GREEN BANK NETWORK

coalition for green capital

MARCH 2019

GREEN BANK INSIGHT

Bioenergy and Resource Recovery

PRIMARY AUTHORS: Abe Wapner, Rob Youngs, Coalition for Green Capital

www.coalitionforgreencapital.com

ABOUT GREEN BANK NETWORK INSIGHTS

Green Bank Insights are a Green Bank Network (GBN) product that consist of short reports that highlight collective successes and innovations of GBN Members and Green Banks in specific areas. They are an opportunity for the GBN Members to share their experiences and engage in continuous dialogue with the broader green finance community. The authors would like to thank the following organizations for their contributions to this document: Clean Energy Finance Corporation (Australia), Connecticut Green Bank, Green Finance Organisation (Japan) and Green Investment Group.

This paper was made possible with the support and partnership of the ClimateWorks Foundation.

ClimateWorks FOUNDATION

About the Green Bank Network

The Green Bank Network (GBN) is a membership organization managed by the Natural Resources Defense Council and the Coalition for Green Capital. It was founded in December 2015 to foster collaboration and knowledge exchange among existing green banks, enabling them to share best practices and lessons learned. The GBN also aims to serve as a source of knowledge and a network for jurisdictions that seek to establish a green bank. The GBN founding members are the Clean Energy Finance Corporation (Australia), Connecticut Green Bank (US), Green Finance Organisation (Japan), GreenTech Malaysia, NY Green Bank (US), Green Investment Group (U.K.) and Rhode Island Infrastructure Bank. Visit us at greenbank-network.org/about-gbn.

About the Coalition for Green Capital

The Coalition for Green Capital (CGC) works to establish Green Banks on the state, federal, and international levels by conducting in-depth analyses, leading fundraising and business planning efforts, and providing specialized consulting services. With CGC's leadership and technical support, Connecticut created the first state Green Bank in the US with near unanimous bi-partisan support. CGC then followed that with work in New York, Hawaii, California, Maryland and many other states supporting Green Bank design and implementation.

CGC is working internationally on a number of Green Bank projects, including in South Africa where CGC worked with local stakeholders to design and raise capital the first Green Bank in emerging markets—the Climate Finance Facility—supported by the Green Climate Fund. CGC works on a number of other Green Bank scoping and design projects in Latin America, Africa and Southeast Asia.

Contents

Introduction

This paper discusses different Green Bank approaches to financing projects in the bioenergy and resource recovery sectors. The goal of this paper is to provide an overview of the technology and present examples of successful projects to share lessons learned and best practices. Several example projects in the bioenergy sector are first-of-kind or were developed under new regulatory regimes, and benefit from Green Bank "first mover" financing. Innovative financing approaches and methods for addressing both real and perceived risks across a number of markets can be drawn from the examples presented by Green Bank activity in the bioenergy and resource recovery sectors.

Technology and Sector Overview

Modern bioenergy, including technologies such as biogas, biofuels and waste-to-energy is an important energy source worldwide. Bioenergy is a fast growing sector, with annual growth rates of 15%.[1]

The International Energy Agency (IEA) report "Renewables 2018" refers to modern bioenergy as "the overlooked giant within renewable energy" with modern bioenergy (including use in electricity, mobility and heat in buildings and industry) responsible for half of all final renewable energy consumed in 2017. In other words, modern bioenergy (excluding the traditional use of biomass) provides as much final energy as hydro, wind, solar and all other renewable energies combined.[2] Bioenergy accounted for about 10% of total final energy consumption for all energy sources, and 1.4% of global power generation in 2015.[3]

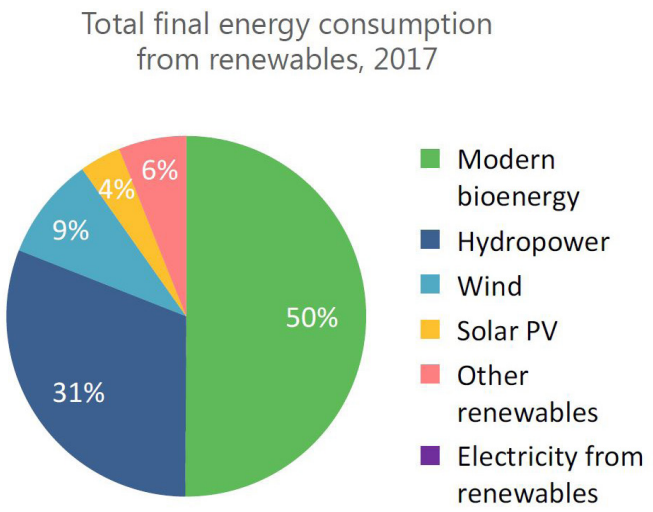

Figure 1. Total Final Energy Consumption from Renewables, 2017 (IEA Renewables 2018)

