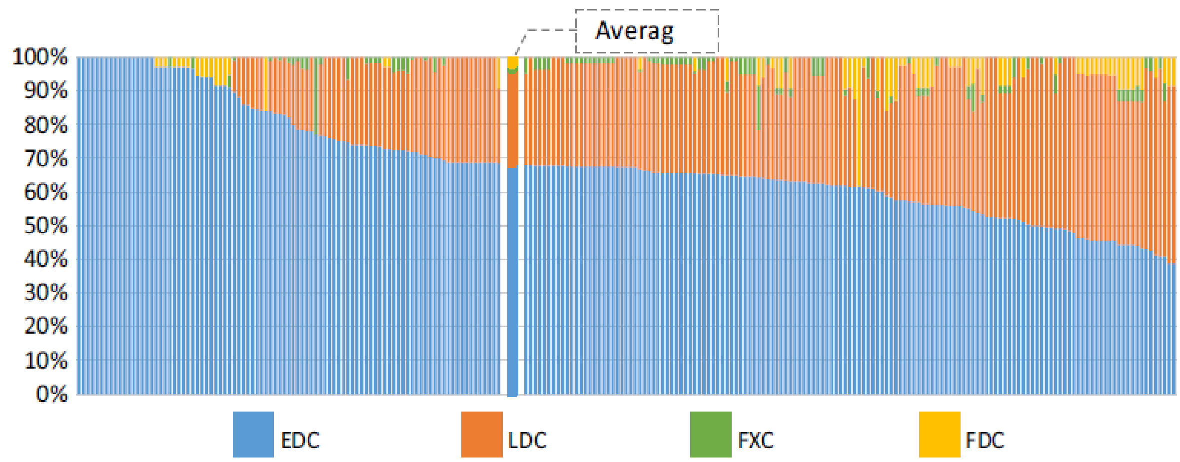

Figure 2: Share of price components in the cost calculations of typical multi-family house in Sweden, 237 price models included. Image adapted from [4]

Figure 2 shows the share of price components charged by 80 DH companies (in Sweden). In average, 68 % of the total costs are represented by the production cost, and EDC and LDC accounts for more than 95% of the total costs.

In this perspective, a different approach where the pricing mechanisms of the district heating will be able to properly reflect the production costs to the end users could improve the competitiveness of the district heating sector.

One of the solutions proposed in [5] and [6] is to adopt the so called “dynamic tariffs”, where the district heating price varies along the year in function of the production costs. This way, consumers are aware of how much they spend in a specific period and they can take initiatives for reducing their heat bill by reducing the heat consumption during peak hours and increasing it when the heat demand is low (and prices too).

2.2 Electricity cost structure

Compared to other European countries, household customers in Denmark currently pay a comparatively high price for electricity. The high electricity price is among other due to the high amount of taxes charged to the customers.

To introduce more renewable energy into the Danish energy system, the electricity price is planned to be significantly lowered in the coming few years. Figure 3 below shows the composition of the electricity bill for residential customers for 2018 and the expected for 2022 and from which it can be seen that the PSO-taxes disappears just as the energy tax is lowered by appx. 60% [7].

