Fostering renewable energy integration in the industry

RE- INDUSTRY

March 2017

IEA-RETD
Renewable Energy
Technology Deployment

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EXECUTIVE SUMMARY

According to the IPCC 5th assessment report [1], t**he industry is one of the largest energy consumers (28%) and greenhouse gas (GHG) emissions contributors worldwide (30%)**. Industrial actors will have to play a significant role in GHG emission reduction, both by reducing their energy intensity and their carbon footprint. **Integrating renewable energy (RE) production assets in their facilities is one means to achieve** the 1.5-2ºC commitment of the Paris Agreement.

The IEA-RETD RE-INDUSTRY study explores state-of-the-art RE applications in the industry and provides lessons learned for industrial actors and recommendations for policy makers. The report contains two sections: a review of 20 case studies and a section on policy options and lessons learned[1].

RE integration in the industry is already widespread worldwide, mainly driven by its direct benefits for industrial players in a changing energy environment.

Energy is, and will remain, a fundamental input for the industry, but new modes of energy procurement and use are technically and economically available all over the world, adapted to local contexts. **RE integration in industry has already been adapted globally by a number of industrial players out of self-interest**. More than 200 projects were identified across **all geographies**, involving **different industrial sectors** and using an **extensive array of RE technology options**, from traditional ones such as rooftop solar PV to more innovative ones such as hydrogen production from a renewable source.

Different integration schemes are possible, from simple and investment-light projects to more complex, interwoven projects yielding greater reductions in energy consumption and GHG emissions.

- Green power procurement with a third party power producer on the premises of the industrial asset – Volkswagen Chattanooga plant (US) purchases green power under a 20-year PPA from a 9.5 MW_e solar PV park adjacent to the manufacturing plant.
- On-site installation of fully owned and operated renewable power generation assets – Brewery Vestyfen replaced an oil-fired boiler by a 4 MW_{th} wood boiler (Denmark). Diavik Diamond Mines installed a 9.2 MW_e onshore wind farm in its off-grid mine (Canada).
- On-site installation of RE production assets and process adaptation – Tenon Manufacturing (New Zealand) modified its natural gas-fuelled kilns to run on geothermal steam (27 MW_{th}).
- Paradigm shift: renewable raw materials and energy and valorisation of by-products – Jain Irrigation System Ltd (India) transforms by-products of the tomato transformation process into biogas in the plant, digestate is then valorised on secondary markets as bio-compost.

RE integration in industrial assets brings direct benefits to the industrial players, beyond what could be expected from the simple purchase of renewable power. The project drivers and the motivation of the industrial players vary widely depending on their location and their energy needs:

- Reduced energy costs and price hedging from future increases of fuel and grid prices – The dependence of Codelco Gabriela Mistral Division mine (Chile) on high prices of road-transported fuel was a key driver of its thermal solar project (annual savings of €5.3 million).

[1] This study does not include overall statistics or statistical evidence. The 21 detailed case studies analyses are available in a separate document.

- Improved energy supply reliability – Unstable supply due to its distance from the main distribution power grid drove Australian Tartaric Products (Australia) to develop a more grid-independent and stable electricity supply solution (CHP from grape waste).
- Increased productivity – Productivity increased by 5% at Tenon Manufacturing plant (New Zealand) after its 27 MW_{th} geothermal project.
- Additional revenue-generating opportunities through the sale of excess energy to the power grid or heat networks or other industrials – Additional power generated by solar PV installation at Pepperidge Farm plant (USA) is sold to the grid at retail price according to the net-metering scheme in place in Connecticut.
- Greater coherence with corporate environmental and local commitments – Beyond economic profitability (annual OPEX reduction of €8 million), Hima Cement Ltd (LafargeHolcim Group - Uganda) developed its coffee husk project to create income-generating activities offering a waste recovery solution to local communities.

Various barriers still hinder full RE development in the industry. However, industrial players and policy makers have a wide array of options to overcome them.

Eight issues have been identified that can tilt an industrial actor towards or away from deploying RE production assets in its facilities. **Diverse policy options can be implemented to topple those barriers**.

Energy production regulatory regime (1): In various legislations, it is difficult to a) **Error! Reference source not found.produce energy using independent players** and b) valorise **energy through self-consumption and/or the right to sell the energy produced. But these** are **fundamental requirements** for RE deployment in the industry. Policy makers may ensure that these two regulatory requirements are implemented within the **energy production regulatory regime**.

Investment (2): Third party energy production schemes represent a significant opportunity for industrial actors who lack the **equity capital / cash needed to develop RE projects**. RE projects require substantial up-front investment costs compared to the power purchase option and traditional fossil fuel generation units. **Investment support mechanisms** could be implemented to lower upfront costs for industrial companies.

Payback times and return on investment (3): Beyond investment, RE projects often come with longer payback times and lower return on investment compared to the core activities of an industrial company. **Preferential rates for the purchase of decentralized RE** could be provided by public authorities to industrial companies (i.e. feed-in-tariff, net-metering, etc) as well as guidelines **and a regulatory framework for valorisation of by-products** that can enhance return on investment of RE integration projects. **Different leverage exists at the industrial plant level** to overcome this issue:

- Transfer the investment to a third party energy producer
- Oversize the installation to sell energy surplus to energy utilities and/or other industrial actors
- Enhance the value of various by-products (mainly in biomass projects)
- Anticipate and enhance heat/power synergies and energy efficiency

Technology maturity (4): Contrary to mature **RE technologies** (solar, wind, geothermal and biomass), **some RE technologies applicable in the industrial context still require developments** such as tri-generation (power, heat and cooling generation) or renewable heat integration for various industrial processes. Varying technology maturities call for different financing and technical support from public entities. Investing in non-mature RE technologies carries specific risks that industrial players are not likely to be willing to take. Public entities should **finance pilot projects to develop best practices** and **encourage industrial actors to participate in RE technology development and OEM companies to provide RE solutions which could lead to faster deployment within a certain sector**.

Operability and integration (5): An RE integration project has to **bring either higher productivity or easier operability (in terms of supply) to the industrial actor**. Adequate integration of RE production assets in an industrial site requires deep knowledge of: RE technologies, industrial processes and industrial, environmental, health and safety standards. Industrial players could plan RE asset accounting for **synergies between process and energy streams, especially heat integration**. The creation of **poles of excellence at local level focused on RE integration into industrial processes** can help standardize renewable heat integration for selected sectors.

Risk mitigation and insurance mechanisms (6): Industrial companies deploying RE assets onsite may incur **three important risks** that may be seen as no-go barriers for many:

- Continuity of supply can pose a risk on the plant's operations, particularly in the case of less mature RE technologies or highly integrated RE production schemes (i.e. seasonality of biomass feedstock)
- Non-mature technologies can threaten the safety of the industrial facility (i.e. risk of explosion)
- The RE asset's profitability depends on the solvency of the off-taker: industrial plants can be affected by market cycles or security issues which can lead to downsizing, relocation or even shut down.

At the same time, RE assets can also become a factor of risk reduction through security of supply and lower exposure to market energy price fluctuation. **Public policy should offer financial guarantees for RE in industry projects and guarantee them a reliable and affordable access to the grid for back-up**.

Contractual scheme complexity (7): The **specific contractual complexity of power/heat purchase agreements** and **participation in the retail or wholesale electricity market** can prevent industrials considering their application. Third party power producers look for 20 year PPA contracts, whereas industrial players have shorter time frame activities mainly determined by their market cycles. New, **shorter-term contractual schemes** that fit better with industrial players' constraints need to be developed.

Awareness (8): Communication on existing support mechanisms (incentives, guarantee, etc.), costs and best practices appears to be **essential to fill the gap between simple knowledge of the subject and concrete implementation on the ground**. Public entities should facilitate **sharing relevant information** on RE technologies and existing public technical and finance support. Industrial companies and OEMs should consider joining groups such as **inter-professional associations** to share knowledge with counterparts.

Beyond direct financial incentives, innovative public support schemes should be implemented to facilitate RE integration projects.

Amongst the recommendations, **three topics – over and above additional financial incentives – appear to have a high leverage potential on RE integration in the industry** and should be promoted by policy makers in the global context of direct subsidy reductions due to public budget cutbacks.

- **Guarantees to address risks**: RE exhibits intrinsic risky characteristics (with additional maturity issues for some technologies). There is an opportunity for policy makers to shift their efforts away from direct public financing to enabling private financing by providing financial guarantees (i.e. loan guarantee) on RE projects in the industry to help industrial actors to obtain funding.
- **Third party power production to address pay-back time and operational implementation**: To reduce investment, simplify project implementation, reduce payback time and remove auxiliary assets from their balance sheets, industrial players are willing to transfer ownership of their projects to third party power producers. Moreover, allowing third party power production can initiate the transformation of a country's energy sector towards decentralized poles of power generation.
- **Localized policy demonstration projects and clusters to test optimal regulatory solutions**: Policy makers are eager to see the development of new technologies and expertise in their territories but do not wish to adopt measures that could have a significant impact on the grid and their revenues from taxes. By providing implementation feedback, policy makers can have a clear idea of the extent of those risks and thus continue to encourage the development of new energy production schemes.

The integration of RE production assets in the industry is already a real dynamic across diverse industrial sectors worldwide. Nevertheless, public support and technical, contractual and business innovation are still required to make RE integration a widespread practice in the industry globally. Policy makers should ensure that regulation allows and even fosters different RE integration schemes. Industrial actors should accelerate their commitment to adapt their financial and contractual engineering to such schemes. If those barriers are lifted there is plenty of room to generate many new and successful projects in the coming years.

GLOSSARY

Anaerobic Digestion: Process by which microorganisms break down biodegradable material to produce fuels and reduce waste

ATP: Australian Tartaric Products, one of the companies interviewed during the case studies

B2B: Business-to-business

B2C: Business-to-consumer

Bagasse: fibrous residue of sugar cane stalks

Bioslurry: liquid residue from the digestion of organic waste, which can be used as fertilizer

CAPEX: Capital Expenditure

CHP: Combined Heat and Power, a process by which both heat and power are valorised from fuel combustion

CO2eq: CO2 equivalent

Cogen (Cogeneration): combined production of two types of energies (heat and electrical or mechanical power)

CSR: Corporate social responsibility

Digestate: Solid residue from the digestion of organic waste, which can be used as fertilizer

DSO: Distribution System Operators

EJ: Exajoule

ETC: Evacuated Tube Collectors, a technology used for solar heat collection

GHG: Greenhouse gases

Gt: Gigaton

IEA: International Energy Agency

IEA-RETD: International Energy Agency - Renewable Energy Technology Deployment

IPCC: Intergovernmental Panel on Climate Change

IRENA: International RE Agency

JISL: Jain Irrigation Systems Ltd., one of the companies interviewed during the case studies

Ongrid / Offgrid: industrial sites that are connected / not connected to a regional or national power grid from / to which they can buy or sell power

OPEX: Operating expenditure

PPA: Power Purchase Agreement

R&D: Research and development

RE: Renewable Energy

ROI: Return on investment

SME: Small and medium enterprises

Solar PV: Solar photovoltaic

SPV: Special Purpose Vehicle

Trigeneration: combined production of heat, electrical and mechanical power

INTRODUCTION

RE integration in the industry goes well beyond the simple considerations of corporate social responsibility (CSR) and public branding. It actually originates from the current status of energy and the megatrends that will necessarily induce its development (demographic, geopolitical, environmental and economic pressure, higher demand for energy and overall increase of energy costs, etc).

RE integration in the industry is necessary to achieve global climate change mitigation goals. In parallel, industrial players can directly and indirectly benefit from such projects on their own sites. Similarly growing RE integration in the industry represents a significant business opportunity for renewable equipment and technology suppliers, as well as for engineering companies.

In order to achieve the targets set in the Paris Agreement, all greenhouse gas (GHG) emitters need to participate in the global reduction effort. The Paris Agreement's central aim is to strengthen the global response to climate change by keeping a global temperature rise within this century well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C.

Industry is one of the largest energy consumers and GHG emissions contributors worldwide (176 EJ and 15.44 $GtCO_{2eq}$ in 2010 according to the IPCC 5th assessment report [1], respectively 28% and 30% of world's total). Industrial actors will play a significant role in GHG emission reduction, both by reducing their energy intensity (amount of energy used per unit of wealth produced) and their carbon footprint (amount of CO_2eq emitted per unit of energy consumed). Integrating RE production assets in their facilities is one means to achieve these objectives.

In June 2014, the International RE Agency (IRENA) evaluated the potential for renewable energies in the manufacturing industry (the manufacturing industry represents 70% of global industry energy consumption) [3]. Based on internal projections, the IRENA estimated that consumption would grow to 185 EJ by 2030, 28 EJ (15%) of which could economically come from renewable sources. **The potential for emissions reduction in the industry is vast and achievable.**

At the same time, **the integration of renewable energies on industrial assets can bring direct benefits to the industrial companies operating those assets,** over and above what could be expected from the simple purchase of renewable power. These benefits can take the form of:

- Reduced energy costs and price hedging from future increases of fuel and grid prices
- Improved energy reliability and increased productivity
- Additional revenue-generating opportunities through the sale of excess power/heat to the power grid / heat networks and/or other industrials
- Greater coherence with corporate level's environmental and local commitments

Waste heat valorisation is also a critical potential for emission reduction in the industry; wide implementation of waste heat measures should be supported by public policies and accurate regulatory mechanisms[2].

[2] Waste heat is not included in the scope of this study which focuses on RE.

Energy is, and will remain, a fundamental input for the industry. However, new electricity procurement methods, adapted to local contexts, are technically and economically available all over the world and have already been adapted by a number of industrial players.

In order to provide inspiration and state-of-the-art application of RE in the industry, the IEA-RETD commissioned the following study to present best practices, existing and emerging technologies, drivers, barriers, lessons learned from industrials as well as policy recommendations on the topic. It will also serve as a basis in preparation of the IEA Secretariat roadmap on the role of RE in the industry.

The report is structured around two sections: a review of case studies from real world integration of renewables in industrial processes and a policy section, guided by the analysis of the previous case studies.