The IEA analysis predicts that over the 2018–2023 period, bioenergy will continue to have strong growth and will remain the predominant source of renewable energy, although its share of total renewable energy is projected to decline from 50% of final renewable energy in 2017, to 46% as the expansion of both solar PV and wind accelerates in the electricity sector. In terms of electricity generation alone, worldwide bioenergy is the third largest renewable energy source, following wind and solar.

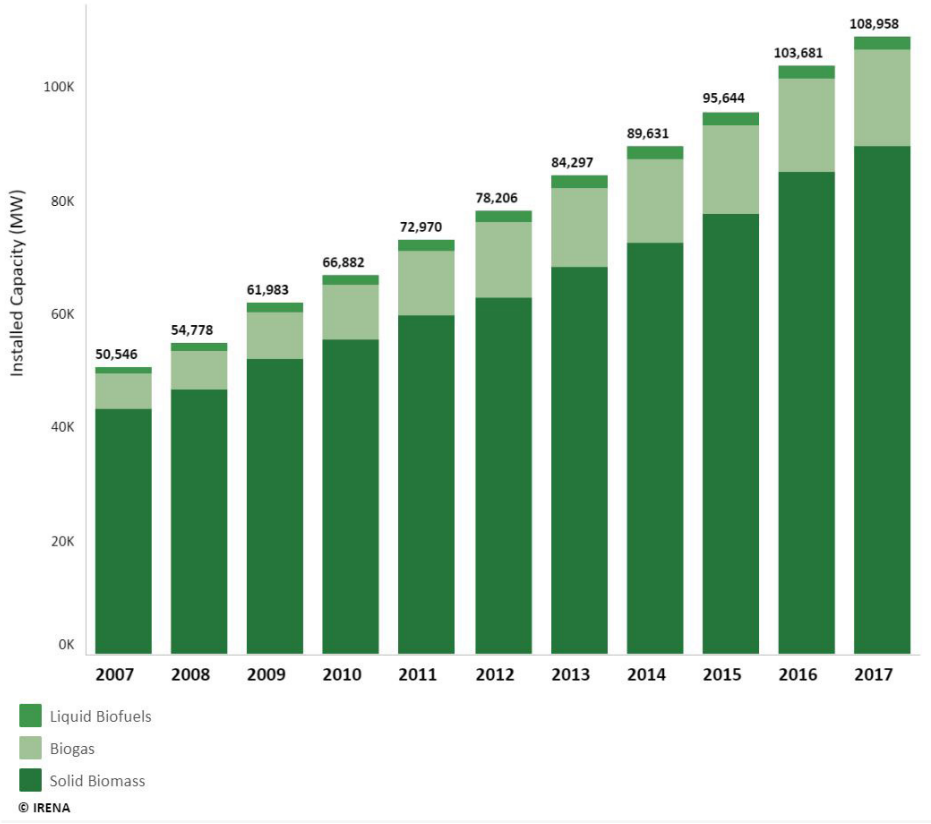

Figure 2. Trends in Bioenergy (Installed Capacity)

1 World Bioenergy Association. "WBA Global Bioenergy Statistics 2017"

2 International Energy Agency. "Renewables 2018"

3 International Renewable Energy Association. "Bioenergy"

The Waste Hierarchy

Bioenergy and resource recovery technologies (such as biogas and composting) are commonly viewed in the context of the Waste Hierarchy, which is an internationally recognized system for prioritizing waste related activities. The Waste Hierarchy is broadly segmented into three tiers, although each tier can be further segmented. Both bioenergy and resource recovery activities are grouped in the second tier of the Waste Hierarchy, with bioenergy representing a subsection of resource recovery.