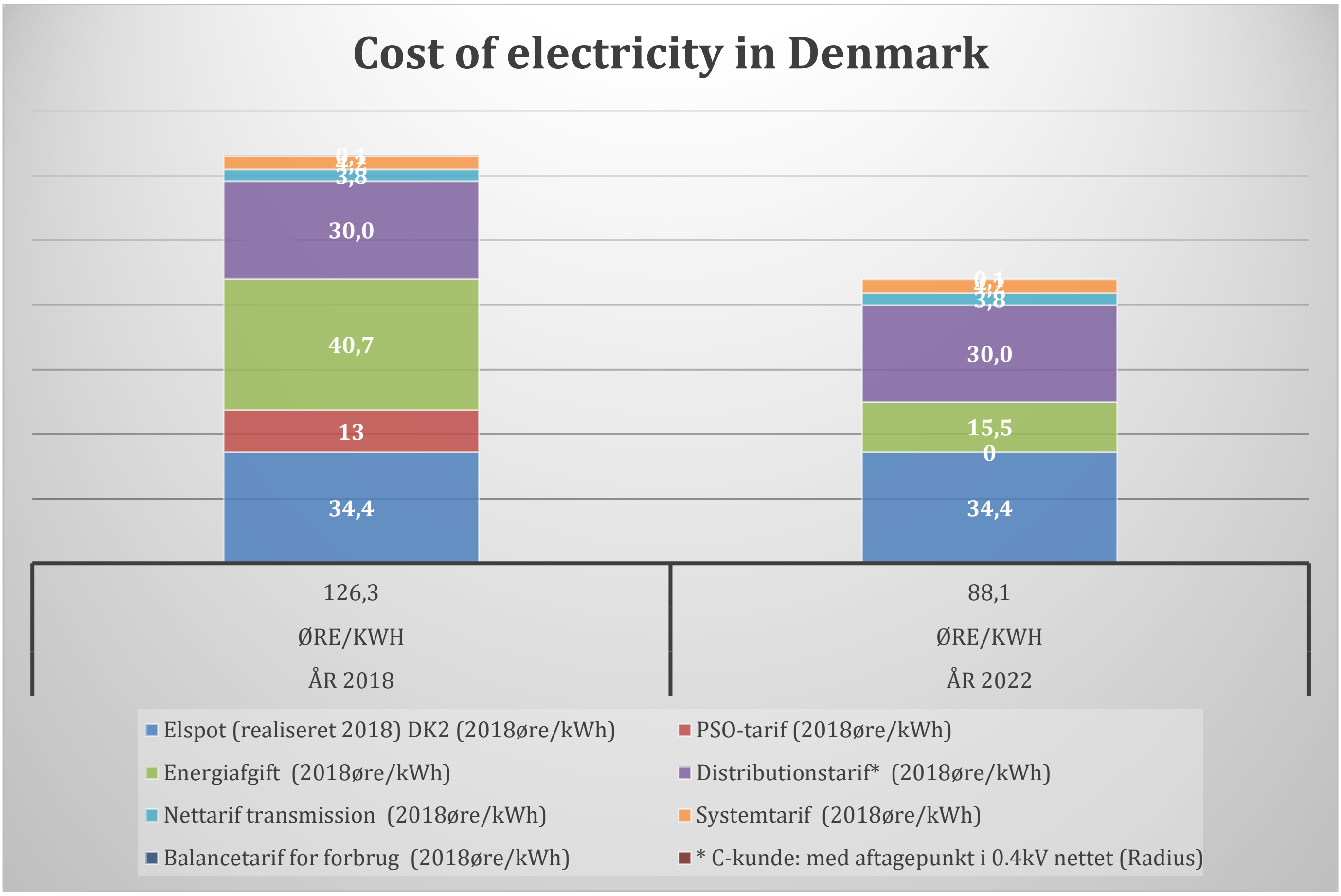

Figure 3: Composition of the residential electricity price for a consumption below 4000 kWh/y in year 2018 and 2022 [7]

Dynamic tariffs: Description and differences

The term dynamic tariff refers to a type of tariff where the prices of the commodity varies according to the production cost, in contrast with the flat tariff, where the price of the commodity traded is typically constant throughout the year. Today, several dynamic tariffs are used in energy markets and each one of them could be the more suitable for a certain system according to specific characteristic of the system itself. The following paragraph presents and describes the most common type of dynamic tariffs.

Time of use (TOU) tariff: Prices are set for a specific period on an advance basis and typically they do not change more than two or three times during the period considered (e.g. on daily basis). TOU tariffs do not reflect properly marginal production costs of the commodity, which typically vary on hourly basis, rather they reflect average production costs during peak periods (high rates) and off-peaks periods (low rates). Therefore, compared to the flat tariff, TOU tariffs tell to the customers which are the prices in pre-established period, allowing them to change their consumption in response to price variations and manage their energy cost. Moreover, due to its simple structure, customer's risk of incurring in financial losses is limited when they are subject to a TOU scheme.

Critical peak pricing (CPP) tariff: The structure is very similar to the TOU tariff, however, compared to latter, it tends to penalize customer who consume more during periods of high demand (which typically correspond to high production costs periods). In some cases, CPP tariffs are designed to give higher rewards toward customers willing to increase the consumption during hours of low demand. Most of the time, prices during the peak periods reflect the costs of generating and/or purchasing the energy at the wholesale level.

Real-time tariff: Energy retail price changes as often as it varies at the wholesale level, usually on hourly basis, and the retail price reflects production costs. In theory, this is the most beneficial price scheme for both the system and customers since it encourages the latter to reduce energy consumption during periods of high demand and, at the same time, it promotes a higher consumption during periods of low demand. Moreover, when adopted by a consistent number of customers, it can help reduce price volatility to which energy markets are subjected. Nevertheless, in practice, it is difficult to adopt because prices are known only one day in advance (when the wholesale market is cleared) meaning that consumers have to schedule their consumption on daily basis. Even though the schedule process could be facilitated by the use of smart meters, a real-time tariff requires the willingness of the consumers to radically change their habits, exposing them to the risk of financial losses.

