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Review of urban energy transition in the Netherlands and the role of smart energy management

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ABSTRACT

This paper gives a review of the most important backgrounds and trends of the present energy supply system in the Netherlands. Options are discussed for the integration of renewable energy and the present policies are reviewed that stimulate the energy transition. Last, the role of smart energy management as part of the integration of renewable energy into existing infrastructures is discussed.

1. Introduction

The use of traditional, carbon based fuels contributes to the accumulation of carbon dioxide in the earth's atmosphere with global warming as a consequence [1]. Governments and citizens of many countries in the world recognize the need for energy savings and a transition towards energy from renewable sources. The European Union developed legislation and member states are committed to reach energy savings and increased renewable energy shares for 2020 (so called 20–20–20 goals: 20% energy saving, 20% renewable energy share in 2020). Road maps are also developed towards 2050 to have a completely renewable energy system [2].

This paper reviews backgrounds of the Dutch energy transition and policies in place for the integration of renewable energy for urban areas. The paper explains the history of the Dutch energy system up to the present system which is supplied by a mixture of fuels and renewable resources and why the use of natural gas is still dominating within this mixture. The paper also explains policies developed for the transition to more renewable resources. For this paper, an urban area is interpreted as a district or community containing houses and possibly some other buildings like offices, schools and small companies. Such an area can be a village or a district of a city.

The paper starts with a review of the most important backgrounds and trends of the present energy supply system and the energy transition in the Netherlands in Sections 2 and 3. The present Dutch policies for stimulation of renewable energy integration are reviewed in Section 4. Options for renewable energy are discussed in Section 5, followed by the current issues for integration of renewable energy and the role of smart control in Section 6. The paper ends with conclusions and an outlook in Section 7.

2. Energy supply and consumption in the Netherlands

In the Netherlands, 3200 peta Joules (PJ) of primary energy (i.e. input energy from resources such as crude oil, hard coal, natural gas) is used per year. In Fig. 1 the distribution of primary energy towards consumption categories is shown for 2015. The built environment includes the whole category "households", a large part of the category "services" and a small part (only the buildings, not the processes) of the category "industry". The primary energy consumption in the Netherlands is 3060 PJ in 2015 and constitutes a mixture of sources, refer to Fig. 1. The final energy consumption (secondary energy, i.e. produced from primary energy) is 2070 PJ per year of which 1232 PJ is consumed for the thermal demand, 353 PJ for the electrical demand and 485 PJ to drive vehicles.

The built environment (households and services, i.e. office buildings) is the largest energy consumer: 33% of the final consumption, i.e. 490 PJ or 24% for heating buildings and hot water and 195 PJ or 9% for electrical appliances. The built environment has a low temperature (LT) heat demand (below 100 °C). On the other hand, the industrial sector (478 PJ thermal demand) has a

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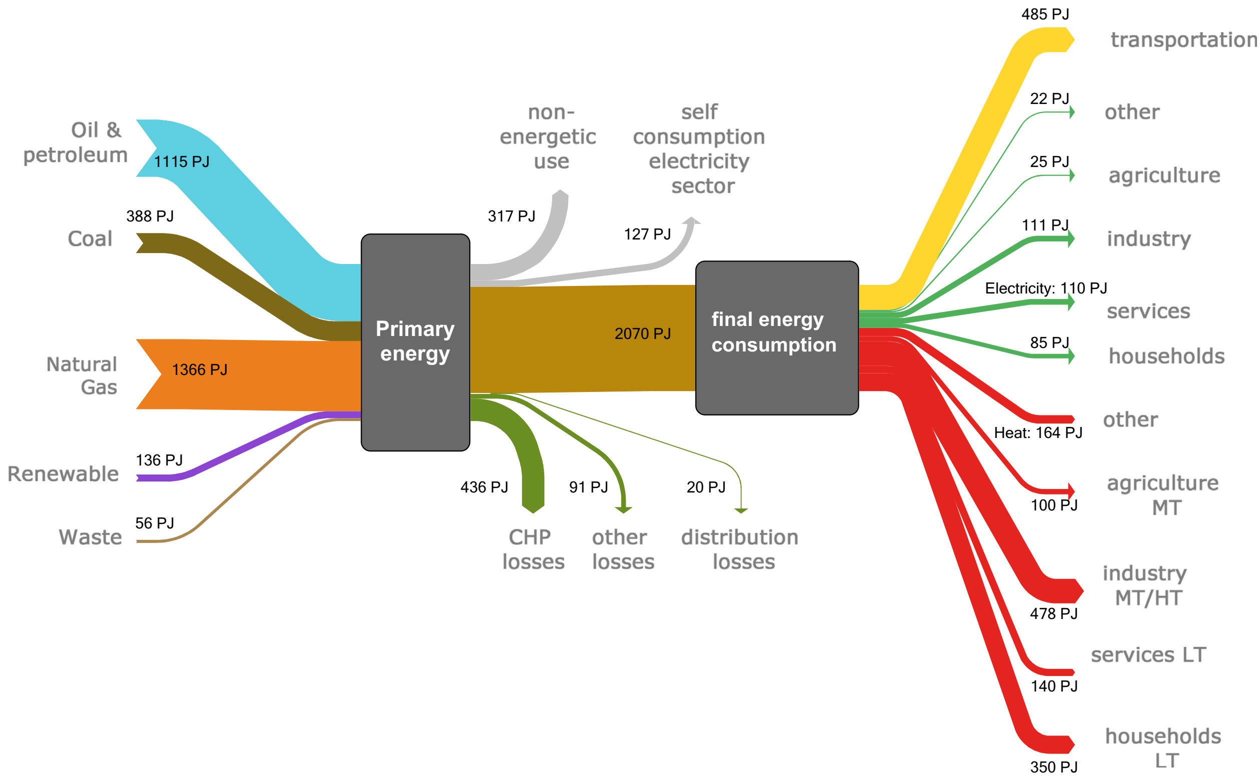