A powerful tool for decision makers, the Waste Hierarchy can help frame policy and investment priorities in the waste sector. Since post-consumer waste is estimated to account for 5% of global greenhouse gas emissions,[4] supporting resource recovery and bioenergy projects aligns Green Banks and other leading green finance institutions with their mission to alleviate climate change. For example, Australia's Clean Energy Finance Corporation (founding member of the GBN) uses the Waste Hierarchy to frame its activities. As stated in an August 2018 CEFC media release: "The internationally-accepted 'Waste Hierarchy' lists avoiding and reducing waste as its preferred outcomes. Its least preferred outcomes are treatment and disposal. Resource recovery, which involves reusing, recycling, reprocessing and energy recovery, is an important middle tier where the CEFC's finance for projects is making a difference."[5]

According to the Waste Hierarchy, the highest priority, and thus the first tier in the hierarchy, is the avoidance and reduction of waste generation. This tier of activity encompasses ways "the community, industry and government can reduce the amount of virgin materials extracted and used."[6] The goal of this tier is to maximize efficiency and avoid unnecessary consumption. Behaviors encouraged by this tier can include, *inter alia*, selecting items with the least amount of packaging, consuming leftover food (rather than disposing of it), avoiding disposable goods or single-use material and buying recycled, recyclable, repairable, refillable, re-usable or biodegradable items.

Figure 3. The Waste Hierarchy[7]

4 World Bank. "What a Waste: A Global Review of Solid Waste Management"

5 Clean Energy Finance Corporation (CEFC) "CEFC and Sacyr target landfill and emissions with innovative solutions for green waste" 2 August 2018

6 US Environmental Protection Agency. "The Waste Hierarchy"

7 Irish Department of Communications, Climate Action, and Environment. "Waste Hierarchy"

Below "avoidance" in the Waste Hierarchy is recycling. When raw material can be recycled, this can generate major savings in requirements for new resources. Recycling is usually defined as when material is diverted from a landfill and instead turned into a products that can be used for something else. This activity can include not only recycling of paper, plastic and metal, but also composting of organic materials if the process meets quality protocols.[8]

Benefits of recycling can include: reducing the amount of waste sent to landfills and incinerators, conserving natural resources such as timber, water and minerals, increasing economic security by tapping a domestic source of materials and preventing pollution by reducing the need to collect new raw materials.[9]

After "recycling" in the Waste Hierarchy comes recovery, predominantly energy recovery, which can include production of electricity, heat and liquid biofuels. The energy recovered can be considered renewable if the feedstock utilised to create energy is considered renewable (e.g. organic material). The goal of this tier is to extract as much energy content as possible from the items before disposal.[10]

The lowest tier in the Waste Hierarchy is treatment and disposal. This can include depositing waste at a registered landfill or incinerating waste without energy recovery. This last option in the Waste Hierarchy is seen as one to be carefully managed as landfills are expensive and can take decades to fully remediate. For example, a 2015 report from the CEFC cites a source from MRA Consulting Group which estimates the costs of landfills to be A$120/tonne after post-closure remediation.[11]

8 Irish Department of Communications, Climate Action, and Environment. "Waste Hierarchy"

9 US Environmental Protection Agency (EPA) "Recycling Basics"

10 United Nations Institute for Training and Research. "Guidelines for National Waste Management Strategies"

11 Clean Energy Finance Corporation. "The Australian Bioenergy and Energy from Waste Market"

Technologies

Resource recovery and bioenergy rely on a suite of technologies for recycling and extracting remaining energy from waste. Some of the most common include:

Industrial Composting

Composting plants are commercial-scale facilities which process large amounts of organic waste. Diverting organic waste from landfill to a composting facility has the potential to significantly reduce emissions that would otherwise occur when organic material decomposes in a landfill and releases methane. Composting plants assure optimal process conditions, fast degradation, good emission control and good compost quality. Under these conditions, microorganisms grow on organic waste, breaking it down to CO2 and water and using it as a nutrient. Part of the energy stored in the organic waste is released into the surrounding environment as heat. In industrial composting facilities temperatures in the composting heaps range between 50°C and 60°C.[12] The outputs of composting plants include heat, water, CO2, and fertilizer.

Industrial Recycling

Industrial-scale recycling facilities process large amounts of waste to separate and then resell it to producers. Waste is fed through a series of machines including hoppers, rakes and magnets which sort and separate metals, plastics, and paper/cardboard products. When like materials have been grouped, they are compacted into bales and resold to manufacturers. This process can be significantly more energy efficient than procuring virgin materials. For example, the direct energy required to recycle aluminum is 88% less than that required to produce primary aluminum.[13]

Anaerobic Digesters

Anaerobic digestion processes organic materials and biomass into methane. This "biogas" is created by bacteria which consume biomass inside a sealed digester and produce methane as a by-product. The biomass used in anaerobic digestion can include municipal solid waste, manure, crop residues, compost, food waste, paper and waste water.[14] The remaining material, digestate, is rich in nutrients and can be used as fertilizer. The resulting biogas can be used for heating or power, which is considered renewable energy.