In order to have a better comprehension of how dynamic tariffs are designed, a generic example is given in Figure 4 where the price, expressed in €/MWh, at which consumers purchase the energy for 4 different tariffs: flat, TOU, CPP and real-time tariff is shown. The time period considered is 24 hours. The dotted blue line represent the marginal production costs at wholesale level, which vary on hourly basis, while the red line reflects the different types of retail tariffs. The production costs curve could represent the typical production costs for electricity, with low demand during night time and peak demand between 18:00 to 20:00.

While the flat tariff does not consider the different production costs along the day, since it is calculated simply by taking the daily average of the production costs, dynamic tariffs tell the consumers which are the periods where it is more/less worthy, for end-users, to purchase electricity. As mentioned before, the TOU tariff has the simpler structure with high rates during the day and low rate in the night. Similarly, the CPP tariff offers two different rates (day/night) except for the period between 18:00 to 20:00, where the production costs are the highest. During this period, the CPP tariff reflects the marginal production costs and consumers willing to purchase during these hours will incur in high expenditure. Finally, with the real-time tariff, electricity tariffs correspond to the marginal production costs at each hour of the day.

When moving from the simplest tariff scheme, the flat tariff, to the most complex dynamic tariff scheme, the real-time tariff, customers have the possibility to reduce their consumption during peak production costs periods. However, the complexity of the dynamic tariff schemes increases and it is questionable whether customers are able and willing to properly react to the dynamic tariffs.

It is worth clarifying that dynamic tariffs are intended to better reflect production costs onto the consumers expenditure, therefore they will only affect one of the bill components (though EDC accounts for more than 70% of the total costs), while distribution and other costs will remain the same.

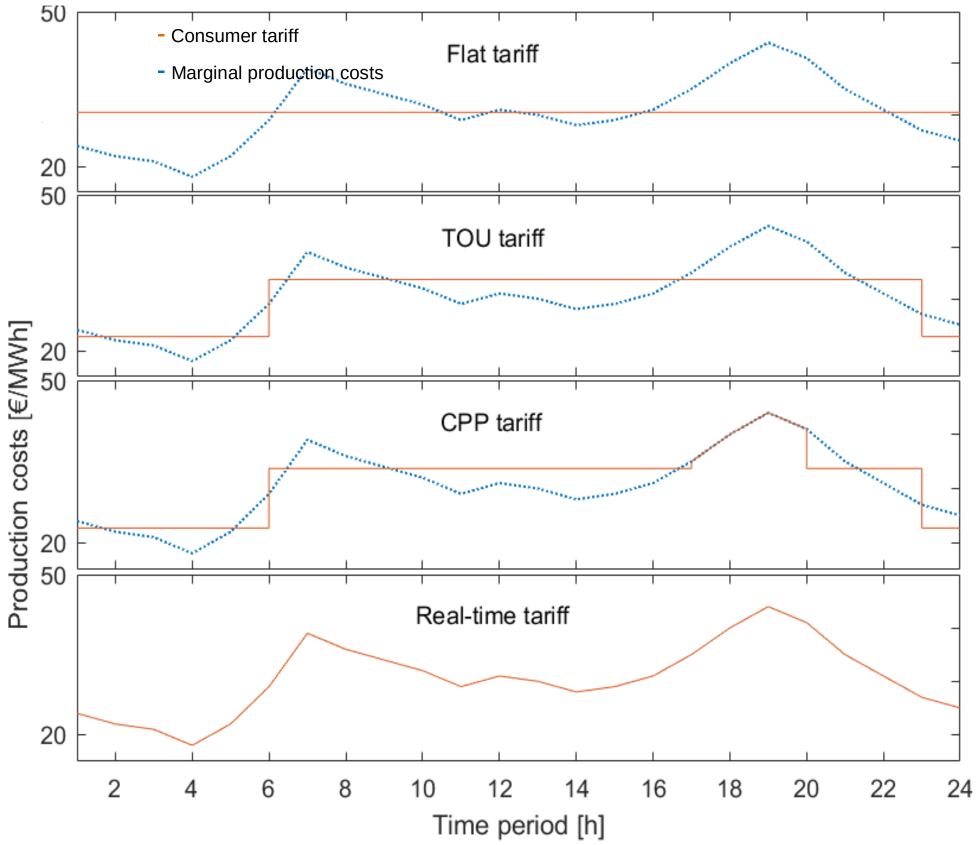

Figure 4: Comparison between flat tariff and dynamic tariffs (TOU, CPP and real-time tariff). The dotted blue line represents the production costs. Time period is set to 24 hours

