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Norwegian Waste-to-Energy (WtE) in 2030: Challenges and Opportunities

Michael Becidan*[a], Liang Wang[a], Morten Fossum[b], Hans-Olav Midtbust[c], Johnny Stuen[d], Jon Iver Bakken[e], Egil Evensen[b]

[a]SINTEF Energy Research AS, NO-7465, Trondheim, Norway
[b]Statkraft Varme AS, NO-7005, Trondheim Norway
[c]Energos AS, NO-7072 Heimdal, Norway
[d]EGE (Waste-to-Energy Agency) Oslo, NO-1215, Oslo, Norway
[e]Hafslund ASA , NO-0247, Oslo, Norway
michael.becidan@sintef.no

The Norwegian Waste-to-Energy (WtE) industry faces a difficult situation on many levels: (a) an internationally open and competitive market with significant export of both MSW (Municipal Solid Waste) and C&I (Commercial & Industrial) waste to Sweden, (b) low energy revenues reduce profitability, (c) a limited national market (both concerning district heating and industry customers), (d) questions about CO_2 footprint and (e) a more and more stringent regulative framework. All that comes in addition to an array of technical challenges associated with waste as a fuel for combustion applications.
This work is a short discussion of important aspects, both challenges and opportunities, for the Norwegian 2030 WtE industry. The authors are from the three largest WtE actors in Norway, a WtE technology provider and a leading R&D institute. The reflection axes are articulated along three questions:

1. What are the unique advantages offered by WtE to the Norwegian society?
2. What are the challenges faced by WtE in Norway?
3. What are the novel aspects that will be essential for Norwegian WtE to take into account in the coming years?

1. Introduction

Before discussing the current and future Norwegian WtE sector in details, it is important to summarise the status in Norway concerning the bigger picture, i.e. its energy mix, climate goals and achievements and overall waste management.
The total yearly energy use in Norway was about 217 TWh (for both 2012 and 2013), half of it being electricity. Electricity is almost exclusively (more than 95 %) produced by renewable hydropower (hydropower production was 127 TWh in 2013). A noticeable and specific feature of the Norwegian energy use is that electricity covers the majority of the heat demand, with wood stoves in second place and district heating in third place covering a few percent compared to the 35-50 % level in other Nordic countries (Sweden, Finland, and Denmark).
Even though Norway is not an EU member country, it has implemented, through the EEA/EFTA agreement, the EU Renewable Directive with a national goal of 67.5 % RES (Renewable Energy Sources) by 2020 from a 2012 value of about 64.5 %.
Norway produces a total amount of waste of about 10.7 Mt (SSB) with a population of just above 5 million inhabitants. As shown in Figure 1, Norway is a typical Nordic country with high levels of material and energy recovery (respectively 35 and 40 %) and limited landfilling. While biogas production from wastes/by-products (food, manure, etc.) generates growing industrial and R&D interests, it only represents a very small fraction of biodegradable waste treatment today.

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Concerning biomass and MSW, two momentums should be further mentioned:

- The Norwegian national bioenergy plan is an important document pertaining to bioenergy, and therewith MSW (OED, 2008). It sets the overall goal of doubling bioenergy production, from 14 to 28 TWh, between 2008 and 2020. The bioenergy production (SSB, 2014) was about 17 TWh in 2012 and 2013, indicating that reaching the 2020 goal appears difficult.
- In 2012, a common Norwegian-Swedish green electricity certificate market was established but did not include WtE. According to the current prognosis, it is mainly hydropower that will benefit from this scheme in Norway.