Waste-to-Energy

Waste-to-energy (also called Energy-from-Waste) is the method of generating electricity or heat from the primary treatment of waste. Most waste-to-energy production involves the combustion of materials including municipal solid waste, commercial and industrial waste and biomass. For example, in the United States, materials such as paper, cardboard, food waste, grass clippings, leaves, wood and leather products still account for nearly 2/3 of municipal solid waste.[15] Waste is usually incinerated at special waste-to-energy plants that use the heat from the combustion process to make steam for generating electricity or provide heat for district heating or manufacturing. In addition to producing heat and electricity, waste-to-energy can reduce the volume of waste by 87%.[16]

12 European Bioplastics. "Industrial Composting."

13 United Nations Institute for Training and Research. "Guidelines for National Waste Management Strategies."

14 Balmoral Group. "Anaerobic Digestion."

15 Energy Information Administration. "Energy from Municipal Solid Waste."

16 Ibid.

Green Bank Activity

Green Banks have been active partners in the development of the global bioenergy and resource recovery market. Green Banks have used innovative financial structures, first-mover investments, and partnership with private capital to drive greater investment into the sector. Examples of Green Bank activity among leading members of the Green Bank Network are presented below.

Clean Energy Finance Corporation

Australia's CEFC has been a leader in the bioenergy sector for some time. Publishing a detailed report in 2015 titled "The Australian Bioenergy and Energy from Waste Market," CEFC identified an investment opportunity between A$3.5–5 billion in the Australian bioenergy and resource recovery sector between 2015–2020. To drive growth in this promising market, CEFC has made a variety of investments including first-of-kind investments to demonstrate the potential of proven technologies to provide benefits to Australian businesses.

CEFC is applying the Green Bank model to deliver first-of-kind bioenergy and resource recovery projects. Most recently in October 2018, CEFC provided a A$90 million commitment toward Australia's first large scale energy-from-waste project, a A$700 million, state-of-the-art plant at Kwinana in Western Australia capable of processing 400,000 tonnes per annum of waste and producing 36MW of electricity.

CEFC has also made several other bioenergy, resource recovery and recycling related investments, many of which are first-of-kind. These include:

- A$30 million investment program with Visy Industries to significantly increase its waste recycling and processing capabilities, in part to offset the impact of changes in the international recycling market.
- A$38 million commitment in the composting sector, to Melbourne's South Eastern Organics Processing Facility, annually converting 120,000 tonnes of kerbside food and green waste materials into high-grade compost, substantially reducing GHG emissions and increasing local landfill diversion.
- A$90 million corporate loan to Australian waste management company Cleanaway for a range of projects to accelerate moves away from traditional landfill solutions with technologies and practices that will help achieve better environmental, social and economic outcomes.
- A$30 million to leading resource recovery company ResourceCo to produce a solid fuel by processing 250,000 tonnes of non-recyclable waste streams into Processed Engineered Fuel (PEF).
- A$10 million commitment to Landfill Gas Industries to expand bioenergy at landfill sites in Central and Southern Queensland.
- Finance to enable major Australian garden products supplier Richgro to harness anaerobic digestion technology to meet all its power needs by recycling organic waste.
- An investment with JBS Australia, the country's largest meat processor and exporter, to capture and use biogas at its Dinmore, Queensland facility to reduce dependence on grid-connected natural gas by roughly 50%.

The CEFC is also working with Foresight Group to identify and develop opportunities to invest equity in a range of bioenergy and energy from waste projects in the Australian market. Internationally, the Foresight Group has financed waste projects with an annual waste processing capacity of 1.9 million tonnes. The CEFC work with the Foresight Group aims to help accelerate and widen market uptake of bioenergy and energy from waste technologies that have a proven track record overseas but are not yet widely deployed in Australia's energy mix.

Green Finance Organization

Japan's Green Finance Organization (GFO) has successfully financed bioenergy projects to drive local markets in Japan. These projects are further examples of how the Green Bank model can be used to catalyze investment and industry growth.