1. METHODOLOGY

The case study review is based on an extensive survey of existing projects of RE integration in the industry. More than 200 projects have been scrutinized on every continent, for every industry and using an extensive array of renewable technology options. Out of these, 21 case studies have been selected for detailed review, covering most geographical locations, sectors and technologies. Figure 1 shows the breakdown of listed and selected projects by geographical location, industrial sector and type of RE technology. Figure 2 represents the 21 selected projects analysed during the study.

For each of them, project leaders within the organisation were interviewed in order to understand key drivers for the project, a detailed description of the technology used and its integration within the industrial process, as well as a technical, economic and policy assessment of the project. The case studies are as follows and their review can be found in a separate document:

1. *Australian Tartaric Products (ATP)* CHP from grape waste at a distillery plant (Australia)
2. *BMW* landfill gas CHP, solar and hydrogen for plant and handling equipments (USA)
3. *Brewery Vestfyen* wood-fired steam boiler (Denmark)
4. *Codelco* solar flat-plate collectors to produce hot water for copper mining (Chile)
5. *Colruyt* power-to-hydrogen from wind and solar energy to feed forklifts and trucks (Belgium)
6. *Diavik Diamond Mines* wind turbines for power generation at mining site (Canada)
7. *EnFa* 100% self-sufficient factory combining solar photovoltaic energy (PV) and biogas CHP (Germany)
8. *Jain Irrigation Systems Ltd (JISL)* trigeneration from anaerobic digestion at a vegetable and fruit processing plant (India)
9. *Jiangsu Changshu Jinhong* textile printing and dyeing plant using solar evacuated tube collectors (ETC) to pre-heat process water (China)
10. *Mitr Phol* sugar mill CHP from bagasse (Thailand)
11. *Munster Joinery* wind power and biomass combined heat and power (CHP) for a door and window manufacturing plant (Ireland)
12. *Nuova Sarda Industia Caesaria* solar steam for cheese production (Italy)
13. *Pepperidge Farm* hydrogen fuel cell and solar PV at a food processing plant (USA)
14. *Petroleum Development Oman* solar enclosed trough steam generators for enhanced oil recovery (Oman)
15. *Roquettes Frères* biomass boiler and geothermal plant for starch factory (France)
16. *SATMAR* sea water heat pump for aquaculture (France)
17. *Sony* green power certification program (Japan)
18. *Tenon Manufacturing* sawmill timber drying using geothermal steam (New Zealand)
19. *Volkswagen* Chattanooga manufacturing plant’s solar park (USA)
20. *Hima Cement (LafargeHolcim Group)* – Switch from fossil-fuelled to biomass- and waste-fuelled kilns to produce cement
21. *Brau Union Österreich (Heineken Group)* – World’s first carbon neutral brewery (Austria)

Building on the review of these case studies as well as the authors’ knowledge and experience of RE, industry and their common interactions, this study presents key lessons learned by industrial companies as well as recommendations for policy makers to further facilitate the use of RE within the industry. The core of this report (see 3), is structured around the main issues and opportunities that arise from the integration of RE production assets on industrial sites.

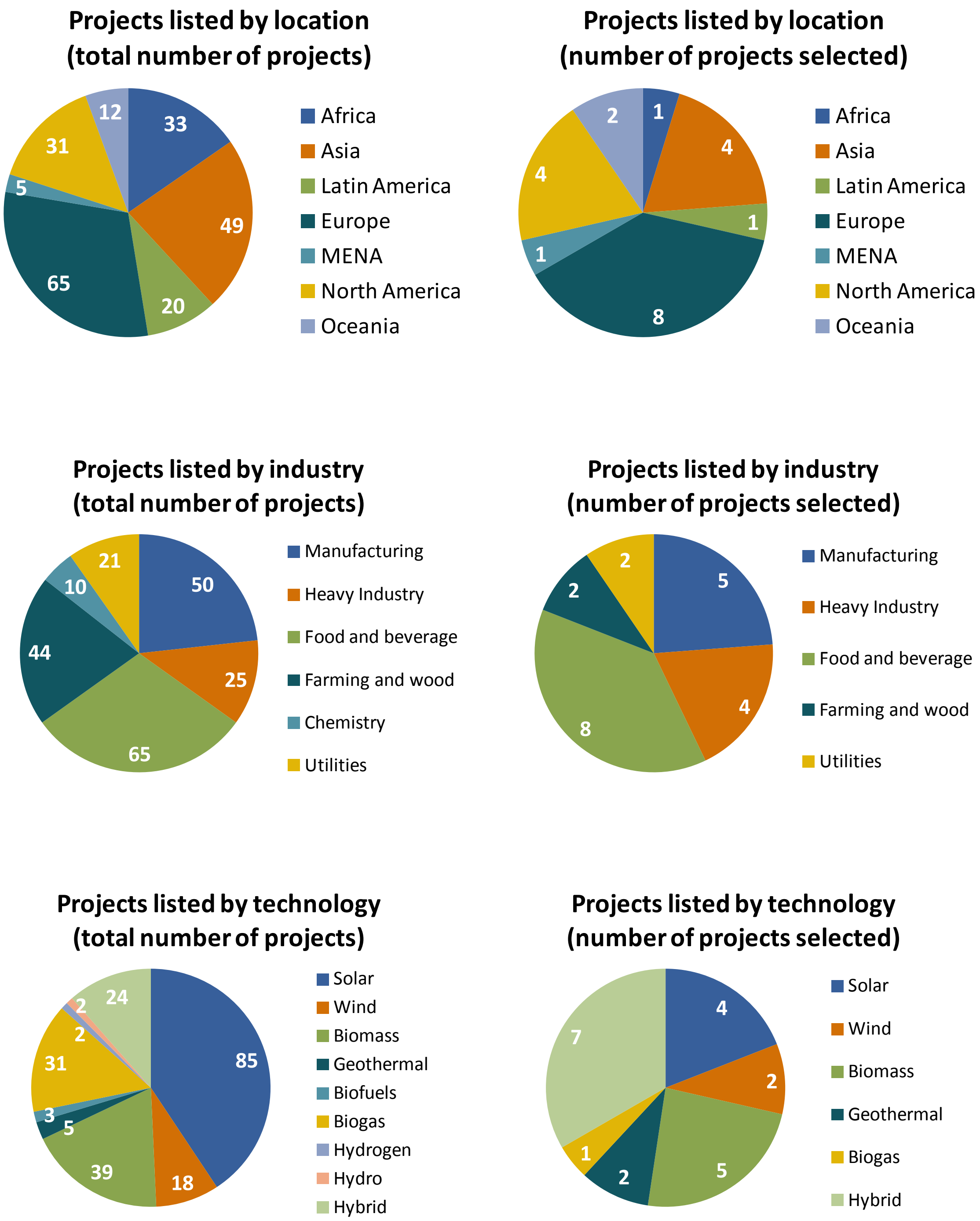

Figure 1. Breakdown of listed and selected projects by geography, industrial sector and type of technology

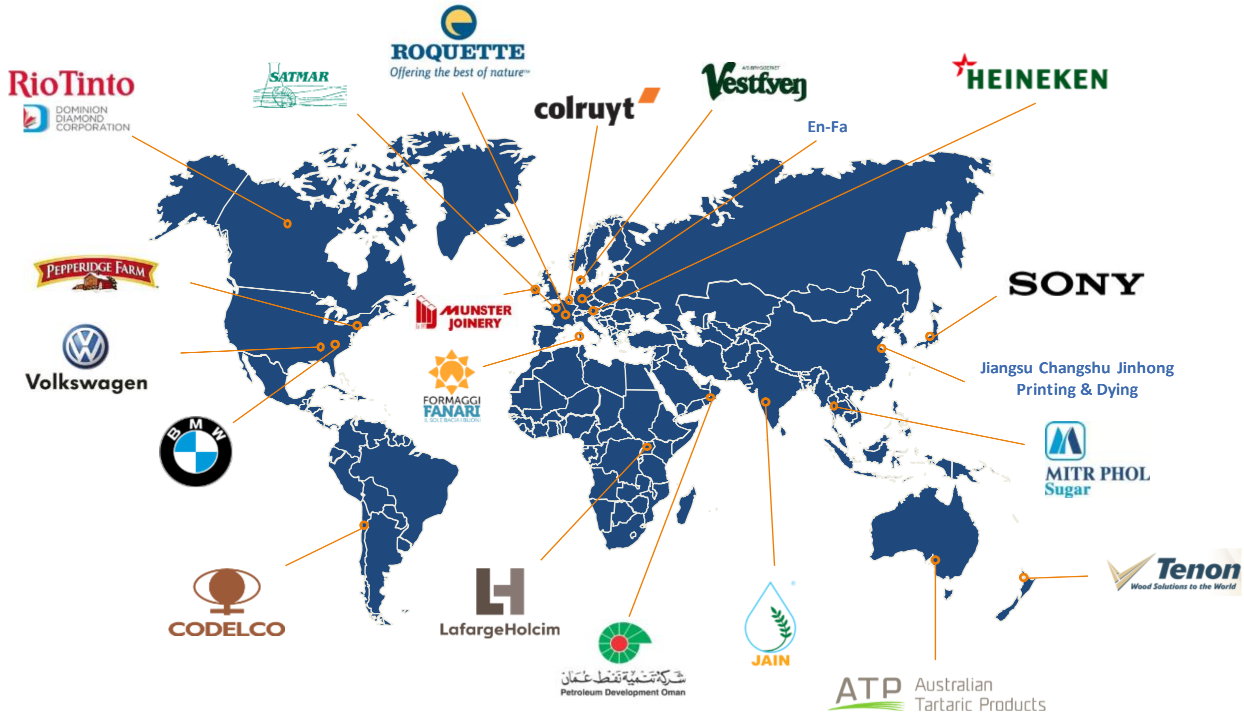

Figure 2. Overview of the 21 selected case studies

2. CASE STUDY SUMMARY

The case study analysis resulted in the following key findings:

- Drivers differ widely across the projects
- Renewable power and/or heat integration projects lead to a large array of positive environmental impacts
- Different levels of renewable energy integration are possible from green power procurement to more complex RE integration schemes within the core production processes
- Financial support is not always required to run a successful project

2.1. DRIVERS DIFFER WIDELY ACROSS PROJECTS

The review of the case studies shows that project drivers and industrial players' motivation to develop onsite RE vary widely depending on their location and their energy needs.

- **Developed vs. Developing countries**

On average, developing onsite renewable power production capabilities as part of the company's larger commitment to environmental protection was more often stated as an important driver for projects in developed countries than those in developing countries (with the exception of JISL's trigeneration project in India and accounting for the fact that out of the 20 case studies, only 3 were rolled out in developing countries).

Conversely, all projects in developing countries (JISL trigeneration in India, Mitr Phol CHP in Thailand, LafargeHolcim in Uganda, and the textile plant using solar ETC in China) were partly or fully motivated by profitability concerns (from avoided costs and extra revenues), compared to a third of the projects in developed countries.

In developed countries, more than the energy savings that renewable can potentially bring, it is the reduced uncertainty on the future evolution of energy prices that industrial companies look for.

- **On-grid vs. off-grid industrial sites**

Companies developing RE projects on off-grid industrial sites (copper mining in Chile and diamond mining in Canada) were mainly concerned with the reliability and the cost of their fuel supply. Both relied on heavy diesel imports by truck and/or plane and saw an opportunity to limit this reliance through solar PV and wind installations.

For on-grid industrial facilities, energy supply reliability can also be an issue in countries with grid reliability concerns such as Australia (CHP for Distillery case study), India (JISL trigeneration unit) and the USA (Pepperidge fuel cells).

- **B2C vs. B2B industries**

There is a clear divide between B2C and B2B industries in terms of drivers for RE projects. For B2C industries, RE projects are more often part of a larger environmental plan with its own drivers such as corporate image or long-term sustainability of the business (Volkswagen solar park, Sony green certification, BMW landfill gas, Nuova Sarda Industria Caesaria solar steam project out of the six B2C projects).

Conversely, B2B companies tend to look more at the operational benefits of such projects (easier operations for Tenon timber drying; better use of resources for Petroleum Development Oman; valorisation of by-products for JISL and Mitr Phol; profitability and reduced volatility of energy prices for Tenon timber drying, SATMAR oyster farm, Munster joinery windows and doors plant, Mitr Phol sugar mill, ATP distillery, Roquette starch factory, JISL food processing plant, Jiangsu Changshu textile plant, Diavik mines and Codelco mines).

- **Regulatory pressure**

Regulatory pressure was mentioned as a defining driver in one case study only (Solar ETC for Jiangsu Changshu textile plant)

2.2. ENVIRONMENTAL BENEFITS OF RE HEAT AND POWER PRODUCTION

Besides economic drivers, the different RE integration schemes can lead to diverse environmental benefits.

Fuel switching to generate heat can have a positive impact in terms of GHG emissions reduction; this is particularly the case for industrial plants that aren't connected to heat networks. As an example, LafargeHolcim's project for energy recovery from coffee husks in Uganda reduces the Hima Cement plant's GHG emissions by 67,000 tons of CO_2 per year.

The recovery of local biomass waste and by-products to produce heat also has positive environmental impacts, particularly in terms of waste disposal impacts.

- The BMW Manufacturing project in Spartanburg (USA) has reduced the carbon footprint of the landfill that supplies its cogeneration turbines.
- The Australian Tartic Products plant in Colignan (Australia) reduced the impact of the local wine industry by collecting 90,000 tons/year of waste from wineries within a 100 km radius and using it as a fuel in its 8 MW boiler.

Fuel switching for power generation also leads to a reduction in GHG emissions, notably in off-grid industrial sites where the alternative is mainly fossil fuels (diesel generators). The onshore wind project ($9.2MW_e$) allowed the Diavik Diamond Mines to reduce its GHG emissions by more than 14,000 tons CO_2 per year. GHG emission reduction would be lower for RE projects in on-grid industrial sites, particularly in countries where the grid emission factor is low because the national power generation mix mainly relies on RE sources.