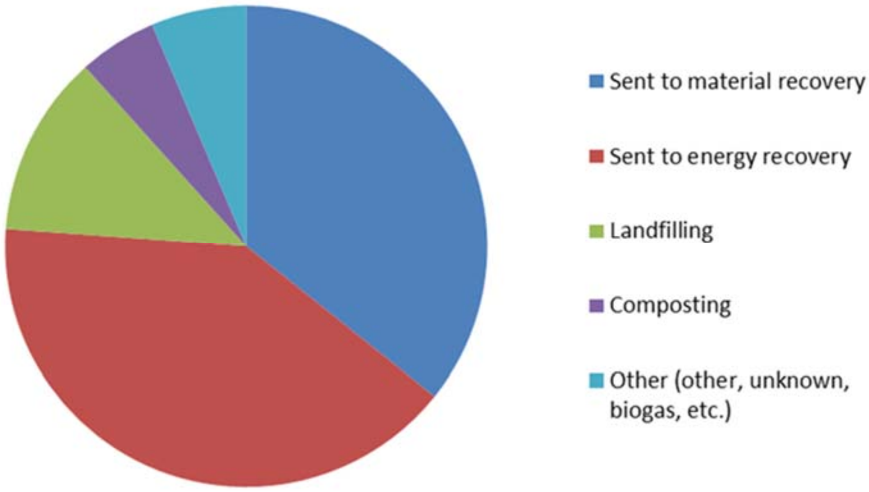

Figure 1. Waste (all types) treatment in Norway (SSB, 2012)

2. The sector today: short description of MSW and WtE in Norway

As a EEA/EFTA country member, Norway is implementing EC directives and has therefore a similar regulatory framework as other EU countries in WtE questions such as gaseous emissions limits and "R1 formula", with a few exceptions of tougher regulations concerning, for example, Hg and water effluents.

There are currently 17 WtE plants in Norway that process about 1.70 million tons MSW (2013, approx. 60 % from households) and produce about 4 TWh for district heating networks (see further details in the next section), as well as some steam to the industry and some electricity. The majority of Norwegian WtE plants are of medium to small capacity, with the smallest national average size in Europe, namely 60 000 t/y (EC JRC IPPC Bureau, 2005). Concerning the biogenic fraction of MSW in Norway, the latest study (Avfall Norge, 2010) evaluates it at about 52 % (on energy basis). While the majority of energy from waste is of biogenic origin and can readily be considered renewable, the remaining fraction "renewability status" is debated. While some consider that it is of fossil origin and should therefore be considered non-renewable, other argue that it could not be disposed of in any other way, hence producing "waste/surplus heat", a renewable energy according to Enova. It should be noticed that about 50 % of WtE is computed as renewable in the Norwegian national statistics. This open debate is far from being only technical and any "final" decision may actually have social, political and industrial implications.

The latest trends in Norwegian WtE can be summarised as such: (1) strong increase in the total capacity (it was about 1.25 Mt/y in 2010 compared to 1.70 today) – with an average throughput of about 90 % of their nominal capacity; (2) landfill ban for organic waste (2009); (3) MSW export to Sweden (several hundred thousand t/y); (4) a significant fraction of the energy (mainly heat) produced is not delivered to any customer (evaluated at 21 % in 2011 in Ulvang (2012)), especially during the summer; (5) the capital city (Oslo) has newly implemented source sorting of food waste (in addition to paper, plastic, glass and metal); (6) the number of landfills has been reduced.

Concerning bottom and fly ash, a field where no EU regulatory agreement (concerning final treatment/disposal) has been reached so far, Norway implements two distinct solutions: fly ash is to be sent to special landfills for hazardous wastes (two exist, the main one is located on the Langøya island in the Oslo fjord) while bottom ash is landfilled or utilised in ordinary landfills. In spite of several industrial and R&D initiatives, no other disposal/use is currently authorised.