GFO supplied 70 million Yen in equity to the construction of the Hokkaido Betsukai biogas power generation facility. The transaction is notable as it marks the first time pasture grass silage will be used for biogas power generation in Japan. The project will also innovate by tapping multiple revenue streams. The main source of revenue for the project will be a 20 year PPA for the sale of power to Hokkaido Electric Power Co. but the project will also draw revenue from the sale of fertilizer byproducts. Through its investment in Hokkaido Betsukai, GFO hopes to prove the viability of a new technology in Japan and stimulate rural economic development.[17]

GFO also invested 390 million Yen in equity to SymEnergy's wood biomass gasification power generation project. Innovative technology will harness residual heat during power generation to improve the project's profitability, which have been historically limited for small scale (<5MW) woody biomass generation projects in Japan. GFO provided an equity investment in the project because of the potential to drive private investment into the sector and to "promote the wider business development of similar small scale woody biomass power generation."[18] GFO's 390 million yen investment was matched by 409 million yen in private partner investments and an additional 1.9 billion yen loan from private capital sources. GFO was successfully able to use their Green Bank financing tools to drive private investment into bioenergy.

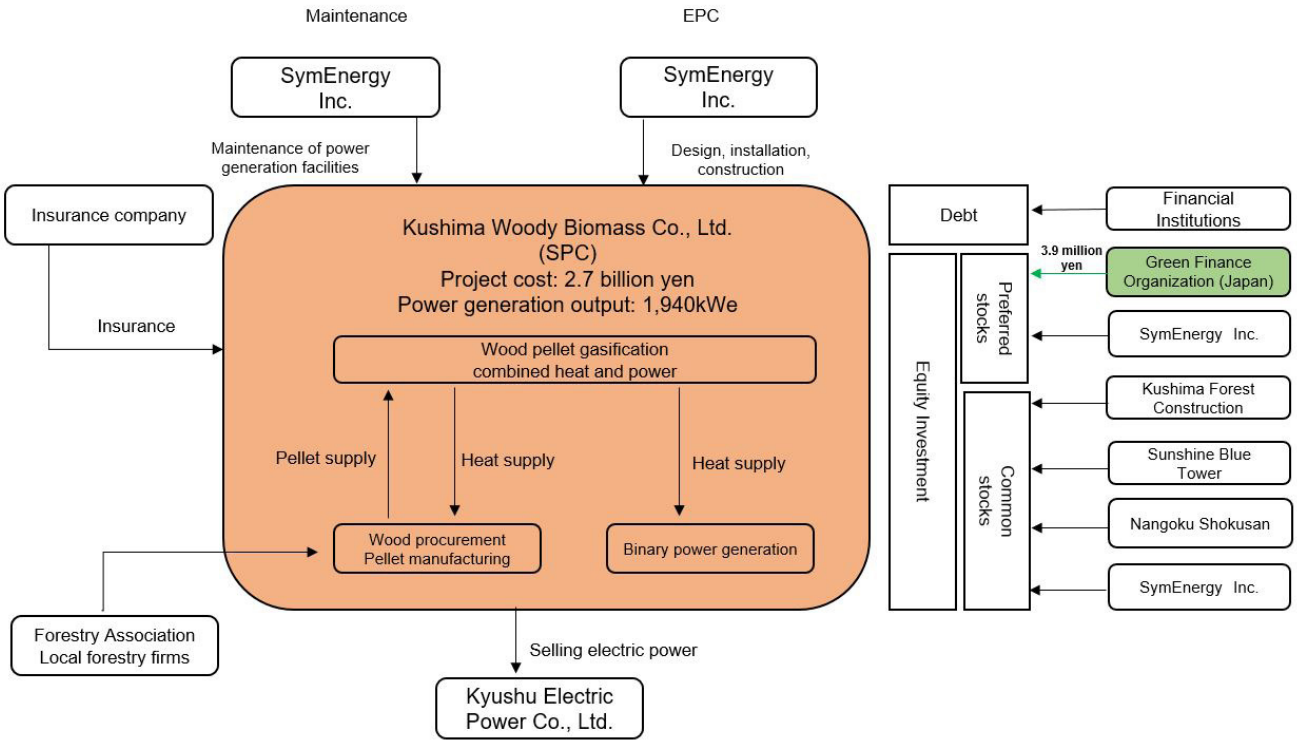

Figure 4. GFO Drives Greater Investment in Kushima Biomass Project [19]