3. EXAMPLES OF DYNAMIC PRICES AND TARIFFS

3.1 District heating system

3.1.1 Competitive DH tariffs in Denmark

A Danish study which gives guidelines for establishing a competitive district heating [8], points out that TOU tariffs for the heating sector are more effective when designed on a seasonal basis rather than on a daily basis, since outdoor temperature is the parameter that affects the heat demand the most. In this way, customers will face high prices in the winter period, low prices in the summer and medium prices for mid-season periods, as shown in below Figure 7.

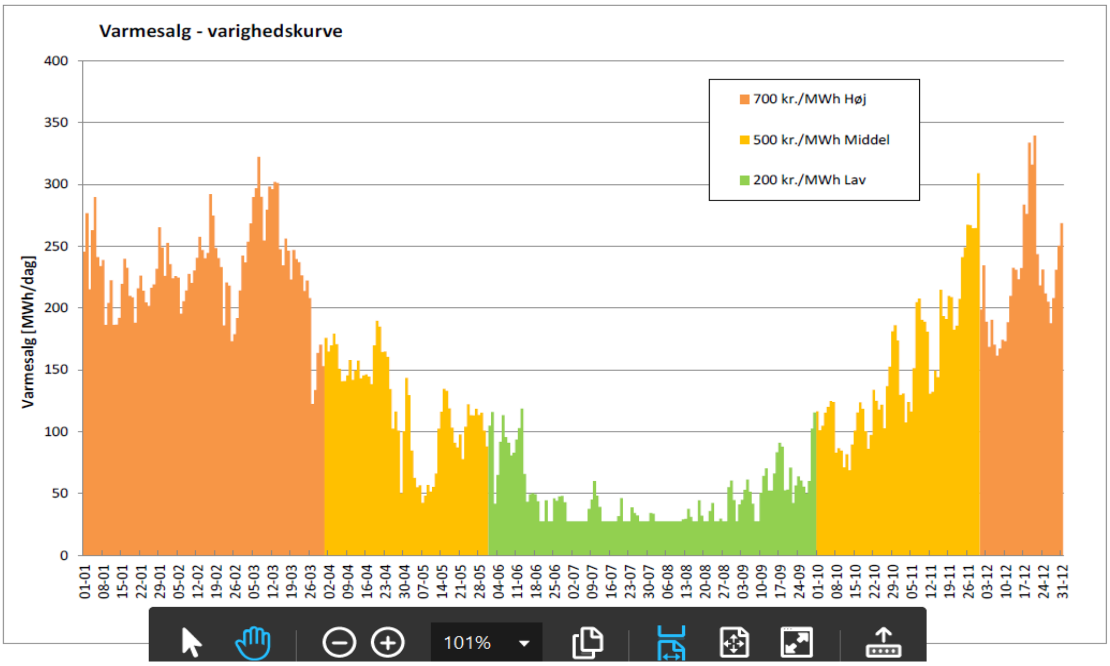

Figure 7: Example of season TOU tariff in the Danish district heating sector. [8]

Several DH utilities in Denmark have also started to promote tariffs that tend to reward customers willing to actively manage their heating consumption as can be seen from the below examples:

Vestforbrænding

In order to attract more customers, Vestforbrænding has designed a DH tariff which is divided in two parts: a fixed and a variable quota. The fixed tariff is based on the last three years of consumption, and it has been designed in order to encourage end users to reduce their consumption or to take energy saving measures. In addition, if customers decide to adopt energy saving measures (replacement of the windows and more insulation etc.) the fixed tariff will be adjusted by starting from the day of the replacement, incentivizing investment on energy saving measures.
The variable part, which accounts for 50 % of the bill, is adjusted yearly in relation to the development of the natural gas price [8].

Kalundborg

From January 1st 2016, Kalundborg utility, has introduced a new tariff system which rewards heat customers that are able to reduce their district heating return temperature. Customers with a return temperature lower than 45 Cº (considered as the standard return temperature) will see a reduction in their heating bill equal to 3.75 Kr./MWh per degree below 45 Cº [9]. On the other hand, if the return temperature is higher than 45 Cº, customer pay an additional penalty by the same amount as the reward.