3. What are the unique advantages offered by WtE to the Norwegian society?

3.1 Increased energy flexibility and increased use of local energy sources

As previously mentioned, the energy use for heating purposes in Norway has for many years mainly been based on electricity produced by hydropower. In the 1990's Norway experienced an energy crisis due to large yearly variations in hydropower production combined with limited transfer capacity from Europe. This resulted in a new national strategy (Energimeldingen, 1998-99) for energy production and hence the creation of Enova SF - the public enterprise for economic support of environmentally friendly energy projects - in 2001. The new national strategy included an energy development program with a twofold goal: (1) increased energy flexibility based on energy production from local, renewable energy sources as well as (2) reduced dependency on electricity for heating. This national aim was further emphasised by new climate aims in 2002 (Klimameldingen, 2001-02) which included the promotion of WtE to replace fossil energy sources (residential oil boilers for example). These important signals from the Norwegian government led to a significant increase in the building of new WtE plants with energy production for district heating, electric power and industrial steam. Figure 2 shows the historic use of fuels in Norway for district heating from 2004 until today.

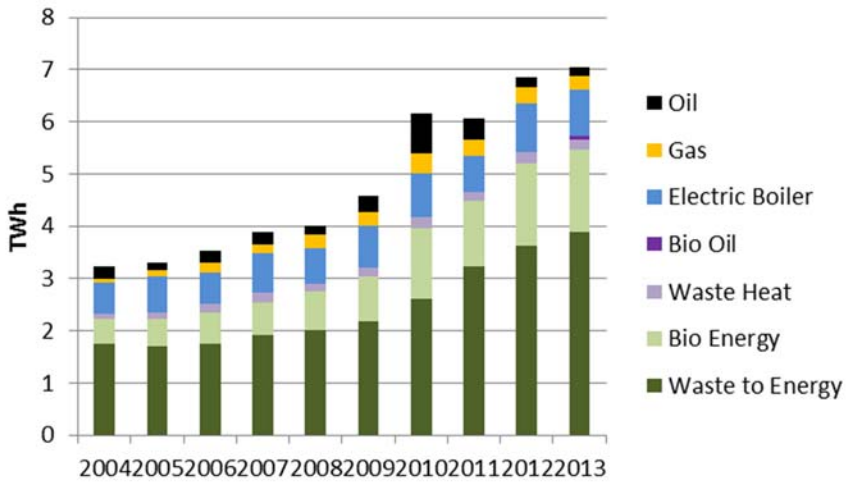

Figure 2. Energy sources in district heating plants in Norway (SSB, 2014)

The evolution observed clearly shows the major role WtE plants have in the increased energy flexibility and increased use of local renewable energy sources. Today, more than 50 % of the total district heating production in Norway is provided by WtE plants. The second contributor is bioenergy. WtE plants generate energy from local residual waste; contribute to energy supply security and greenhouse gas emissions reduction.

3.2 WtE plants are vital for fulfilling the national goal for waste treatment

The Norwegian waste treatment strategy is similar to the goals and vision set by the EU and is based on increased material recycling and reduced landfilling (see the hierarchy of waste management options and the Landfill Directive). Norway introduced also, as a few other European countries, a total landfill ban on biodegradable waste in 2009. This landfill ban can only be fulfilled by using WtE plants in combination with material recycling. After material recycling (source sorting) of several fractions (paper, plastic, metal, glass, wet organic matter etc), WtE plants produce energy from the remaining waste fraction that is contaminated and has a complex and heterogeneous composition. The WtE plants act as a sink for pollutants with their thermal treatment processes destroying organic pollutants and extracting chemical pollutants via advanced flue gas cleaning system. This increases the quality of the material within the waste circulation system. Furthermore, WtE plants increase material recycling by sorting out valuable elements from bottom ash for example ferrous and non-ferrous metals.

4. The challenges faced by Norwegian WtE

The future of the Norwegian WtE market looked promising at the beginning of the 2000’s. The shortage of processing capacity was significant and a landfill ban for biodegradable waste was announced for 2009.

During this period, a significant number of WtE plants were built or expanded to cope with this national capacity shortage, still leaving a shortage of approximately 1 mill tons. Despite these facts, three Norwegian WtE plants closed down in 2010-2011 with a total annual capacity of 80,000 t/y. This was simply due to unsufficient profitability.