Fig. 1. Primary energy consumption.

mediate to high temperature (MT/HT) demand (100–500 °C/500–1500 °C). Through industrial processes this heat is converted into a LT-heat waste stream, in the range 20–80 °C. Other LT-heat waste streams are conversion losses of the electricity sector, i.e. 436 PJ in the same temperature range. Together, this amounts to 914 PJ which could potentially be used to supply the entire heat demand (490 PJ) of the built environment. Fig. 1 is constructed based on information provided in [3–5].

The Netherlands relies for more than 90% on natural gas combustion in boilers for the supply of the building related thermal demand. For the electrical energy demand, 84% is converted by natural gas and coal combustion. Due to recent low prices of coal, the share of coal increased in recent years which also led to an increase of the related CO_2 production. The remaining part of the electrical energy demand is supplied by waste co-generation plants, wind turbines and solar PV [3].

While combustion of natural gas leads to 50% less CO_2 emissions compared to combustion of coal, the Dutch energy system was relatively environmentally friendly in the past, in comparison with many countries which use predominantly coal combustion. However, large scale combustion of fossil fuels increases the CO_2 concentration in the atmosphere, which causes temperature increase (global warming) on the planet. In the last decades it has become clear that this effect changes climate systems all over the world with serious consequences to nature and population. Hence, environmental policies aim to out-phase the use of fossil fuels entirely. Recently, new agreements on climate change are adopted by the UNFCCC (United Nations Framework Convention on Climate Change) [6] with a treaty to limit global warming to 2.0 degrees and to strive for a limitation of 1.5 degrees. The treaty is signed by many governments in the world, including the Netherlands.

The Dutch ministry of economic affairs, responsible for energy policies, has announced a shift of paradigm: initiatives towards integration of renewable energy in the heating sector will be encouraged in order to phase-out the use of natural gas completely by 2060 [7]. In [8], the Dutch government translates this vision into policy measures and proposals. An important step towards realization of the ambitions is the so called "energy agreement" between the government and the major economical sectors (energy, industry, services) [9,10] in which targets for the short to mediate term are agreed for energy saving, increasing the share of renewable energy, finance and job creation. Part of this deal is the structural plan for large scale offshore wind turbine fields [11] and support for local urban energy initiatives [12].

3. Backgrounds of the energy transition

Traditionally, thermal energy for heating purposes is delivered by fuel combustion. Since the discovery of fire, many thousands of years ago, people used wood as fuel. Population growth, formation of larger cities during the industrial period and increasing depletion of wood reserves in many industrialized countries led to replacement of wood by coal. In the Netherlands, from the early industrial period until the 1950s, coal has been the dominant fuel for households but this ended in a relatively short time period due to the discovery and exploitation of natural gas reserves. Today, natural gas is the dominating fuel for households and industry and Dutch manufacturers of natural gas boilers and appliances have a world leading position in efficient, innovative technology. The fast Dutch transition process of replacing coal with natural gas, is a prove in itself that countries can make the transition to new energy sources in a relatively short period of time [13].

Another example which proves that transition towards a high share of renewable energy is possible is Denmark. From the 1980s Denmark made a transition from complete dependency on fossil fuels towards the present situation where the country has the highest share of renewable energy from wind turbines and solar energy in the world [14].