17 Coalition for Green Capital. "Hokkaido Betsukai Biogas Power Generation." 2018

18 Green Finance Organisation (Japan). "Investment in Wood Biomass (Gasification) Power Generation Project." October 2016

19 Ibid.

Green Investment Group

From its launch in 2012, the UK's Green Investment Group (GIG, formerly the publicly-owned UK Green Investment Bank) included resource recovery (waste to energy) as a central pillar of its early operations, alongside offshore wind and industrial energy efficiency. GIG had invested more than US$1.3 billion in waste and bioenergy facilities by the end of 2017 and the number continues to grow.[20] Similar to GFO, GIG has often sought to finance "leading edge" projects that are less straightforward or without significant local precedent. As the GIG noted in 2018, "to date, the main focus of investors has been with local authority pubic private partnership (PPP)/public finance initiative (PFI) waste projects. The majority of the required investment in this area is now largely behind us, although there are some important projects still outstanding."[21] GIG has worked with new technologies or revenue streams outside of straightforward single power purchase agreement (PPA) including more 'merchant' projects.

One example of a first-of-its-kind investment GIG has made in the sector was an £80 million commitment which paired with £220 million of private debt to develop the Kemsley energy from waste combined heat and power plant in 2016. This project was "the first large-scale energy from waste facility supported by the Contract for Difference (CfD) mechanism."[22] CfDs allow generators to sell electricity into the market as usual, through a PPA with a supplier, but reduce exposure to variations in electricity prices by providing a variable top-up from the market price to a pre-agreed 'strike price.' At times when the electricity market price exceeds the strike price, the generator is required to pay back the difference, thus protecting investors from over-payment (see Figure 5). By enabling an innovative contracting technique to move forward and develop additional track record, GIG demonstrated the role of catalytic Green Bank financing, and encouraged additional private investment in the resource recovery sector.

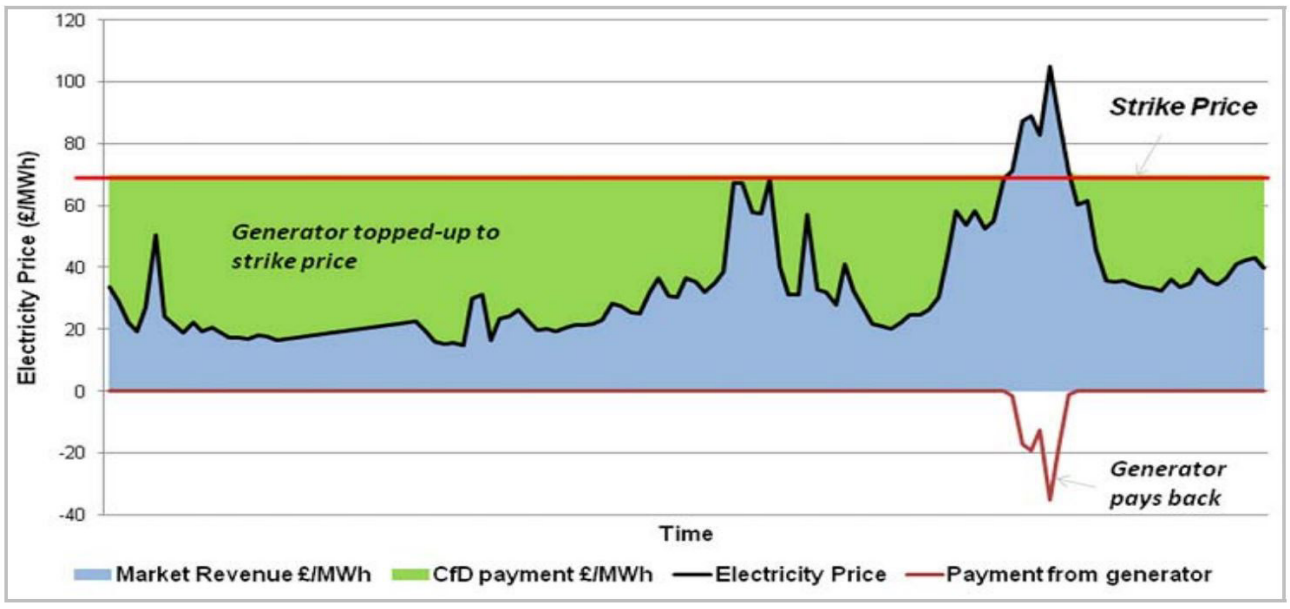

Figure 5. Contract for Difference Model [23]