Currently, several Norwegian WtE plants are suffering from low profitability. The main reason is that the processing capacity exceeds the waste arising in the Scandinavian market where the gate fee is basically set by the Swedish WtE plants. They can offer more favourable rates because of significantly higher revenues from energy sales than the ones achieved by Norwegian WtE plants. Swedish WtE plants are benefitting from well-developed district heating systems that enable the WtE plants to deliver recovered energy as heat plus higher energy prices than in Norway.

A market with excess capacity will put the gate fees under pressure and that is not financially viable in the long run. There are two alternatives, either reduce the processing capacity or increase the demand for processing capacity. One the one hand, a movement towards capacity reduction has, as already mentioned, started and will probably continue if nothing is changed. If the capacity is not reduced, WtE plants will continue to suffer from low profitability and sooner or later several of them will be forced to discontinue their operation. On the other hand, an increase in demand for processing capacity can be achieved by the import of waste from markets with insufficient capacity, i.e. countries where the waste would otherwise be landfilled. The main challenge is to be able to implement this in a cost efficient manner in order to ensure that the gate fee is acceptable for continued operation. It is possible as exemplified by the WtE agency in Oslo (EGE Oslo), currently importing waste from the United Kingdom.

If the current WtE market is stabilised, there will still be a challenge to establish new WtE plants in the Norwegian market. The main reason is the lack of good project opportunities, i.e. projects that can secure a long-term, strong and stable revenue stream from energy sales. The major cities in Norway (Oslo, Bergen, Trondheim and Stavanger) have already a well-developed infrastructure for district heating. The remaining district heating market is limited and only for small-scale applications. This makes it difficult to realize WtE plants that can secure a full utilization of recovered energy. A possibility to improve energy utilisation is combined heat and power (CHP). However, even that prospect is challenging from a financial point of view for two reasons: (1) high investment costs; (2) minor differences between the energy prices achievable for the sales of heat and electricity in Norway. This will cause a significant reduction in the revenue stream for a WtE plant that has to sell electricity rather than heat.

Another possible market sector is the industrial hot water/steam market. Several WtE plants in Norway are currently integrated in the industry. An example is the FREVAR WtE plant located in the Øra industrial area (near Fredrikstad). It delivers about 200 GWh/y heat to industrial actors (FREVAR, 2014). The challenge with these projects is that the WtE plant is often dependent on a single large customer that might shut down or reduce its activities abruptly due to fast-changing market situations. Furthermore, large industrial energy consumers are used to significant discount in energy prices and they are normally not willing to commit to long term energy supply contracts. The result is that it is more challenging to fund these projects as the potential profitability is low.

5. What are the novel aspects that will be essential for Norwegian WtE to address in the coming years?

The Norwegian WtE industry must find its place in a circular economy, and concentrates even more on bringing back a variety of products to the society.

Today's WtE main product is energy, heat and/or power, in addition to the "traditional" service of waste disposal (volume/ weight reduction and hygienic destruction). Energy (heat and/or power) can be seen as the main product because waste disposal has been suffering from decreasing prices (the so-called gate fees) that will probably remain low in the near and medium-term future.

The WtE plants will in the future concentrate on being as reliable, safe and cost-effective energy producers as possible, and will develop technologies and markets that can make use of the totality of the heat produced, as today a significant fraction does not find its way into the district heating systems but is wasted, especially in the summer. This will include technologies that can produce electricity from low temperature heat sources, technologies that can convert the heat (and electricity) to other energy carriers (hydrogen) or energy storage technologies that make sure that most of the energy is used.

Energy systems – based on renewable energy sources – must also go through profound changes. District heating networks must develop flexibility and more efficient/wider markets to make sure that the energy from the district heating network can be sufficient to all thermal energy demands in buildings. It must also be a two-way network, where as much as possible of the energy leaving buildings is reused. See such a possible concept described on Figure 3.