The dependence of off-grid industrial plants on fossil fuel not only leads to environmental impacts but also represents a security issue. As an example, over 250 truck trips per year to transport fuel to the Codelco Gabriela Mistral mine (Chile) were required for operations. The solar flat plate collector project improved the accuracy and reliability of the electricity/heat supply and the safety of the mine by taking trucks off the road.

2.3. DIFFERENT LEVELS OF INTEGRATION ARE POSSIBLE

The global review of existing RE integration projects worldwide and the analysis of the case studies reveal a wide array of integration schemes, from simple and investment-light projects to more complex, interwoven projects yielding greater reductions in energy consumption and emissions.

- **Green power procurement with a third party power producer on the premises of the industrial asset**

This level of integration is the simplest and easiest to manage for industrial companies. The responsibility of investing in, building and operating the renewable power asset is transferred to a third party power producer. The industrial company then contracts with a third party power producer through a long-term power purchase agreement (PPA). The renewable asset is usually built next to the industrial asset but the two are not intertwined, so that the former does not affect the operations of the latter.

Figure 3 below shows the on-shore wind farm that supplies the Munster Joinery plant (Ireland) and the grid.

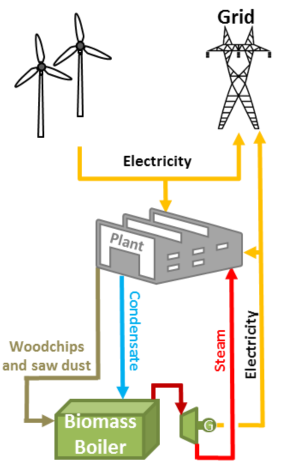

Figure 3. Diagram of the Munster Joinery wind turbines and CHP installation in Ireland

The main advantages of this solution are that investment needs are very low, as are the technical skills required to operate the renewable assets. Moreover, the asset is not consolidated in the profit and loss statement.

The main drawbacks are the low impact of such projects in terms of emission reductions since they only address the issue of renewable power, but not heat, and the share of the economic value created with a third party. Such integration schemes do not seem to be adapted to industrial actors who need a steady supply of steam for their production operations

Even if it is less common than for power, industrial actors can have other types of RE purchase agreement. Like BMW, for example, which negotiated a 20 year flat-rate purchase agreement with Waste Management which operates the Palmetto landfill to ensure a steady supply of landfill gas (163,000 m^3/day) to its Spartanburg plant in the US.

Case studies

Volkswagen BMW CODELCO MUNSTER JOINERY

- **On-site installation of fully owned and operated renewable power generation assets**

This level of integration differs from green power procurement as the renewable asset is fully owned and operated by the industrial player.

This solution offers better integration possibility. For example, it is easier for an industrial player to build and operate a solar roof than to contract a third party power producer to install a solar roof on its facilities; because risks are fully borne by the industrial prosumers and not subject to complex negotiations. Nevertheless, at the same time, not every industrial player has the in-house expertise to design, build and operate RE assets and integrated systems and acquiring that expertise may offset any initial economic gains. Such contractual agreements with third party producers allow this potential barrier to be overcome.

The main drawbacks of these types of projects are the high upfront investment cost, the impact of the project on the company's net revenues (returns on investment are usually lower than those of the industry's core activity) and the need for technical skills to build and operate the asset. Additionally, unless further integrated, such projects have a low impact on process energy consumption.

Figure 4 illustrates the sugar mill and cogeneration plant installed at Mitr Phol factory (Thailand) and fully operated by the company.

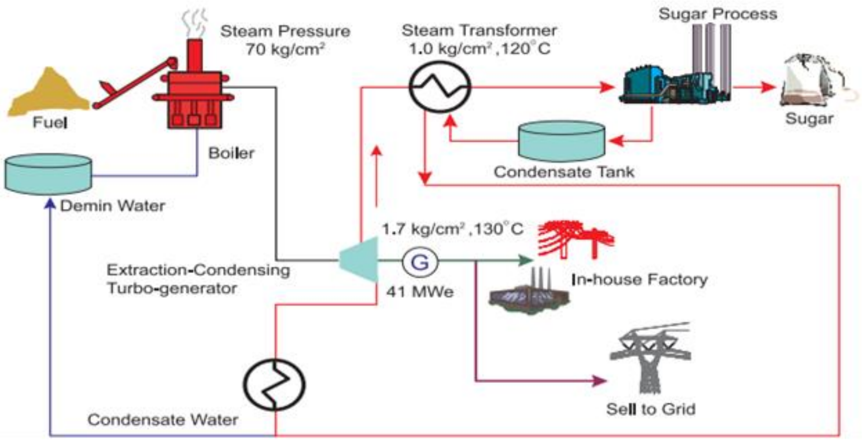

Figure 4. Diagram of the Dan Chang sugar mill and cogeneration plant at Mitr Phol factory in Thailand (Source: Cogen3)

Case studies

Jiangsu Changshu Jinhong Printing & Dying

En-Fa

- **On-site installation of RE production assets and process adaptation**

More than 80% of the total final consumption in the manufacturing industry will come from process energy in 2030 according to the IRENA [3]. This percentage is even higher in the food, tobacco, pulp & paper and non-metallic minerals industries. Consequently, in order to have a significant impact in terms of GHG emissions reductions, industrial companies need to start integrating RE assets within their core processes and have them both adapt to each other.

This requires expert operational and technical skills to design, build and operate the energy asset so that it can be used as leverage for the production asset and they both constantly feed in one another. It is also a much costlier operation than the integration schemes presented above. However, as such types of projects have an impact on GHG emission intensity, switching from fossil fuel-based power and heat supply to RE, and as process energy represents the majority of industrial energy consumption, it can yield savings and emission reductions an order of magnitude higher.

Figure 5 shows the energy supply systems progressively implemented at Heineken Göss brewery. The mashing process was adapted, switching the energy input from steam to hot water to integrate the solar thermal plant into the core processes of the brewery.

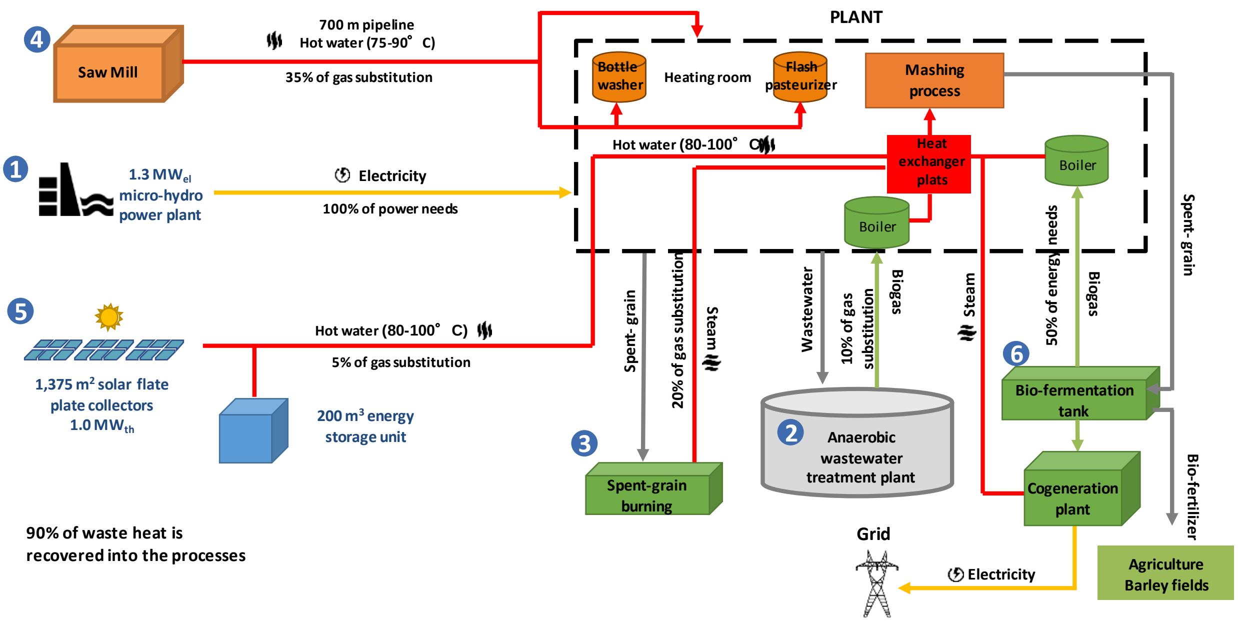

Figure 5. Diagram of the renewable energy supply of Heineken Göss brewery (Austria)

Case studies:

Tenon Wood Solutions to the World   ATP Australian Tartaric Products   HEINEKEN

- **Paradigm shift: renewable raw materials and energy and by-product valorisation**

This can be considered as the highest level of integration of renewables in an industrial facility. Not only is the RE integrated in the industrial process, but it is taken into account in the whole product value chain: renewable raw materials are used in the products and their byproducts are further used for secondary energy either energetically (woodchips, biowaste) or in the production process (bioslurry used as fertilizer).

2.4. FINANCIAL SUPPORT IS NOT ALWAYS REQUIRED

Most of the 20 case studies analysed benefited from direct public financial support:

- Grants to fund upfront investment costs, generally from dedicated public funds and/or programs
- Direct production incentives such as feed-in-tariffs and RE certificates

Nevertheless, three of the reviewed projects explicitly did not receive any financial support from local, national or international public institutions to carry out their project because the industrial players had the equity capital / cash needed or because they entrusted the investment to a third party power producer scheme:

- Diavik Diamond Mines Inc: wind turbines provide electricity for a mine's activities in Northern Canada
- Petroleum Development Oman enhanced oil recovery: solar thermal power is used for oil extraction and replaces natural gas
- Codelco mine in Chile: solar flat plate collectors produce hot water for copper mining. It is operated by a third party power producer.
- Volkswagen Chattanooga plant in the US: a third party power producer, Silicon Ranch Corp, operates the solar park providing electricity under a 20 year PPA to Volkswagen factory, and selling excess electricity to additional clients in the neighbourhood, enhancing the project's overall return .

In two out of four cases, investment barriers – lack of available debt/equity financing or high costs of the RE option – were overcome by passing on the project to a third party player.

In the context of financial constraints, public authorities can have a greater impact with alternative measures to direct public financing:

- **Regulation to facilitate projects**

Simplifying administrative authorisations and construction can reduce the implementation time of RE projects and the funds spent in the process, with a significant impact on payback time, which remains a major barrier today.

- **Regulation to facilitate new modes of energy consumption**

Energy policy makers should encourage new modes of energy consumption that enable better valorisation of RE projects, such as auto-consumption, storage and peer-to-peer exchanges. For this, industries need reliable and cost-effective back-up from the grid at a non-discriminatory cost. In cases where its own electricity consumption is not sufficient to meet the consumer's demand, then it can get electricity from the grid at the current/prevalent wholesale or retail electricity prices.

- **Regulation to facilitate third party financing**

Either through third party investment by a third party power producer or bank financing, public authorities can facilitate these deals through standardising contracts and public guarantees on the projects. Additionally, public policy makers could implement indirect financial support mechanisms like low-interest loans to facilitate third party financing.

3. MAIN ISSUES FOR INTEGRATION OF RENEWABLES ON INDUSTRIAL SITES

Based on the case studies and additional research and calls, eight barriers / issues have been identified.

- Energy production regulatory regime (See 3.1)
- Operability and Integration (See 3.2)
- Investment (See 3.3)
- Return on investment (See 3.4
- Risk and Insurance (See 3.5)
- Contractual scheme complexity (See 3.6)
- Technology maturity (See 3.7)
- Awareness (See 3.8)

The following are presented below for each theme:

- Description of what is at stake
- Overview of the issues
- Lessons learned for industry decision makers
- Policy recommendations
- Potential positive externalities

3.1. ENERGY PRODUCTION REGULATORY REGIME

Why is it at stake?

There are two prerequisites to the deployment of RE in industry: The regulations must allow
a) for energy production by independent players; and,
b) for energy valorisation by independent players through self-consumption and / or the right to sell the energy produced.

Main issues

Regulatory regime to allow energy production by independent players

While the production of electricity or heat by independent players is theoretically allowed in many countries, administrative and normative complexity can *de facto* impede industrial players from producing their own RE. The regulations include:

- *Urban planning regulations:* for example, they prohibit the installation of solar panels and or wind turbines near airports (because of reverberation and disturbance) or in a wide perimeter around city and historical centres (because of visual pollution) due to the negative externalities of REN projects.
- *Safety regulations:* a company with a low risk activity (such as food and beverage for example) would fall under a high risk industrial site regulation when installing hydrogen equipment for example. For the company, this means additional safety audits and forms and can be a strong deterrent to developing an on-site RE project. Conversely, an industrial with high risk facilities installing RE assets can be subject to the same norms and regulations for these renewable assets as those that apply to its core business assets, even though the energy production installation does not present any added risk.
  This was the case for a French industrial company: a project to install wind turbines next to a chemical facility was abandoned because the French safety norms (Seveso) had to apply to them.
- *Normative complexity:* the sole complexity of declaring a power production activity can be enough to deter an industrial company from investing in a RE asset, when power production is not its core business.

Incentivize energy production for own use

Once the first prerequisite has been met (power production), the possibility of benefitting from the energy produced for self-consumption and / or by selling excess energy to the grid is not always guaranteed.

- *Self-consumption:* In the case of off-grid industrial sites, grid connection costs are usually not supported by the utility or through advantageous tariffs. An industrial player will have low incentives to produce its own electricity, pay for grid connection, and sell power back to the grid when the price paid for the power repurchase by the utility do not reward distributed generation at its true cost. An industrial player that cannot consume the power it produces and for which selling it to the grid entails additional costs for unfair revenues cannot valorise an RE asset investment.
- *Selling energy to the grid:* energy trading regulations can be such that only a limited number of utilities are allowed to participate in the market (onerous fees and review processes for example). Where self-consumption is not sufficient to provide a reasonable rate of return for an RE investment, and if industrial players cannot register as independent power producers to sell the extra energy produced to neighbouring customers through local grids or inject it back in the national grid, they will have no incentive to produce energy on site. The ability to sell extra energy is one of the main levers to improve an RE production asset's return on investment.