HOFOR

Also the district heating company of Copenhagen, HOFOR, has introduced a tariff which rewards/penalizes customers with a return temperature lower/higher compared to the standard return temperature. In 2018, the cooling requirement has been set at 32 ºC [10]. Customers with a return temperature which is 5 ºC higher or lower than the cooling requirement are not subject to extra payment or bonus. However, if the return temperature is above 37 ºC, customers pay an additional fee equal to 5.40 Kr./MWh, for each degree. Similarly, customers with a return temperature below 27 ºC will be rewarded with the same amount of 5.40 Kr./MWh.

3.1.2 District heating in Sweden

Stockholm open district heating

Stockholm Exergi, the owner of the Stockholm district heating network, has recently opened the district heating market to third parties. In this way, external suppliers with a constant amount of excess heat can sell the excess heat produced to Stockholm Exergi. The idea behind is to recover the huge amount of waste heat produced by industry and business facilities, thus increasing the energy and fuel efficiency of the district heating network. In addition, the use of excess heat will reduce the use of the most expensive and fossil fueled boilers during peak hours demand [11].

Payments to external heat suppliers are based on delivery temperature, outdoor temperature, and type of agreement. Stockholm Exergy offers two types of contracts to the heat suppliers: **Open District Heating Call** and **Open District Heating Spot.**

With **Open District Heating Call** suppliers and Stockholm Exergi agree on a monthly fixed level of capacity to be supplied and a variable energy payment for the heat delivered. In return, Stockholm Exergi guarantees to purchase the excess heat if the outdoor temperature is below 12 °C.

The **Open District Heating Spot** agreement is less binding toward suppliers since the latter can decide when to supply the heat based on their circumstances, and no specific capacity demand is required. In this case, however, there is no guarantee that the network accepts to purchase the excess heat.

Deliveries to the district heating network can be made in 3 different ways and can be seen in below figure 5:

1. The option named ”Prima” guarantees the highest payments but it requires, that the delivery temperature is between 68 ºC and 103 ºC (during winter time the network requires a higher temperature compared to the summer period).
2. With the option ”Mix”, suppliers have the obligation to deliver the heat at 68 ºC throughout the year.
3. Finally, with the option ”Return” deliveries are made to the district heating network return line (in the other two cases the heat is delivered to the forward line) and the delivery temperature need to be at least 3 ºC higher than the incoming return temperature. Payments for the ”Return” option are lower compared to the other options, since the minimum heat temperature required is lower.

It is interesting to note that the outdoor temperature affects the payment level the most. During the warm season, or when the outdoor temperature is above 20 Cº, the payment level is almost the same with the three options, since the supply temperature required by the system is low, and providing a high temperature does not bring any economic advantages. On the opposite, when the weather is extremely cold, below -10 Cº, the payment level for suppliers able to provide excess heat at temperatures higher than 68 Cº is significantly higher.

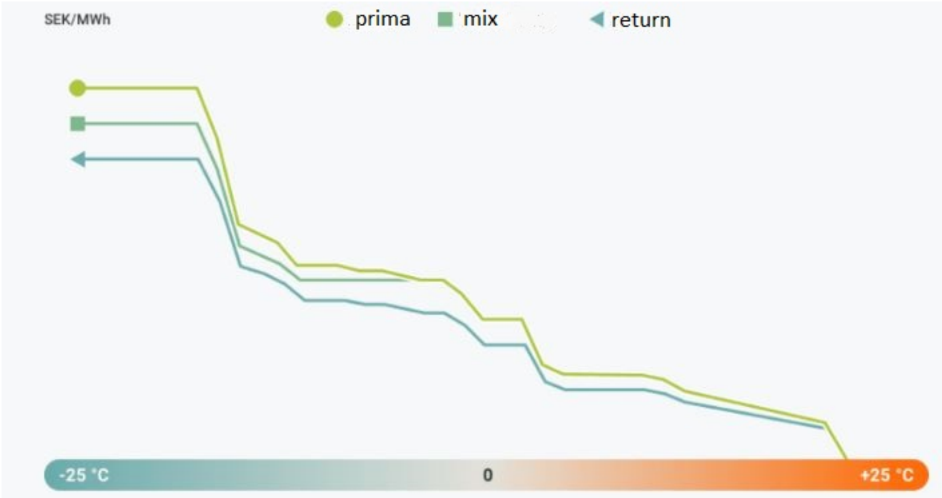

Figure 5: Payment (expressed in SEK/MWh) as a function of both delivered temperature and outdoor temperature [11]

3.2 Electricity system

3.2.1 TOU tariffs across Europe

TOU tariffs in the electricity market have been used in several European countries since the 90s. The below describes how TOU tariffs have been designed in some selected European countries.