20 Delony, Jennifer. Renewable Energy World. "UK Green Bank Continues on Path of Waste-to-Energy Investment." December 2017

21 Green Investment Group. "Investing in the Next Generation of Waste Infrastructure." 2018

22 Green Investment Group. "Kemsley energy from waste CHP plant agrees project finance package." July 2016

23 European Commission. "United Kingdom Electricity Market Reform - Contract for Difference for Renewables." 2014

Another example of GIG's work with waste-to-energy projects includes a £20 million investment in Evermore Renewable Energy's wood-fueled combined heat and power plant in 2013. Over the project life it is forecast to save 2 million tonnes of wood from going to landfill and is expected to deliver a reduction in greenhouse gas emissions of around 3.7 million tonnes. The project was GIG's first investment in Northern Island and was forecast to be the "largest renewable energy project in Northern Ireland, increasing the amount of renewable electricity currently generated in Northern Ireland by approximately 10%."[24] Similar to other Green Bank activities which finance more complicated projects, the Evermore project relies on multiple revenue streams including electricity sales to the national grid and heat output for an integrated wood drying facility.

GIG has also made several other bioenergy and resource recovery related investments, many of which are first-of-kind. In December 2017, GIG made a £136 million investment to acquire 50% stake in Covanta's operational waste facility in Dublin, Ireland.[25] In December 2018, GIG and Covanta announced the acquisition of a 50% stake in the Earls Gate Energy Centre, a 21.5 MWe Energy-from-Waste facility located in Grangemouth, Scotland. The project includes an innovative heat offtake agreement to provide heat and power to local industry, including chemical manufacturer and site utility service provider, CalaChem.[26]

Connecticut Green Bank

The Connecticut Green Bank has successfully financed bioenergy to drive the market forward. By investing in first-in-kind projects, the Connecticut Green Bank demonstrates the value of Green Bank financing to prove project viability and spark growth in the bioenergy and resource recovery market.

An example of Connecticut Green Bank's activities supporting bioenergy projects is its work with Quantum Energy in Southington, CT. In the Quantum Energy project, the Connecticut Green Bank offered a $2 million low interest loan to help cover the $14 million costs of an anaerobic digestion facility. The facility processes over 40,000 tons of food waste per year and provides energy (using "virtual net metering" policy benefits) to government facilities in Southington, CT. By financing this first-in-kind project, the Connecticut Green Bank planted a flag in the Connecticut bioenergy market, paving the way for similar projects in the future.[27]

The project financed by the Connecticut Green Bank also sparked a greater clean energy movement in the town of Southington. 2G Energy, Inc. installed a combined heat and power facility to capitalize on the available biogas created by the anaerobic digester, selling electricity to the town of Southington.[28] Commercial Solar Works also installed solar panels on the roof of the anaerobic digestion facility, making the facility a prime candidate for a micro grid.[29] This growing activity in renewable energy development is just one example of how Green Banks can catalyze market growth far beyond their initial investment.

24 Newton, Paul. Utility Week. "First Green Investment Bank funds for Northern Ireland." July 2013

25 Green Investment Group. "Green Investment Group invests in Covanta's Dublin facility as first step in partnership to co-develop waste-to-energy projects in UK and Ireland." December 2017

26 Green Investment Group. "Green Investment Group supports decarbonisation of Scottish economy by energising Grangemouth's local industry."

27 Quantum Biopower. "Quantum Biopower unveils Connecticut's first food-waste-to-energy facility." December, 2016

28 Quantum Biopower. "CHP system comes online at US food waste recycling plant." December, 2017

29 Quantum Biopower. "Quantum Biopower Completes Solar Installation at AD Plant." August, 2018

Conclusion

The global market for bioenergy and resource recovery is large and rapidly growing. There is substantial potential for further growth in the sector, including the use of new technologies, new feedstocks and new business models with multiple revenue streams (including sale of biogas, electricity, heat, compost, carbon credits, etc.). New regulatory and policy regimes are enabling further project development, including models such as Contract for Difference, regional carbon markets, incentives for local microgrid development and more. To further develop this potential, Green Banks are working to mitigate risk, lead new investment and spur new levels of private sector investment in the bioenergy and resource recovery market.