This is particularly true when the RE project needs to be oversized (compared to plant needs) to benefit from the scale effect: in this case, the company needs to be able to sell the excess electricity produced to make the investment worthwhile.

- *Normative complexity:* as for production, even if selling energy is theoretically allowed, normative complexity can effectively hinder the installation of RE projects. Mandating that industrials selling energy locally be regulated by codes related to energy suppliers connected to the grid (more stringent constraints) can deter industrial companies from investing, especially those that want to remain focused on their core business.

Example of optimising biomass feedstock and return on investment

Mitr Phol sugar mill in Thailand is a good example of the major benefits that are untapped by power trading. The company wanted to recover the waste from sugar cane with a biomass unit that would in turn provide heat for the refining of sugar cane. Sugar cane refining is a highly seasonal activity due to harvest patterns. It made economic sense for the company to invest in a biomass cogeneration unit rather than a simple boiler because the plant could operate over long periods of the year, which implied selling extra power. It mainly produces heat during the harvest season and electricity the rest of the time.

Figure 6. View of Dan Chang Cogeneration Plant (Credit: Cogen3)

Lessons learned for industrial actors

Adapt the solution to the size of the company

The ability of an industrial company to participate in the physical and financial trading of power will usually depend on its size and can be an interesting option when the industrial has a dedicated energy department and the adequate competencies for such a project internally.

For smaller industrial firms, where regulation mandates that energy producers be registered as such and follow specific standards and codes, companies willing to produce RE onsite to remain focused on their core businesses can contract out with an independent party. Under a long term PPA, the company can transfer its responsibilities to a third party producer in charge of operating the renewable assets.

Contract with a third party power producer

Under all circumstances, whether mandatory or not, it is advisable that industrial companies contract with a third party power producer to limit their liabilities toward communities in terms of reliability and adequacy of electricity supply and project longevity.

Case study example: A PPA allows the Chilean mining leader Codelco to externalize their investment to a third party and secure long-term stable energy prices for their Gabriela Mistral division.

Enhance the value of heat production through self-consumption

Heat purchase agreements are even less standard and developed than electricity power purchase agreements due to operational constraints on pressure and losses in transport and temperature, among other reasons. Heat purchase agreements are often negotiated over the counter between the industrial actors, the heat network operator and possibly with other local public stakeholders (e.g. the local authorities).

Although there have been some success stories of public-private agreements to allow the use of industrial heat in public heat networks (e.g.: Arcelor Mittal in Dunkirk, France [4]), administrative procedures and technical feasibility can be quite time-consuming and expensive. Industrial companies should therefore focus on maximising the value of heat through self-consumption.

Think dynamically when sizing the project

When deciding to oversize a renewable power production asset to benefit from advantageous power repurchase conditions in the market, industrial prosumers should assess the risk of regulatory changes (such as reduction of feed-in-tariffs or interruption of net metering rules) in the short/mid-term.

Policy recommendations

Allow for third party power production

As stated above, the foremost requirement for the deployment of REN assets in the industry is a regulation that allows for independent power production. Numerous interviewees throughout the study have highlighted the need for an energy production regime allowing for the trade of electricity produced on industrial sites.

Case study examples:

- Silicon Ranch Corp, the company operating the solar park providing Volkswagen Chattanooga plant with electricity under a 20 year PPA, sells excess electricity to additional clients in the neighbourhood, enhancing the project's overall return
- Under the net metering rules of Connecticut, Pepperidge farm benefited from schemes allowing it to combine self-consumption and sale of excess power to the grid.

Develop standard interconnection contract terms for industrial prosumers

In order to facilitate the trade of electricity, policy makers should develop standard interconnection contract terms for industrial prosumers, allowing them to connect to the grid and export power under regulated conditions.

Countries with ambitious RE targets have set rules regarding the access of renewable power assets to the transmission and distribution power grids to facilitate their integration into the grid. In many jurisdictions, renewable power producers have priority access to the grid (interconnection) over fossil-fuel based power generators.

Guarantee payment stability for energy exported to the grid

Policy makers should also create and implement transparent and stable policies offering investment security for industrial prosumers including guaranteed payments for power exported through net metering, net billing or feed-in tariffs. Guaranteed payments to the industrial prosumers may require strengthening utilities' credit-worthiness (national and regional) through debt repurchase, refinancing, etc., as utilities are usually the players mandated to purchase renewable electricity from distributed generators.

Simplify authorisation and administrative procedures

Lastly, policy makers should simplify safety regulations and procedures for mature technologies with low risk, as well as provide clear regulatory categories for industrial prosumers which operate renewable assets on site.

Provide guidelines and a regulatory framework for trading of heat

Although it accounts for a more significant share of the energy consumed by industrial players, renewable heat that is produced on site is still more difficult to sell outside the factory's operations as heat purchase agreements with local players through heat networks remain technically and contractually more difficult. In fact, its quality depends on temperature and pressure, in addition to strict requirements of stability. Policy makers should experiment with different types of heat purchase agreements between voluntary participants in order to accelerate their standardisation.

Positive externalities

Rural electrification

In areas where the power grid is under-developed and / or unreliable, allowing industrials to participate in the energy market through transparent and stable mechanisms can compensate for the lack of energy infrastructure while limiting the additional costs that would be incurred by the expansion of the grid. Industrial prosumers can therefore become actors of rural electrification.

As such, policy makers can also contemplate sharing the investment costs with the industrial prosumer for the benefit provided locally and nationally (generation capacity, transmission and distribution infrastructure investment deferral, saving for utilities through peak demand reduction).

For more information, please refer to the following study: United Nations Industrial Development Organization, *Industrial Prosumers of Renewable Energy – Contribution to Inclusive and Sustainable Industrial Development*, 2015.

3.2. OPERABILITY AND INTEGRATION

Why is it at stake?

The RE project has to bring its industrial developer either lower energy consumption, higher productivity or easier operability (in terms of supply). To ensure an adequate integration of an RE production asset in an industrial site requires considerable knowledge on: renewables themselves and their characteristics; industrial processes; industrial, environmental, health and safety standards; and local context.

Main issues

Adequate skills and expertise

Operating an energy-producing installation can be quite different from the traditional activities of a manufacturing plant, so industrial actors can be deterred by this need for new skills and experience. Operators in charge of running a specific production facility may well lack the skills to run a power production asset so industrial players need to recruit specific profiles with knowledge of a business not related to the core business (for example high voltage electricity).

Recruiting such personnel with these specific skills could be quite expensive for an industrial player, even more for small industrials. Implementing such a human resources strategy might be interesting in large-scale RE projects with important operations and maintenance needs or in RE projects involving significant core production process adaptation and integration issues.

Difficult integration within the industrial processes

Industrial installations and industrial processes might not be adapted to integrate RE assets, yet RE integration on industrial sites will only be an impactful leverage if there is integration in the industrial core processes. On the other hand, renewables integrated within the processes may add risk to the industrial processes (performance, output), assets and their efficiency.

Producing thermal energy on site can cause more difficulties than producing electricity because processes using thermal energy require a specific temperature that needs to be delivered exactly by the renewable producing asset. Furthermore, thermal energy at a specific temperature cannot last for long without a stable supply and there can be significant losses. Therefore, despite the flexibility it offers in terms of energy supply, owning renewable heat assets requires being able to respond steadily to heat demands and/or to prepare a backup heat delivery or storage plan.

Finally, switching from fossil fuel energy production to RE production can add complexity and costs in terms of operation and maintenance. For example, biomass boilers require more O&M than gas boilers, as maintaining good availability and quality requires more effort in the case of biomass (humidity, storage, sustainable biomass logistics).

Focus on renewable heat integration into the core production processes

The integration of renewable heat into the core industrial processes is more complex than renewable power integration.

This type of project may well require advanced feasibility studies to design and size the interaction between the heat generation asset and the production process, beyond assessing the local renewable heat potential. Feasibility studies of the integration of renewable heat into the core processes should focus on the adequacy of the processes with the heat needs, in terms of temperature, pressure, and availability.

- Göss brewery developed a comprehensive study to better understand its energy needs and energy losses throughout the production process, before integrating RE heat generation. This step was crucial to integrate solar thermal supply into the process more easily. The mashing process was adapted, switching the energy input from steam to hot water, to integrate the solar thermal plant into the core processes and the mashing tun was equipped with heat exchangers plates.

Additionally, not all renewable heat technologies meet all industrial heat needs. For instance, current solar thermal technologies hardly reach temperatures above 200 °C (except for CSP technologies in high solar irradiation regions). As a result, geothermal energy and biomass valorisation are the only renewable heat options for industrial sectors where production processes require high levels of temperature (glass, metallurgy, oil and gas, cement, etc).

Industrial actors who have developed biomass-based heat projects highlighted the following operational constraints that should be anticipated:

- Biomass boilers require more space than gas or oil boilers, notably bigger combustion chambers (Mitr Phol Sugar in Thailand), and fuel (wood, straw, etc) storage areas (Brewery Vestfyen in Denmark, Roquette Frères in France)
- Biomass boilers are more complex to operate than a gas or oil boiler which leads to higher and greater operations & maintenance needs (Brewery Vestfyen in Denmark)
- Certain types of biomass boilers require wood feedstock processing: sawdust collecting and wood chipping (Munster Joinery in Ireland)
- The variability of the feedstock's moisture and calorific value (Brewery Vestfyen in Denmark) and its seasonality require a feedstock management system, including large long-term storage areas to avoid loss of calorific value (Mitr Phol Sugar in Thailand). The project can be very season-dependent if the boiler is fuelled with by-products/waste that cannot be easily stored (Jain Irrigation Systems in India).

Difficult integration in the factory and its surroundings

Negative externalities of RE project can impede its integration in the factory and the surrounding area: Wind turbines are associated by some people with infrasound/low-frequency noise and visual pollution; the supply of feedstock for a biogas project generates truck traffic, noise and odour pollution if not directly sourced from the factory by-products. There can also be issues of space availability to make this type of project possible, particularly in densely-populated areas. The social, environmental and safety impact of such a project must be quantified to adapt it and respect norms that can be quite stringent. The project can thus face public opposition which raises risks and additional costs.

Case study examples:

The decreasing exploitation of geothermal resources in New Zealand due to a limited number of permits and the fact that geothermal projects can potentially cause social acceptability challenges when planned in touristic areas or on local Maori sacred grounds were presented as limits and shortcomings by Tenon Manufacturing (even if it didn't face direct opposition from local communities).

The integration of Göss brewery in its surroundings and its environment has been a constant concern in the development of the different RE production assets over the 10 past years as the factory is located within the small town of Göss (See Figure 7 below). Therefore, as an example, the brewery decided to entrust the investment of the biogas plant to a third party: BDI. The development of a non-odorous installation was one of the key elements of the requirement specifications and one of the main conditions of the contract. BDI developed a gas-tight system to avoid odours.

Figure 7. Overview of Brau Union Österreich's Göss brewery in Austria (Credits: Brau Union Österreich)

Integration with the electrical grid

If the industrial site discharges too much power that the grid cannot absorb, then new lines and/or substations have to be built. These costs may be charged to the company.

Lessons learned for industrial actors

Plan the renewable asset accounting for synergies between process and energy streams

To make the most of integrating an energy-producing asset on site, focus should be given to the global synergies between all the value chains in the factory, rather than peripheral energy uses only (lighting, building heating, etc.). For example, streams of process heat can be considered in relation to sanitary hot water and organic feedstock or waste with biogas production, etc.

Case study example: BMW Manufacturing developed a multi-energy project on its production plant in Spartanburg, US (See Figure 8 below), the largest in the world. Landfill gas supplies two on-site gas turbines (5.5 MW) that generate 38% of the plant's electricity demand. Heat recovered from the turbines is used to produce 275˚C pressurized hot water in a thermal treatment bath process and for refrigeration. Part of the hot water is used by one 3.5 MW and one 2.1 MW absorption chillers to provide refrigeration to the campus facilities. Thermal storage is also used to help provide the 53 MW peak refrigeration load, in order to reduce peak electrical load for refrigeration.

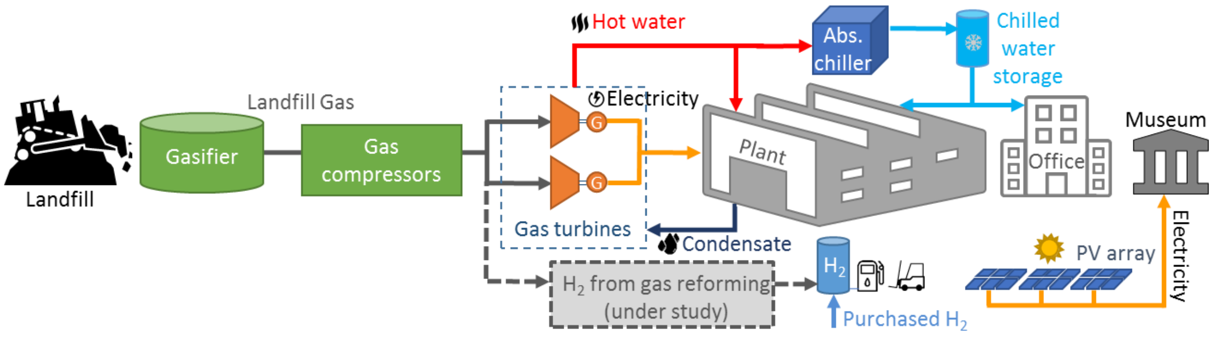

Figure 8. Diagram of the RE project at the BMW Spartanburg plant in the US

Anticipate and adapt the integration to the factory and its environment

Industrial actors should adapt projects and types of RE sources to the factory and its environment.

For example, biogas installations can generate odours and truck traffic so they are not adapted to residential areas. For the project to be successfully implemented in the factory and its environment, attention should be paid to environmental and safety norms as well as public involvement.

Solar PV integration on rooftops is another example that does not require core process adaptation. Nevertheless, the installation of solar panels can be quite problematic if it requires strengthening of the rooftop structure. Industrial players could anticipate this type of integration difficulty in their new facilities making them “ready” for solar PV integration on their rooftop.