3.2.2 United Kingdom

UK was the first country introducing a TOU tariff, called Economy 7, in the electricity sector in the early 90s [12]. Economy 7 offers two different rates, a high rate during the day and a low rate during night time (from 11 p.m. to 7 a.m.). The tariff was introduced to encourage people to increase the electricity consumption in the night as UK traditionally produce most of its electricity from coal and nuclear plants which cannot be turn off during night time, where the demand is typically low.

Table 1 compares the yearly electricity tariffs between the flat tariff and Economy 7.

Type of tariff\Time	7:00-23:00	23:00-7:00
Flat tariff (DKK/kWh)	1.02-1.44	1.02-1.44
Economy 7 (DKK/kWh)	1.10-1.53	0.59-0.85

Table 1: Electricity price comparison between yearly flat tariff and Economy 7 [12]

Even though Economy 7 was first adopted by a consistent number of customers (around 5 million persons), in the last years, the number of end consumers adopting Economy 7 is rapidly decreasing. Indeed, the fact that tariffs are higher during the day (compared to the flat tariff) makes Economy 7 feasible only for customers with storage heaters, which allows to switch part of the electricity consumption during night. Moreover, it has been shown that in order to have a significantly financial return, end users should consume around 40 % of the total electricity consumption during the night, which is a hardly realistic target even with the use of a storage heaters.
In 2017, Green Energy UK, the first British company offering 100% renewable electricity [13], introduced a TOU tariff with 3 different electricity prices. Table 2 shows the price range of the tariff and compares it with Economy 7 and the flat tariff.

Type of tariff\Time	7:00-16:00/19:00-23:00	16:00-19:00	23:00-7:00
Flat tariff (DKK/kWh)	1.02-1.44	1.02-1.44	1.02-1.44
Economy 7 (DKK/kWh)	1.10-1.53	1.10-1.53	0.59-0.85
TOU tariff (DKK/kWh)	1.02	2.12	0.42

Table 2: Electricity price comparison between flat tariff, Economy 7 and the TOU tariff offered by Green Energy UK. (While flat tariff and Economy 7 have a price range, TOU tariff has a fixed price because is offered by one company)

It can be seen that the great advantage of the new tariff is to offer the same price as the flat tariff during the day and at the same time offering a more competitive price during the night. End users should only try to limit the consumption during the period between 16:00-19:00 in order to reduce the electricity expenditure. By offering a very low price during the night, the goal of the company was to encourage end users to install battery energy systems. Moreover, the tariff is also designed in perspective of a huge adoption of electric vehicles, which are usually charged during the night. [13].

3.2.3 Italy

Enel, the biggest Italian electricity provider, had also introduced a TOU tariff (in form of dual tariff) starting from January 1st, 2017 [14]. The tariff scheme (Table 3) is a similar concept to the Economy 7, having a higher rate during day hours and a lower rate in the night compared to the flat tariff. Even though the night tariff is less advantageous compared to Economy 7, the dual tariff is more tempting for end customers since the period of low price starts at 19:00 (rather than 23:00) and customers do not need to change their habits radically to achieve reasonable cost savings.

Type of Tariff/Time	8:00-19:00	19:00-8:00 and weekends
Flat Tariff (DKK\kWh)	1.05	1.05
Dual Tariff (DKK\kWh)	1.10	1.02

Table 3: Electricity tariffs in Italy: flat tariff and dual tariff [14]

3.2.4 France

France is probably the country where dynamic tariffs for the electricity market is most commonly adopted by the end customers (also because of the long tradition of use electricity for heating purposes). Électricité de France (EDF), offers three different tariff options for end users: Option Base, Option Heures Creuses and Option Tempo. Option Base is a flat tariff while Option Heures Creuses is a TOU tariff similar to Economy 7 used in UK and the dual tariff used in Italy. Table 4 shows the price for the 2 tariffs.

Type of Tariff/Time	7:30-23:30	23:30-7:30
Option Base (DKK/kWh)	1.10	1.10
Option Heures Creuses (DKK/kWh)	1.18	0.93

Table 4: Option Base and Option Heures Creuses tariffs (prices are for end users with a power rating lower than 6 KVA).