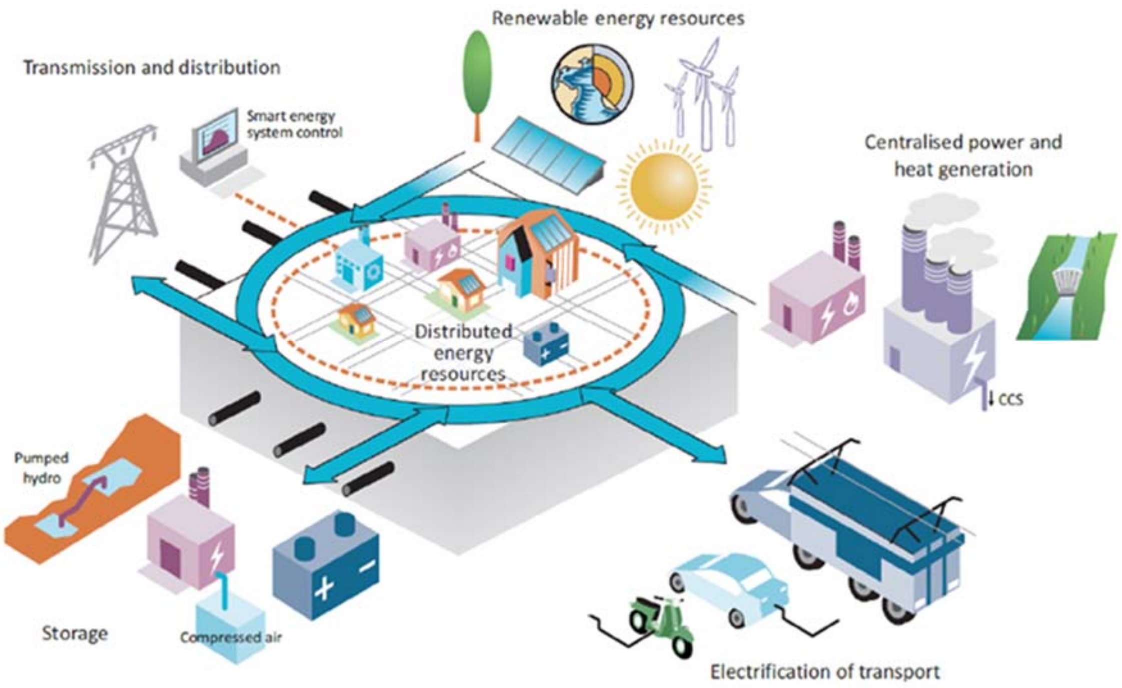

Figure 3. Smart, renewable, multidirectional and integrated energy system incl. WtE (IEA, 2014)

Sorting waste from all markets (household, industry, service, construction) will increase. Food waste will be sorted out to produce transport fuel (biogas) and fertilizer, and as much plastic as (economically and environmentally) possible will be material recycled. The plants must be able to either sort out recyclable materials before converting it to energy, or process waste fractions that cannot be treated in any other way. This trend will probably lead to new requirements concerning the (online) measurements of the heat value of the waste going into the furnace and require even more efficient flue gas cleaning systems.
In the longer term, there is even a possibility to be part of "urban mining" for valuable materials from old landfills. There is also the prospect of extracting high added-value chemical elements such as rare earth metals, but no technical solution is commercially available yet.
The by-products from WtE will increasingly be converted into marketable products. The technologies for extracting metal fractions from bottom ash and fly ash are soon to be standard solutions. The mineral fraction (phosphorus, etc.) from bottom ash is still not part of a commercial market, but recent developments suggest that this also can be converted into raw materials for, for example, clinker, cement or concrete.
Public perception is also a challenge. WtE plants must be able to explain and defend their roles both in responsible waste management and energy production systems. A key aspect is to make sure that the fossil CO_2 emitted is reduced to a minimum, and that it is emitted because there is no better way to re-use it.

6. Conclusions

The Norwegian WtE sector is facing great challenges especially low profitability due to international competition and low energy prices. But an evolution (a revolution?) towards new products, new markets, boost of energy sales and a stronger role in material recycling may well ensure its central place in a circular, renewable and sustainable economy.

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