Case study example: Hima Cement Ltd had to conclude different biomass supply agreements and invest in storage equipment in order to address the seasonality of biomass feedstock and the impact of climate change (drought) in Uganda. Biomass feedstock does not only come from local coffee farmers nowadays, but also from sugar cane farms and industrials in neighbouring countries like Tanzania and the Democratic Republic of Congo.

Use the services of external specialists, especially for new builds

When building new factories, one should think ahead to the potential integration of an RE production asset. It is advisable to use the services of an external engineering company specialised in renewable asset integration when building the factory and/or adding an asset to an existing factory, as this skill is hardly ever found within the industrial company itself. This in turn requires the existence of a competent external expertise for these particular projects.

Policy recommendations

Create a centre of excellence at local level focused on RE integration in industrial processes

This centre of excellence, specialising in the smart design of industrial assets to integrate RE production, should include research and development centres, education and training centres and local experimental areas (through simplified implementation regulation). The centre of excellence can attract industrial players through tax breaks, call for proposals, and availability of a competent workforce.

A specific emphasis could be put on renewable heat integration into core industrial processes. on-site research and development work could be carried out by those centres of excellence in collaboration with industrial players to standardise renewable heat integration in the main production processes in selected industrial sectors.

Additionally, manufacturers of industrial process equipment could participate in such collaborative initiatives and enrich their offers through new products taking into account renewable heat integration and production process adaptation issues.

Support non-industrial actors such as technology developers and operators

Support the development of technologies within industrial facilities that can offer renewable heat at all levels of temperature with or without feedstock. For example, current solar systems cannot economically produce high temperature heat. Policy makers can nudge technology developers towards developing concentrated solar power for industrial use through targeted support schemes, like financing applied research and pilot projects through the reimbursement of human resources costs and tax credit. The *Crédit d'Impôt Recherche* mechanism in France is an example of such targeted support schemes.

Nevertheless, such public support is not always required and industrial players in collaboration with technology developers can experiment with innovative renewable heat supply schemes like the Petroleum Development Oman project developed with GlassPoint.

Facilitate the implication of third party players within their industrial clients' facilities

Policy makers should set a jurisdictional and regulatory framework for third party companies to own, operate, re-sell or dismantle an RE production system on an industrial site, thus being valid at every stage of the project.

Prepare for the integration of such projects to the grid

Policy makers, together with local utilities and regulators, should aim at optimising the use of existing electricity grids to prevent the extra-added cost required for connecting RE projects close to industrial sites. This means making the best effort among all the involved stakeholders to gather the needs and bundle the projects to ensure that new grid lines are better used when renewables are deployed.

Positive externalities

Highly qualified job creation

Helping industrial sites to integrate renewable assets into their processes and operate them will create new highly qualified jobs within a factory: operators who know both the processes and the RE technologies. When combined with local clusters of excellence, they can in turn train others and contribute to greater job creation and building expertise.

3.3. INVESTMENT

Why is it at stake?

RE projects immobilize capital expenditure (CAPEX) by opposition to power purchase and require higher up-front investment costs than traditional fossil fuel generation units.

Main issues

Financing availability

Industrial facility managers may lack the equity capital needed to invest in RE production assets on their sites due to tight budgets. Moreover, cash pooling is often managed at the corporate level where decision makers are reluctant to invest in non-strategic and non-revenue-generating assets. Industrial actors tend to invest their cash in core business operations/assets in priority; the difference between loan interest rates and the return on investment of the project can also drive industrial decision makers regarding RE integration projects.

Capital lockup

Even though technological costs are driven down by research and development, engaging in an RE integration project for the industry requires high investment capabilities, which affect companies' financial ratios. This is even more relevant when the financial impact of the RE project is compared to the simple purchase of heat and power (with no up-front CAPEX disbursements) rather than to on-site fossil fuel generation alternatives. Specific costs that are usually higher for renewable projects include:

- *Project feasibility assessment costs*: it is necessary to determine beforehand what the available renewable resources are and how they can be exploited, compared to standardized fossil fuel solutions.
- *Equipment costs*: renewable technologies are less dense than fossil energy ones, hence RE projects require substantially higher up-front capital investments than fossil fuel equipment on a per kW basis, but their operations expenditure is lower during the entire life of the project (except potentially biomass projects), not to speak about fuel price risks and environmental concerns.
- *Engineering, procurement and construction costs*: integration of renewables on an industrial asset is more complex and less standard than integration of fossil fuel units which has been carried out for decades. It is the case, for example, when integrating solar panels on a rooftop, as engineering has to take into account the existing ventilation system or the maximum weight the rooftop can support. Biomass projects usually have higher operations expenditure than other RE technologies, organic fuel costs can fluctuate too or organic feedstock storage is usually required.
- *Administrative costs*: Becoming a power producer and vendor carries additional paper requirements compared to being a simple power consumer.
- *Grid connection costs*: the on-site production of power might require adapting connection with the grid to allow for bi-directional exchanges.

Lessons learned for industrial actors

Transfer the investment to a third party power producer

To invest in a project with limited funding, industrial actors can adapt their project structure to transform CAPEX into operating and maintenance costs (OPEX), through third-party investment mechanisms, such as a third party power producer. This way, both the high amount of investment and the risks are transferred to the third party (see 0).

Case study examples:

- Pepperidge Farm project: the company member of the Campbell Soup Group concluded a PPA with BNB Renewables to purchase 100% of the electricity produced by the 1 MW solar PV array (See Figure 9 below), at competitive rates with the retail electricity market. BNB Renewables financed the solar PV installation.
- Codelco Gabriela Mistral Division concluded a PPA with Energía Llaima to externalise the investment and to secure long-term stable energy prices (crucial issue for high energy-intensive activities in off-grid areas).

Figure 9 . View of the solar PV plant at Pepperidge Farm (Credit: Pepperidge Farm)

Search for alternative funding schemes

The use of crowdfunding mechanisms for local energy projects is still nascent but gaining traction. This financing mechanism could be particularly interesting for small and medium enterprises with local content to experiment with, with the support of local authorities. Projects for SMEs are often too small for specialized infrastructure investors and pass under the radar, even if the expected return on investment is high. However, they can have very high local visibility if they bring environmental, health and social benefits to the neighbouring communities, so they can raise contributions from a larger number of people with publicity from local authorities.

Policy recommendations

Provide investment support mechanisms

Direct financial support is not needed in an increasing number of RE projects. In the case studies presented in this report, the majority of projects were partly financed by direct public investment subsidies (from the Connecticut Clean Energy Fund, the French Renewable Heat Fund, the Sustainable Energy Authority of Ireland or the Suzhou Municipal government, among others). Others benefitted from investment tax credits (Pepperidge Farm) and preferential loan rates (Jiangsu Changshu Jinhong printing and dyeing). Three projects did not receive public subsidies: Diavik Diamond Mines Inc, Petroleum Development Oman and Codelco – Gabriela Mistral division.

Where necessary, investment support can take the form of:

- *Direct subsidies and grants*: subsidize investment costs through calls for proposals and grant applications, from energy specific and/or performance criteria funds. It can be particularly interesting to include RE technology incentives in phase-out plans of high carbon footprint equipment. When industrial actors are confronted with the phase-out of energy-producing equipment (such as gas or coal boilers), the cheapest option is often to prolong the life of the asset through retrofits. Specific incentives should thus be offered to tilt the decision towards deploying RE assets.
- *Subsidized loans*: a public agency can support and pay part of the loan (usually the interest rates) or provide low interest loans and loan guarantees.
- *Investment tax credits, deductions and exemptions*: providing investment tax credits can reduce the impact of an RE investment on the P&L of an industrial company by reducing its tax liabilities for a given year.
- *Direct production incentives*: providing direct financial support according to the RE outputs, through feed-in-tariffs or RE certificates. Such financial support mechanisms are likely to be expensive; they would have to be time limited.

Enable third party power purchase through third party power producers

In a number of countries, such as in Sub-Saharan Africa, industrial players can only buy electricity from the state's utility or self-consume the electricity they produced. It is necessary to allow for third party power purchase agreements to topple the barrier of capital lock-up for most actors.

Positive externalities

Lower energy costs for all customers

By allowing industrial customers to directly contract with third party power producers, policy makers can decrease the burden they impose on utilities through subsidized electricity purchase by large customers. In turn, the savings can be passed on to residential and commercial customers through rates decreases.

3.4. RETURN ON INVESTMENT

Why is it at stake?

RE projects often come with long payback times and lower return on investment compared to the core activity of the industrial company.

Main issues

Return on investment varies widely across renewable power in industry projects. These variations can be caused by many factors including technology used, availability of resources, attractiveness of power repurchase terms, current energy spend, etc. This is particularly true of new technologies that have not yet achieved a learning curve cost reduction such as power-to-gas or battery storage.

Moreover, the expected return on invested capital of renewable assets is usually lower than the return on invested capital of production assets.

If the non-financial benefits (image, positive environmental impacts, GHG emissions reductions, R&D, etc.) of deploying renewable energies on an industrial site does not outweigh the lack of competitiveness of the solution, industrial companies will likely not invest in the project.

To make matters worse, evaluating the return on investment of RE assets is not straightforward as they yield long-term savings rather than immediate net revenues. Savings can also vary depending on the evolution of energy prices over time and thus depend on the time horizon considered.

The specificity of RE projects is their high CAPEX, low OPEX, and long lifetime, which results in paybacks that are often far too long for industrial players (> 5 years) due to the cyclicality of their markets and the lifetime of their production assets. Mining industries, and particularly diamond mining actors, can more easily integrate RE on their production sites than consumer goods manufacturing industries, due to the longer time horizon of their activity.

Moreover, as the gains from RE projects are avoided costs, they fluctuate based on the evolution of the fossil fuel and power market price, creating additional uncertainty on the payback period.

Finally, payback time is a widely used concept that does not take into account the benefits accruing after the payback time is elapsed. Each industrial sector has defined required payback time according to specific market cycles. An RE project with a good return on investment (ROI) would probably have a payback time of 3 years whereas a manufacturing industrial actor may have a required payback time of 6 months.

Lessons learned for industrial actors

Transfer the investment to a third party power producer

By contracting power purchase agreements with third party power producers, industrial players can drastically reduce payback time (see 0), from more than five years to next to zero. Industrial players can transform CAPEX into OPEX, as the third party power producer will endorse the total investment and drastically reduce payback time, making them more disposed to engage in RE production asset integration.

Share the risks and investment through an SPV

An intermediate project financing structure between direct investment and third-party investment is the creation of a special purpose vehicle (SPV). Debt raising and CAPEX lockup is transferred to the SPV and the industrial player can share the burden of the investment with third party financiers through capital participation in the SPV, reducing the impact of the investment on its balance sheet.

A significant part of the investment cost is due to the financing of the project through debt and equity. Infrastructure SPVs can benefit from more advantageous interest rates and better debt-to-equity ratios than the company gets for the financing of its core activity, which reduces financial expenses and increases return on investment.

In addition to the financial benefits resulting from this operation, unbundling the renewable asset opens the way for securitization, which in turn can provide a solution to the return on investment time mismatch between the energy production asset and the industrial player time horizon. Senior debt can be secured in exchange for revenues within the first five years while mezzanine debt and equity can complete financing for the more risky part of the project (revenues after five years). Companies can keep senior debt and put the remaining tranche on the market for specialized investors to put their money in.

SPVs need to achieve critical size however (at least €10 million in practice), which can be reached for large projects or achieved through the constitution of a portfolio of similar assets across industrial facilities.

Oversize the installation

In most cases, larger installations offer better economics than smaller installations as operation and maintenance costs can be spread over more production and due to bargaining power on equipment purchase. For some technologies such as wind, there are also increased benefits in terms of productivity in building large turbines (they can reach higher winds and produce more energy). When the optimum size for a renewable installation is larger than the needs of the industrial asset and if selling back extra power is allowed and well remunerated by the grid operator or directly by industrial off-takers, then oversizing the project can make more economic sense and yield a better rate of ROI.

When engaging in RE integration, industrial sites should perform a project business plan analysis to assess the potential of oversizing the project's installed capacity. This analysis should take into account the mechanisms associated with selling the energy surplus to the grid or a heating network and the risks of changing regulations in the short and mid-term.

Enhance the value of various by-products

RE technologies can yield by-products that have economical value and can be used to generate additional revenue. For example, finding an economic value of organic by-products after the energetic use of biomass feedstock (e.g. fertilizers) can improve ROI and shorten the payback time of a project.

Case study example: At Jain Jalgaon Plant in India (Jain Irrigation System), tomato pulp, which is a by-product of the tomato transformation process, is reinjected into the methanisation reactor to produce biogas (See Figure 10 below). JISL has succeeding in giving an economic value to agro-waste that had to be disposed at JISL's expense. Bio-methanation transforms waste disposal expense into valorisation opportunities: electricity/heat generation and sales, as well as digester slurry sales as marketable soil conditioner.

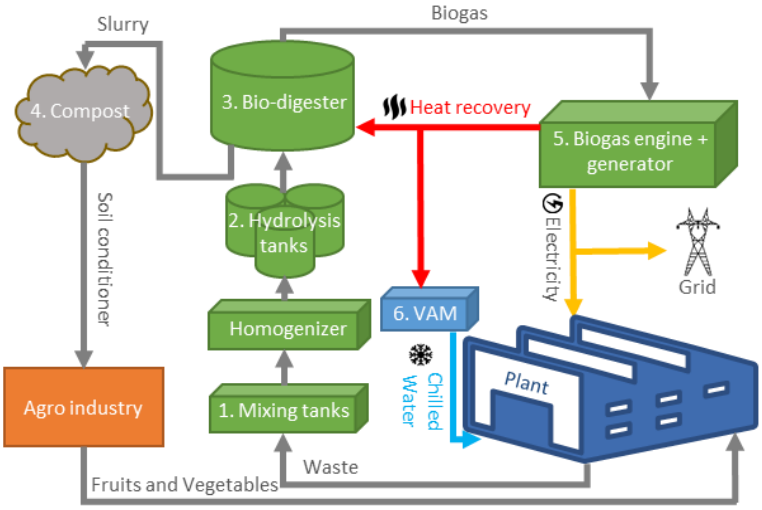

Figure 10. Diagram of the Jain Irrigation System Ltd plant and bio-digester

More generally, biodigesters using organic waste produce bioslurry (by-products of energy valorisation of organic waste) that can then be sold as a fertilizer. It is recommended that industrial players assess the technical potential and market opportunities of by-product valorisation.