Option Base is more suitable for end users with very limited consumption and without electric heating. On the other hand, customers with both electrical space heating and domestic hot water might reduce their expenditure by choosing the Option Heures Creuses [15]. EDF also offers the tariff Option Tempo, suitable for high use household and small business customers. Option Tempo is a form of TOU tariff but with six rates of electricity pricing based on hours of use but also the actual weather. Under Option Tempo, each day of the year is color coded. There are three colors, blue, white and red which correspond to low, medium and high electricity prices, as shown in Figure 6.

The color of each day is determined mostly by the electricity provider (EDF) based on the forecast of the electricity demand, which in turn is highly affected by weather conditions. The French transmission network also has the ability to determine the day's color in case of network congestion. In addition to a color, each day also has an on peak/off peak period where the off peak period last from 10 p.m. to 6 a.m. (except for the red days where it is from 9 p.m. to 7 a.m.).

The rules for end users adopting Option Tempo are [16]:

- The tariff starts each year on September 1st, while the daily tariff starts at 6 a.m.
- The number of days per year of each color are fixed. 300 days are blue, 43 days white and 22 days red.
- Sunday is always a blue day
- Red days cannot occur on holiday or weekend or for more than five weekdays in a row.

Moreover, customers who choose the Option Tempo are informed each night (8 p.m.) about the color of the day after and consumers can adjust their consumption in function of the color. Even though Tempo costumers save in average 10% [16] of the total costs compared to the flat tariff, the complexity of the tariff requires them to constrain their lifestyle, if they want to save money.

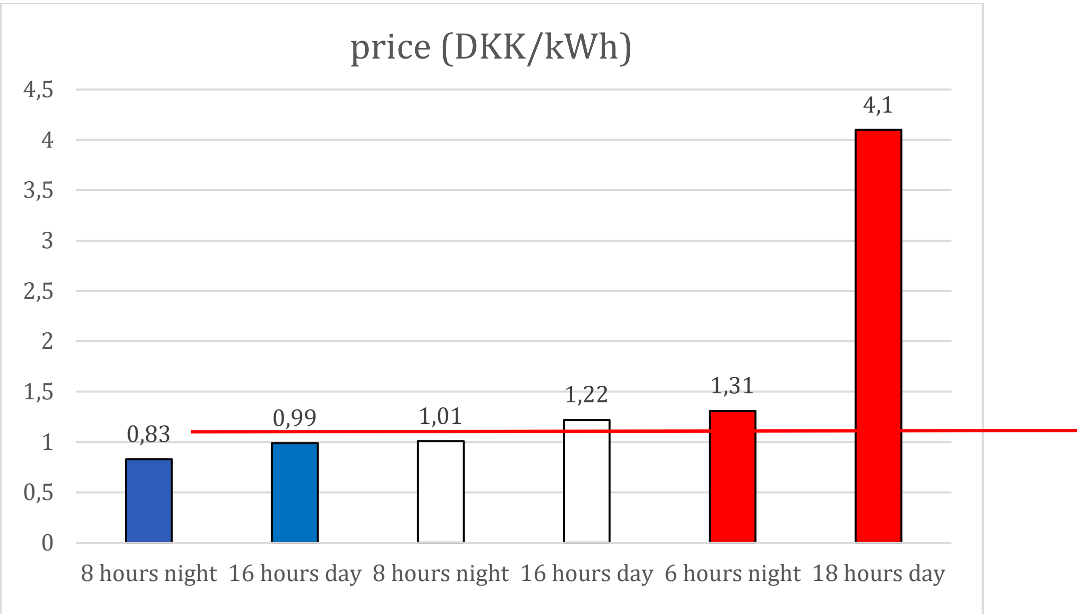

Figure 6: Electricity rates under the Option Tempo: Blue days corresponds to 300 days yearly, white days are 43 while red days are 22. The red line represents the price of the flat tariff.

3.2.5 Denmark

The Danish electricity distribution company Radius, which delivers electricity to most of the households in north and mid Zealand has also introduced a CPP tariffs for its customers during 2019. The old electricity tariff was flat at 37.51 Kr./kWh all year around, but the new tariff has a higher price from 17:00 to 20:00 at 83.50 Kr. per kWh during winter season (October to March), while for the rest of the day and year the price is at 32.36 Kr./kWh [17].