Anticipate and enhance heat and power synergies as well as energy efficiency

When designing the integration of RE with the industrial processes, it is recommended to think in terms of synergies between electricity and heat needs or between heat and water streams.

Case study example: In the SATMAR project, better control of heat through heat pumps makes it possible to reduce the death rate of spats and cold water can be reused for other breeding phases (See Figure 11 below). Doing this can save a considerable amount of energy so that a high share of energy consumption is covered by the renewable installation or more energy is sold to the grid/heat network. Additionally, reusing hot waste water in the core processes could be a lever to reduce the costs of waste water treatment and water consumption, enabling a higher return on investment.

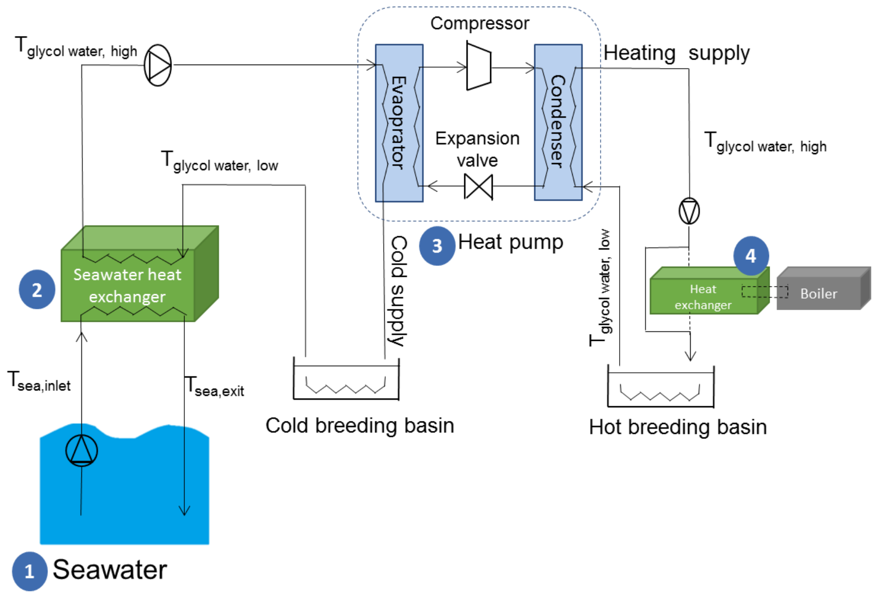

Figure 11. Simplified diagram of the seawater heat pump at SATMAR plant in Aude (France)

Policy recommendations

Allow accelerated depreciation of RE industry assets

Accelerated depreciation of RE assets in the industry diminishes the payback time and increases return on investment for industrial prosumers.

Value the environmental benefits of RE and remove hidden subsidies on fossil fuel energy generation

The energy market should value the environmental benefits of renewables rather than provide hidden subsidies to fossil fuels through preferential power rates for large industrial customers. Nevertheless, public policy intervention would be required in many cases as the classic electric utility business model indeed rewards consumption and not energy efficiency and energy conservation per se. Alternative approaches, such as carbon prices, can be more effective in increasing the value of environmental benefits of clean RE projects and thus making them more attractive to investors and consumers. Public policy makers could play a significant role in developing a market for environmental benefits/credits from clean RE.

Public authorities should review the current state of regulatory mechanisms for the energy industry within their territory to measure subsidies for fossil energy (from fossil fuel extraction to electricity generation from fossil fuels) and readjust their RE support schemes in accordance with their international commitments on reducing greenhouse gas emissions.

Design a utility tariff structure to reflect the benefits provided by decentralized energy projects

Facilities with decentralized RE projects pay higher transmission and distribution costs than conventional facilities per unit of power bought from the grid. While it is normal to account for the additional constraints put on the grid by decentralized energy projects, benefits should be taken into account too (reduction of peak pricing through demand reduction, avoided reinforcement costs). When coupled with energy storage in particular, demand side flexibility should be valued in the contracts with the utility.

Grid connection policies are often discriminatory towards RE projects because utilities (including Distribution System Operators - DSO) do not grasp the full extent of their benefits. Measuring them is complex and requires a precise knowledge of the grid (depending on their location on the grid, RE projects can have vastly different impacts for the utilities).

DSOs are the companies responsible for operating, ensuring the maintenance and if necessary investing in the distribution system development in a given area.

Policy makers should thus encourage the development of smart utilities through deployment of data analytics tools in their operations (with the input of smart meters) so that they can optimize the use of existing electricity grids for the integration of renewables. By doing so, they can prevent extra-added cost required for connecting renewable electricity projects close to industrial sites.

For additional information on residential and commercial prosumers on the current electricity generation models, please refer to the following IEA-RETD studies: Resid*ential Prosumers – Drivers and Policy Options* (2014) and *Tapping the potential of Commercial Prosumers* (2016).

Provide preferential rates for the purchase of decentralized RE

One of the most widely-used policy options for supporting the development of renewables, favourable power repurchase agreements, should be specifically adapted to the integration of RE production assets on industrial sites. These can include:

- *Feed-in tariffs:* feed-in tariffs can be made specifically more interesting for industrial prosumers to account for the extra cost of integration in their industrial processes. They can also reward industrial prosumers based on the level of integration of renewables in their processes: industrial players using RE for all of their processes would be better rewarded than those using them for lighting purposes only.
- *Contracts for difference:* similar to feed-in tariffs (a price difference is paid to the producer when the market price is lower than the reference tariff).
- *Feed-in premium*: power producers are paid a fixed premium on top of market price.
- *Net metering:* electricity exported to the grid is valued at the price the energy producers would pay to purchase it. This can be less interesting than feed-in-tariffs for industrial prosumers as they usually pay less for electricity than retail customers (see also IEA-RETD study, *Tapping the potential of Commercial Prosumers,* 2016)

Additionally, policy makers can exempt industrial RE producers from paying electricity taxes to further foster their development.

Provide guidelines and regulatory framework for valorisation of by-products

Industrial players should be offered the opportunity to sell by-products such as digestate and bioslurry from methanisation through simplified harmless procedures in order to tap extra streams of revenues for their RE projects.

Positive externalities

Better accounting of positive and negative externalities of energy production sources

A readjustment of public subsidies in favour of RE projects can have direct and indirect financial benefits for industrials willing to develop RE projects. The simple savings on removal of subsidies towards fossil fuels (direct ones that usually exist in oil-producing countries; indirect ones through low tax on petroleum products for example in other countries or more developed countries) can outweigh the extra spend on RE projects. On top of that, it can greatly reduce the negative externalities of fossil fuels and offer additional savings, for example in terms of environmental and health spends.

Lastly, correctly accounting for the impact of decentralized renewable power generation on the electric grid will allow grid reinforcement investments to be optimised.

Development of local business ecosystems

The use of co-products as an additional source of revenue for the industry will contribute to the development of local circular economies and industrial symbiosis, as the co-products or waste of one company becomes the feedstock of another. This is also true of initiatives that would trigger the development of peer-to-peer heat exchanges at industrial sites (see 4.3).

Case study example: The Hima Cement Ltd (LafargeHolcim Uganda) coffee husk project has had a positive economic impact on over 60,000 farmers through financing coffee seedling [4].

3.5. RISK AND INSURANCE

Why is it at stake?

Industrial companies deploying RE assets onsite may incur three important risks that may be seen as no-go barriers for most of them: Continuity of supply can pose a risk on the plant's operations, non-mature technology of the renewable asset can threaten the security of the industrial asset, and the RE asset's profitability depends on the financial livability of the off taker (i.e. the industrial asset in most cases).

At the same time, RE assets can also become a factor of risk reduction through security of supply, release from fluctuation of market energy prices and greater stability of supply in regions where grid performances are poor.

Main issues

Continuity of energy supply

Energy supply continuity is a key element for most industries. Revenues lost from a brief period of plant interruption combined with the additional costs of restarting production can thwart the expected benefits from energy savings on through RE deployment, especially in countries where the power grid is quite unreliable.

The risk is particularly acute for renewable installations using immature technologies or mature technologies with no back up in the form of energy storage and/or grid connection. For example, a company that has replaced gas boilers with RE heat supply would have to design a quick back-up supply option in its new heat generation asset. Most of the time, industrial players have an on-site fossil back-up even for heat generation.

Therefore, companies may see a risk in implementing intermittent energy sources or technology with insufficient proof of long-term performance. Conversely, on-site energy production assets can bring greater power supply reliability for production cycles when combined with energy storage solutions, turning the industrial asset shortage- and blackout-proof. This is true of the Pepperidge Farm case study for example, where protection from grid blackout is ensured through CHP fuel cells. It is also often the case in developing countries where grid reliability is quite poor: on average, 4.9% of Africa's annual sales are estimated to be lost due to electrical outages [3].

Fuel supply reliability and protection from price fluctuation

Fuel supply reliability is also enhanced through on-site RE production when resources needed are produced locally and renewed (solar irradiance, wind, waste and bioenergy).

Case study examples

- In the Sony project, drivers for the project included protection from price fluctuation of conventional energies, which was achieved by buying more RE through the company's green power certificate program.
- Fuel supply reliability was also an important driver in the Codelco case study.

Physical safety of the industrial asset and insurance

Faulty equipment of an RE production asset can jeopardize the safety of the whole facility when the level of integration is high. This is the case for explosive technologies such as hydrogen production, storage and combustion as well as for more standard technologies.

In France, farmers sought to benefit from very advantageous feed-in tariffs for building integrated solar PV by covering sheds and warehouses with solar panels, but the cost of insurance for the grain stocked below was near to prohibitive. This is also the case for high value product manufacturing plants such as aerospace.

Operating lifetime of the off-taker

Solvency of the off-taker is the major risk for the profitability of the on-site RE project. RE assets have a time horizon of more than 20 years whereas industrial production facilities can be downsized, shut down or relocated much faster if needed because of evolving political situations or market cycles. In most cases, the largest chunk of the energy produced by the RE asset is consumed by the industrial production facilities. If it shuts down or downsizes, the profitability of the RE investment can be significantly impacted.

Lessons learned for industrial actors

Think in terms of interactions between heat and power

Thinking about integrating power with heat can help diminish the risk on energy supply as heat can more easily be used as a storage option than power.

In the Jiangsu Changshu Jinhong printing and dyeing project, the solar evacuated tube collectors are used to pre-heat a hot water storage facility at 60° before taking the water to 90° with a coal boiler (See Figure 12).

The installation limits the use of coal without putting the operations at risk. In processes involving both heat and power, one can take precedence over the other in case of failure.

Figure 12. View of Jiangsu Changshu Jinhong printing and dyeing Plant (Credit: Sunrain)

Look for technical and contractual backup to ensure continuous energy supply

Ensuring the continuity of the power supply can also be enhanced by combining a number of approaches, including: onsite energy storage equipment, hybridization of existing generators rather than a full switch to renewables and integrating provisions for a reliable supply in the power purchase agreement with the third party power producer. It should be noted however that back-up solutions such as diesel generators add an extra layer of complexity to energy management of the facility and can come at a hefty cost and with serious environmental concerns. Energy storage is easier to implement, but often comes at an even higher price. Contractual backup may also concern fuel supply like diesel for generators.

Distribute the risks across sites and between actors of the same industry

When the supply risk is either too costly to cover through back-up technologies or through private insurances, industrial prosumers should envisage mutualising across similar assets within the same or multiple companies (see 4.3). Industrial prosumers within each sector should work on defining standard measures of supply risk to make this mutualisation possible.

An example of this type of project was identified in Taiwan where two onshore wind farms (total installed capacity of 150 MW; operated by InfraVest Wind Power Group) powered the entire Changbin Industrial Park. [3]

Negotiate equipment guarantees

Physical integrity of the industrial asset can be partly covered through longer and more comprehensive guarantees negotiated with the renewable equipment manufacturer, especially for mature technologies where best-in-class players are confident about the safety of their product.

Source locally

While fuel supply reliability is often a reason stated to justify developing onsite RE production capabilities, industrial prosumers should keep in mind that these renewable fuel resources should be sourced locally. Actually it will probably be very expensive to transport renewable fuel like biomass / organic waste and by-products over long distances to the industrial plants where they would be energy recovered.

The energetic valorisation of external by-products and waste can have negative impacts on the nearby communities, particularly in densely populated areas: extra traffic from fuel supply, noise and smells. Industrial actors willing to develop such projects can limit their impact through local partnerships with feedstock producers.

Case study example: Hima Cement Ltd concluded a supply agreement with local coffee producers to ensure its organic feedstock supply (coffee husks) for its biomass-based heat generation equipment. This supply strategy has had a positive socio-economic impact on local communities and environmental impact regarding local waste management.

Make the industrial asset part of a diversification strategy

Where the value of an onsite RE asset can be enhanced through electricity resale, it can become part of a diversification strategy, especially for small family-owned businesses. The renewable asset has a different risk and return profile compared to the industrial asset. This characteristic can be interesting when trying to guarantee steady revenue for the family’s offspring.

Policy recommendations

Guarantee access to the grid for back-up

Giving access to the grid for back-up in case of breakdown of the on-site power asset can greatly reduce the operational risk imposed by such projects. Industrial players are unlikely to invest in on-site RE production assets if they don’t have grid back-up (except where this is not an option, like remote mining sites).

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[3] This project was not selected in the first phase, detailed analysis of the drivers and impacts of the project are not available.

Offer guarantees for renewable power in industry projects

Since private insurance companies often assimilate the industrial facility and the RE production in their premium calculations, insurance is difficult to get at a reasonable price. Governments could guarantee the risks of integrating renewable assets at an industrial site (power supply risk, risk of the facility's physical integrity and risk for the financial livability of the offtaker) by distributing the risk on a national scale, thus enabling a lower cost for the individual industrial players. The objective would not be to wipe losses resulting from poorly implemented projects but to mutualise well-defined limited risks beforehand.

Public authorities and agencies can also play a role in defining and delivering operational guarantees and technological warranties for safe and mature technologies (see 4.1).

Enable local smart grids

Allowing a pool of industrial prosumers and independent power producers on a common industrial site to access mutualised back-up generation and storage as well as to trade energy produced on site with each other through "smart-grid" type systems can limit the energy supply risk for all participants. Policy makers should encourage such local experiments (see 4.3).

Positive externalities

Network benefits

Allowing industrial prosumers and independent power producers to organize local markets for power, storage and back-up reduces the load imposed on the grid. In turn, this avoids grid reinforcement expenses and limits its risk of failure. At the same time, peak power consumption can be reduced, resulting in large savings for the industry from reduced peak power pricing.

Reduce spending compared to current schemes

Moving from a subsidy model to a guarantee model limits the overall expenses for public authorities and can have a net positive impact on state budgets.

3.6. CONTRACTUAL SCHEME COMPLEXITY

Why is it at stake?

Contractual complexity can prevent industrials considering direct implementation. There is specific contractual complexity between the industrial prosumer and the third party power producer and the utility.

Main issues

Complexity of Power/Heat Purchase Agreements

Specific provisions within PPA contracts can add a layer of complexity, deterring ambitions to produce RE on site. These contracts need to account for the variability of energy production, include a measurement methodology and a common definition to differentiate what is due to controlled and uncontrolled events, as well as agree on the consequent penalties or premiums in accordance with the measured performance of the supplying third party power producer. Especially when it comes to determining the reasons for power fluctuations, industrial prosumers may feel too far away from their core competencies to enter confidently into negotiations with the third party power producer.

For heat in particular, there are currently no standard contracts for heat purchase since heat is not a standardized commodity like electricity (its quality depends on pressure and temperature).

Additionally, third party power producers and industrial player usually don't have the same activity time frame; third party power producers look for 20-year PPA contracts whereas industrial players have a shorter activity time frame mainly determined by their markets cycles. This gap might even be as significant for extractive industrial companies too whose production assets have long lifetime and time horizon.

Case study example: Even if the PPA scheme was presented by Codelco Gabriela Mistral Division as one of the key elements of the project's success, Energia LLaima and Sunmark mentioned that the duration of PPA was the biggest problem for its marketing in the North Chile mining industry.

Complexity of participation in the retail or wholesale electricity market

For industrial prosumers that participate in the retail or wholesale electricity market through the resale of the extra power produced on site, the complexity of purchase and selling tariffs is also far from its core competencies. Grid connection fees, time of use billing for purchase and resale, demand response mechanisms, peak power demand pricing and ancillary services are all too complex for most players without dedicated personnel to fully leverage them.

Lessons learned for industrial actors

Contract with specialized energy management companies for participation in the retail and wholesale electricity market

Industrial players can rely on third party power producers for participation in electricity markets and contract with them under power purchase agreements.

Alternatively, a number of specialized companies exist that offer to manage industrial and commercial customers' energy consumption and optimise it through electricity market participation, with or without additional hardware installed. They take the burden of the complexity off the industrial prosumers' shoulders in exchange for a part of the revenues generated on the market. They can also unlock additional revenues as they aggregate demand response from different customers thus opening up the doors to the capacity market.

Develop new offers to reconcile third party power producers' lifetime requirements and industrial players' market cycles

Third party power producers should manage to make offers with shorter life and an option to extend or not with recycling of the assets in case of no extension.

The UK-based project developer Lightsource RE [6] has developed a more flexible approach to the mining industry than third party power producers' traditional 20-year offers. The company offers 5 to 10 year contracts; at the end of the contract, the client can either renew it or Lightsource RE takes the solar installation somewhere else.

This flexible offer is more adapted to market cycles in the mining sector, subject to high variability of commodity prices.

Figure 13. Solar PV project at Wheal Jane, Cornwall (Credit: Lightsource RE)

Try blockchain transactions

To simplify the contractual complexity of verification within power purchase agreements, companies could try using blockchain technologies for such uses.

Focus on Blockchain

Electrical grid and distribution networks have been designed for centralized “unilateral” production, but today prosumers need to be able to inject electricity onto the grid. To answer this problem, there is a multiplication of small intelligent networks called smart grids. One of the tools used in smart grids is Blockchaining. The Blockchain technology consists in a database recording transactions between actors who have access to the database and guarantee its integrity by a decentralized consensus (see Figure 14 below).

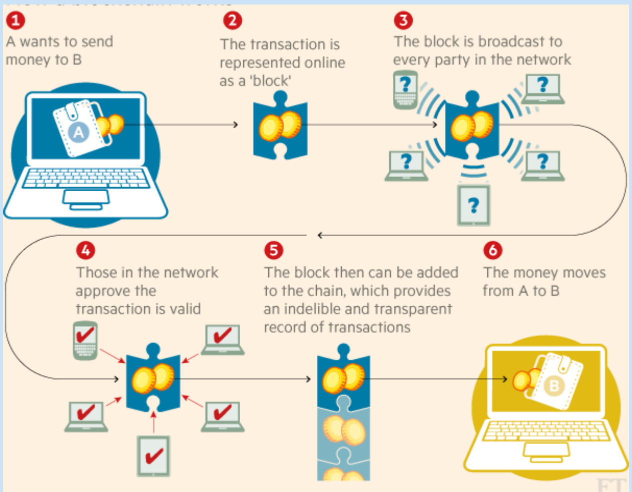

Figure 14. How a Blockchain works [12] – Credit: World Economic Forum

The main reason to introduce Blockchain is to get rid of intermediaries like banks or utilities and allow for direct transactions between a prosumer and an off-taker.

Figure 15 illustrates blockchain use in the Brooklyn Microgrid Project (US).

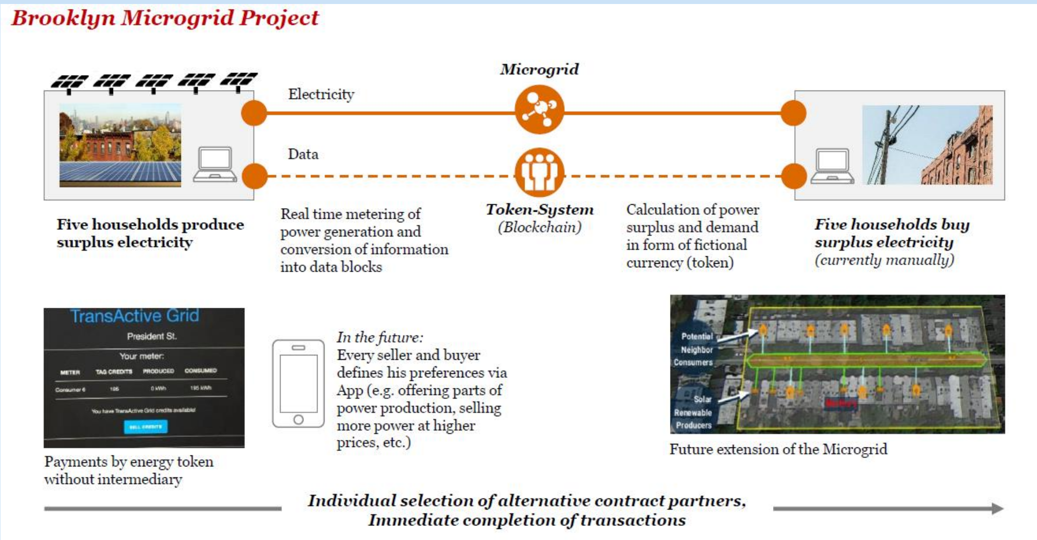

Figure 15. Overview of the Brooklyn Microgrid Project [13] – Credit: pwc

The Blockchain concept could be used to track and facilitate transactions of RE produced by industrial companies but with this new, complex subject, it could take time before it is actually implemented. One of the Blockchain functionalities used in the energy sector is Smart Contracts. These autonomous programs facilitate transactions and reduce the costs of verification, execution, arbitrage and fraud.

Even if Blockchain technologies would be quite relevant for third party power producers in the first place, industrial prosumers could be interested in testing them, particularly if they have oversized their RE production assets (heat and/or power) and have external off-takers (other industrial players in an eco-park for example).

Policy recommendations

Support the creation of simple and accurate contractual schemes

This can be done by harmonising support mechanisms and pricing schemes across renewable energy technologies. Allowing for the experimental use of the blockchain technology for small energy transactions between industrial prosumers, third party power producers and utilities could be another way (probably more in the mid-term).

Positive externalities

Creation of an innovation cluster on blockchain technologies

Developing a successful use case for the use of the blockchain technology on an energy project can open the door for its deployment in many sectors (especially in the financial industry) and give birth to a blockchain pole of expertise in the countries that initiate it.

Increased business opportunities for distressed third party power producers

Easing contractual schemes between third party power producers and industrial companies opens a new market for third party power producers that is more valuable than the traditional business of wholesale to the grid. This can initiate the transformation of a country's energy sector towards decentralized poles of energy generation and production.

3.7. TECHNOLOGY MATURITY

Why is it at stake?

Dominant RE technologies (solar, wind, geothermal, biomass…) are now mature and considered as such by industrial managers and investors. However, other technologies still require development (power-to-gas and tri-generation). Investing in non-mature renewable technologies carries specific risks that industrial players are probably not willing to take.

Main issues

Additional costs of non-mature technologies

On top of costs associated with most on-site RE production projects (project feasibility assessment, equipment, engineering, procurement and construction, administrative and grid connections), investing in non-mature technologies induces additional research and development costs. These costs are borne by the industrial player but benefit the industry as a whole.

Public credibility

Although innovation is widely regarded as a positive value for companies, investing in non-mature technologies can hurt one's public image. Companies effectively have to bet on which technology will develop years or even decades before the technology can become economically viable. When the required research & development programs come at a very high cost, this can be seen negatively by shareholders and financers as it reduces short-term gains and increases long-term risk in the case of failure. This negative view usually lasts until the technology becomes viable, especially when competing technology options seem to be gaining traction at the expense of the developed solution. This was true of technologies that are now mainstream such as solar and wind and could be for emerging technologies such as power-to-gas or biomethane production.

On the other hand, once successful, the company will receive little credit for contributing to the development of a new sector.

Lessons learned for industrial actors

Participate in industry-wide research and development programs

Participating in industry-wide research and development programs on the integration of non-mature renewable technologies for on-site energy production reduces both costs and risks. The program costs are spread over multiple actors and the program can be supported by local authorities that have an interest in positively communicating about it. The higher number of stakeholders also creates more incentive for its success in the long term and relative to competing technology options.

Case study example: The first step of Colryut project for RE-based hydrogen production for fuel cell forklifts in Halle (Belgium) was supported by the European Interreg IV project implemented in Belgium by the Hydrogen Region Flanders - South Netherlands's project which aims to become a leading player in the development of the hydrogen economy. The second step (on-going – see Figure 15 below) has been part of the Fuel Cells and Hydrogen Joint Undertaking, a public private partnership supporting research, technological development and demonstration activities in fuel cell and hydrogen energy technologies in Europe.

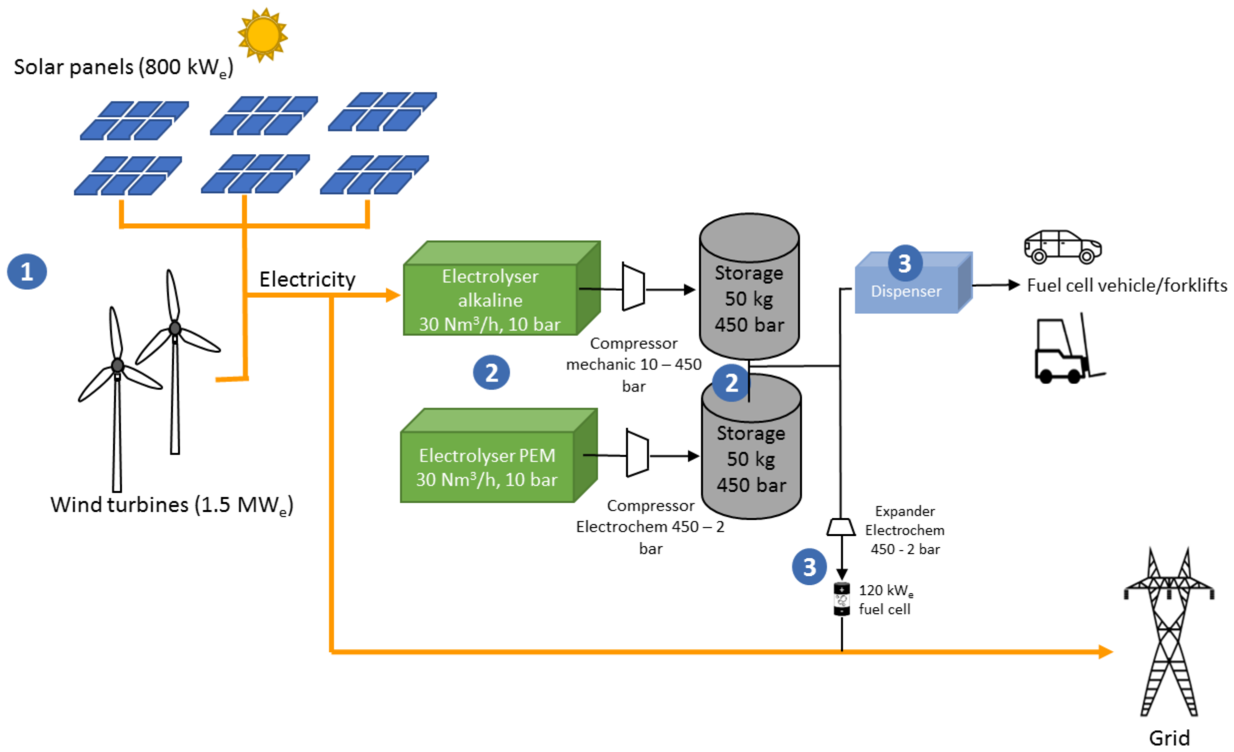

Figure 16. Simplified diagram of Step 2 project at Colryut site in Halle (Belgium) supported by the European 'Fuel Cells and Hydrogen Joint Undertaking' initiative

Policy recommendations

Finance pilot projects to develop best practices

As private actors are reluctant to invest in new technologies, policies should participate in their development by financing pilot projects for non-mature technologies with significant growth potential (see 4.3). One possible lever is to publish calls for proposals specifically targeting non-mature renewable technologies and industrial projects. Policies should also support R&D through budget allocation, operational support (providing test sites, for example) and training.