In this way, the company provides an incentive to households that are willing to and capable of moving parts of the usage of washing machines, tumble dryers and dishwashers outside peak periods. However, in order to take advantage of these savings, the customer will have to have a smart energy meter, and according to Radius they are installed in their area by 2020.

EcoGrid project

The EcoGrid EU was a demonstration project carried out from March 2011 to August 2015, on the island of Bornholm, with the purpose to show in large-scale a generally applicable real-time market concept for smart electricity distribution networks with high penetration of renewable energy sources and active user participation.

Moreover, the project targeted at evaluating the increased share of renewables and whether or not end-users improve their energy consumption when subject to variable tariffs. In order to encourage end users in joining the project, participants (approximately 2000 persons) were equipped with smart meters to properly measure their consumption and to be able to respond to the price variations.

The real-time price was set by the Real-Time Market Operator (RTMO) on the basis of the need for up/down regulation due to imbalance between production and consumption or bottlenecks in the transmission system, and it was updated every five minutes in order to maximize the potential for a dynamic response.

Even though the project lasted 4 years, the real-time market was only fully operational for 4 months, and reliable data and outcome covers only the last two months (March-April 2015). Though, the period was long enough to make a comparison between the real-time market and the baseline. Some of the most important results are [18]:

- The share of renewable energy in the electricity system has increased by 8.6 % and the wind power curtailment was (virtually) reduced by 80%
- Costs in the regulating market were reduced by 5.4 %
- The real time demand response activation have shown 100 % success for down regulation and 80 % for up regulation (meaning that consumers are willing to increase their consumption when the price is low but less keen to reduce their consumption when the price is high). Overall, more than 3% of the total load shifted as a response to the price variation, on daily basis.

Overall, customers reacted positively to the project and more than 70% of the participants were satisfied by the experience. Customers not satisfied by the project, typically had technical issues with the smart meters forcing them to adopt a manual response approach, which was considered too time consuming and risky.

In general, the project shows that a real-time market approach will benefit both the system and consumers and also that it can be used as a textbook example of how to create commitment for smart grid in a population. However, this is particularly true in case of island communities or defined areas, while in large urban areas the recruiting conditions and the choice of instruments can be more challenging [18].

4. SUMMARY

The above mentioned examples of dynamic tariffs adopted by several energy companies from different countries both within the district heating and electricity sectors have shown that there are many ways and reasons for supporting dynamic tariffs as a valid solution for improving the efficiency of the energy system as well as for facilitating the integration of more renewable energy.

Introduction of dynamic tariffs, in particularly TOU tariffs, is widely used on the electricity markets in Europe. Dynamic tariffs for the district heating market is introduced in the “Open District Heating” market concept in Stockholm, but is more focused on the supply of district heating rather than the consumption. The Danish study on competitive district heating prices also looks at dynamic district heating prices and concludes that a daily time resolution could be relevant, but it has not yet, according the authors knowledge, been introduced in any of the district heating companies.

The electricity and district heating markets have substantial differences in their structure, where the electricity market is international and competitive the district heating market is typically local and less competitive. Furthermore legislation and ownership structures vary a lot from electricity to district heating companies, and again from country to country, primarily in the area of district heating.

The price volatility on an hourly basis is also different between the electricity and heating sector. Typically, the electricity price is more volatile and to some extend following the production coming from renewables such as wind and solar.

However there are also similarities and it can be seen that production costs on both electricity and heating is influenced by the demand and the seasonality, especially in the peak load hours being around 06.00-09.00 and 17.00-20.00 and are higher during the winter season.

Having dynamic production cost reflected prices for both the electricity and heat markets available for the customers, should promote both energy saving activities as well as more integrated energy solutions and thereby introduce more renewable energy into the overall energy system.

But to adopt dynamic tariffs for electricity and heating it is crucial that the end users behave as expected and change their consumption in response to price variations and therefore it is very important to develop both attractive incentives and new technological solutions making it possible for the customers to become more flexible.

The concepts of dynamic tariffs both in the heat and electricity markets are still quite few and simple, but with the future integrated and flexible energy system more of these concepts are to be expected.

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Sources	Total electricity costs
Nordpool	**Elspot (realiseret 2018) DK2**
Energistyrelsen	**PSO-tarif**
Skat	**Energiafgift**
Radius	**Distributionstarif***
Energinet	**Nettarif transmission**
Energinet	**Systemtarif**
Energinet	**Balancetarif for forbrug**
	* C-kunde: med aftagepunkt i 0.4kV nettet (Radius)

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