Encourage public companies to participate in the development of renewable technologies

Public companies should be mobilized to share the costs and risks associated with developing new RE technologies for on-site industrial use. Public companies are under less pressure from shareholders and financers. They can take a longer term view than their private counterparts. Public companies' engagement can be independent or through industry-wide R&D projects, with the additional benefit of sharing some of the costs with private actors.

Simplify the procedures and norms applicable for pilot projects

Pilot projects are usually submitted to the same authorisation procedures as more mature technologies. As there is uncertainty regarding the categorisation of such projects, they can even be submitted to multiple regulations at the same time. On the contrary, policy makers should simplify the procedures and norms applicable to pilot projects, within experimental zones to limit the associated risks (see 4.3).

Example of hydrogen production and storage

Traditional regulation regarding hydrogen in the OECD countries can be very strict (potential environmental impacts, security); this can result in show-stoppers such as, administrative barriers, excessive complexities, and extra costs to modify existing systems, for example. The risks associated with the production and storage of hydrogen could be taken into account in an “experimental bubble” giving more initiative to the site manager, for a determined period of time, under certain specific conditions negotiated with local authorities. Public subsidies could subsequently help them “reach the level of normal security standards” once the pilot has been completed and the decision to confirm the investment has been made.

Positive externalities

Development of innovation hubs and technology leaders

Investments in new technologies can help foster the development of cutting edge technology sectors with sought-after skills, so that technology leaders can become the commercial powerhouses of the future. Industrial companies lack specialised profiles and competencies in the integration of new technologies within industrial processes. Policy makers acting as first mover can create a centre of educational and operational excellence in the field.

3.8. AWARENESS

> ***Why is it at stake?***
>
> Industrial companies lack awareness regarding support mechanisms (incentives, guarantees, etc.), costs and best practices, which appears to be crucial in filling the gap between simple knowledge of the subject and concrete implementation on the ground.

Main issues

Knowledge of costs and benefits

Industrial companies will not engage in RE projects unless they have a clear understanding of what the potential benefits are for them, how much they cost and what are their risks. Insurers and banks also require this information for insurance and financing.

Availability and reliability of information

Such information can be difficult to gather as industrial on-site RE projects are scarce and often scattered across sectors and geographies. Moreover, because most on-site RE projects are still used as promotional showcases, industrial companies can express legitimate doubts on the reliability of the information communicated.

Knowledge of operational best practices

In terms of project implementation, the diffusion of feedback regarding decision processes, integration of RE assets in core processes and project management would also help to greatly facilitate future project planning. This information is hardly ever communicated between industrial actors.

Knowledge of support mechanisms

Compiling all information regarding available support mechanisms can become a daunting task for industrial companies. They are provided by a wide range of public and semi-public entities at different levels (communities of countries, countries, regions, municipalities, industry associations, etc.), targeting different technologies and with varying criteria for granting.

Case study example: The combined heat and power from bagasse project (sugar mill in Thailand case study) was supported by the EU-ASEAN (Association of South East Asian Nations) Cogen 3 program, a cooperation program on cogeneration projects, including training, financing, and policy-making, involving parties from the public, private, and education sectors. The existence of such programs can be very hard for most industrial actors to find out about.

Inspiration

Positive feedback from other projects can act as a source of inspiration, especially from similar projects (in terms of technology, size, location and industry). This is one of the global objectives of this particular study.

Lessons learned for industrial actors

Engage in inter-professional associations and sector-specific associations to share information

Awareness issues cannot be addressed without sharing knowledge. An efficient way to share knowledge is to get in contact with peer players, so industrials should consider joining groups such as inter-professional associations, to meet with counterparts also engaging in the same type of projects, and share knowledge with them (on best practices, useful data platforms, procedures, costs and benefits, etc.).

Within these industrial associations, industrial players should not hesitate to share as much technical and economic information as possible on their own RE projects with external players. Information sharing can create cross-company dynamics between industrial actors with similar consumption and RE potential. Also, confidentiality issues should not be overestimated since disclosing information about RE integration on industrial sites rarely gives clues on core processes and businesses.

Communicate positively on success and failure stories

Continuing to communicate on success stories (showcases) acts as a source of inspiration for other players and can position a player as an environmental role model within its industry and to the public. Even stories of failure, if communicated positively, can also benefit the industry as a whole in terms of operational lessons learned and project a transparent corporate image to the wider public.

Policy recommendations

Compile available information and make it easily available

Public entities, like national energy agencies for example, are best positioned to gather and compile information about existing support schemes and public research (at their own as well as other levels). It is important that they create a single information centre to alleviate the burden of research on industrial players. This centre should take the form of easily accessible platforms or regularly updated indexes and reports and should include all types of energies (in particular, heat should not be overlooked), technologies and industrial sectors.

Data to be made available should encompass among other things: environmental regulations, existing standards, permit acquisition processes, available support schemes, guidelines for project implementation, directories of technology suppliers and feedstock retailers, etc.

Ideally, these databases should be made open and contributive so that feedback from private players can easily be incorporated. Policy makers can then communicate on them through specialized reviews and conferences.

Case study example: Besides a grant, the Danish Energy Agency provided informative services (publications, maps and analyses) for the 4MW wood-fired steam boiler project at the Brewery Vestfyen plant (Denmark).

Promote information sharing between stakeholders and facilitate dialogue

To promote information sharing between stakeholders, policy makers should leverage their participation in on-site RE projects by mandating that such projects benefitting from public support publish key elements regarding cost and benefits, as well as operational feedback. They should also act as bridges between different administrations, utilities, industrial players and other stakeholders through the creation of economic interest groups.

Build a comprehensive framework for the integration of RE in the industry and support the development of an external advising service

Beyond information sharing, a consistent framework for RE integration in the industrial energy supply should be created to guide industrial companies that are far from their core activity. Guidelines, although necessary, are not enough, and policies should also help the development of an industrial consulting market to individually inform industrial companies of all the processes they will have to undertake.

4. FOCUS ON THREE INNOVATIVE POLICY RECOMMENDATIONS

The identification of the main issues (against or in favour of) facing the integration of RE within industrial facilities has yielded a number of policy recommendations which can be found in the previous section, at the end of each sub-section. Amongst these recommendations, we wanted to single out three topics – beyond additional financial incentives – that we consider to have both high leverage potential and that are usually underestimated by policy makers.

4.1. PROVIDING LOAN GUARANTEES

Issues at stake

Renewable energies exhibit intrinsic risky characteristics (intermittency, locally available resources, stringent permit requirements, etc) with additional maturity issues for some technologies. They impose additional risks on production assets when integrated together and in turn depend on the financial livability of their off-taker. These risks, combined with a general lack of knowledge from investors, make it difficult for some projects to get financing. Banks and investors will generally ask for guarantees from the project developer.

At the same time, direct subsidies are progressively abandoned due to public budget cutbacks.

There is an opportunity for policy makers to shift their efforts away from direct public financing to enabling private financing by providing general guarantees on renewable projects in the industry.

Policy implementation

Government banks or independent development banks can offer guarantees on loans contracted with private commercial banks through a dedicated guarantee fund.

Targeted beneficiaries

Direct beneficiaries

- Industrial project developers looking for private investments and loans
- Commercial banks. Loan guarantees would enable them to share the financial risks inherent to funding renewable integration projects.

Indirect beneficiaries

- Public finances, where these guarantees replace existing subsidies.

Expected impacts

Direct impacts

- Loan guarantee policies would help remove external funding barriers by offsetting the financial risks associated with such projects.
- Offering loan guarantees to project developers will also help them finance renewable assets at a lower cost by minimising premium risks in interest rates.

Indirect impacts

- Loan guarantees create trust in contrast to subsidies (which are often believed to be short lived), increasing a country's business attractiveness.

Example
Roquette Frères received EUR 13 million from "Guarantee Fund Geodeep". This fund, partly financed by ADEME, aims at providing guarantees to project holders against risks of insufficient geothermal resource. The scheme will compensate project holders in the event of failure of exploration or drilling. It is thus a genuine aid to the commitment of investment by reducing the risk borne by the project

4.2. FOSTERING THIRD PARTY POWER PRODUCERS

Issues at stake

To reduce investment, simplify project implementation, reduce the payback period and remove auxiliary assets from their balance sheets, industrial players are willing to transfer ownership of their projects to third party power producers.

In a number of countries, industrial players can only buy electricity from the State's utility or self consume the electricity they produce. Third party power purchase agreements need to be able to remove the above-mentioned constraints.

Policy implementation

Amend the regulatory framework to allow for the existence of third party power producers where they do not exist

- In countries where there is an integrated monopoly on the production and supply of electricity, the energy sector should be progressively liberalized and the law must allow an industrial player to buy energy from a third party power producer.

Amend the regulatory framework to facilitate the activities of third party power producers where they already exist

- In other countries with no de-regulated electricity markets, third party power producers exist but could still benefit from clearer regulations on their status, especially where self-consumption is favoured. For example, in a case where self-consumption is allowed for industrial players and third party power producers are allowed in the power market, some clarification should be made regarding the authorization for an industrial to purchase power directly from a third party power producer, or if the traditional utility remains the unique power purchaser. The direct participation of third party power producers into the retail market should be clarified.

Prepare model contracts to be used by industrial actors willing to sign a contract with a third party power producer

- Model contracts should be available for small industrial companies that do not necessarily have a strong legal department able to understand contractual risks.

Targeted beneficiaries

Direct beneficiaries

- Industrial companies that have limited investment capacities.
- Industrial companies willing to deconsolidate their investments
- Third party power producers

Indirect beneficiaries

- Traditional actors of the energy sector (see Expected impacts)

Expected impacts

Direct impacts

- Industrial players can transform CAPEX into OPEX and drastically reduce payback time, making them more disposed to engage in RE production asset integration.
- Secure long-term stable energy price

Indirect impacts

- Easing contractual schemes between third party power producers and industrial companies opens a new market for third party power producers that is more valuable than the traditional business of wholesale electricity supply to the grid. This can initiate the transformation of a country's energy sector towards decentralized poles of energy generation.
- Facilitating partnerships between third party power producers and the industry through simpler contract terms can help develop a more local and sustainable economy through industrial symbiosis.

Example

- Pepperidge farm project: the company member of the Campbell Soup Group concluded a PPA with BNB Renewables to purchase 100% of the electricity produced by the 1 MW solar PV array at competitive rates with the retail electricity market. BNB Renewables financed the solar PV installation.
- Codelco Gabriela Mistral Division concluded a PPA with Energía Llaima to externalise the investment and to secure long-term stable energy prices (crucial issue for high-energy intensive activities in off-grid areas).

4.3. PROMOTING POLICY EXPERIMENTATION ON ECO-PARKS AND PILOT PROJECTS

Issues at stake

Integrating renewable assets into industrial production sites is still a nascent practice. To improve this integration process and scale it to more industries, additional feedback and experience is needed. Less mature technologies also require more applied R&D and pilot projects.

However, experimentation is stifled by policies and standards that are tailored to large installations of energy producing companies and which can be very cumbersome for small industrial projects.

Policy makers are eager to see the development of new technologies and expertise on their territories but do not wish to adopt measures that could have important impacts on the grid and their tax revenue. Without project implementation and operational feedback, they cannot have a clear idea of the extent of those risks and thus continue to hinder the development of new energy production schemes.

Policy implementation

Identify potential pilot eco-parks

- This task can be delegated to local bodies in charge of industrial development.

Create a unique administrative desk for permits, financing and advising

- This entity can also be the managing actor responsible for choosing an eco-park, assuring a link between all the stakeholders and offering technical support.

Test different types of policies/support mechanisms and practices in the experimental eco-park:

- Allow for third party power producers in a restricted area in countries with energy monopolies.
- Allow peer-to-peer heat and power exchanges between industrial prosumers in the eco-park.
- Test different power purchase mechanisms between industrial players, third party power producers and the grid.

Test promising technologies, contracts and integration schemes such as:

- Mutualised risk coverage between industrial players in the same eco-park
- Blockchain technology for low cost energy transactions
- Standard contracts for heat transactions
- Advanced integration schemes between power, heat and waste streams and among several industrial sites in the same eco-park

Use the eco-park as a showcase

- The managing entity should enhance the experience through publications targeting the appropriate audience: environmental agencies, inter-professional industrial associations, etc.
- The eco-park can become the backbone for a cluster of technical and operational excellence.

Targeted beneficiaries

- All the stakeholders involved in an RE integration project
- Policy makers

Expected impacts

Developing experimental eco-parks will allow policy makers to gain insights on their policies' impact and on tested market mechanisms without jeopardizing the power grid. It will also foster the development of disruptive technologies and ideas that can lead to the creation of a competitive cluster.

Industrial participants will benefit from technical and operational feedback for future projects.

Example

None of the projects analysed have benefitted from this type of innovative and experimental approach.

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The **International Energy Agency's RE Technology Deployment Technology Collaboration Programme (IEA RETD TCP)** provides a platform for enhancing international cooperation on policies, measures and market instruments to accelerate the global deployment of RE technologies.

IEA RETD TCP aims to empower policy makers and energy market actors to make informed decisions by: (1) providing innovative policy options; (2) disseminating best practices related to policy measures and market instruments to increase deployment of RE, and (3) increasing awareness of the short-, medium- and long-term impacts of RE action and inaction.

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