DECARB EUROPE

Connecting technologies for a cleaner future

DECAR EUROPE

Connecting technologies for a cleaner future

2018

The goal of DecarbEurope is to engage decision-makers in policy and industry with solutions that can, in a cost-effective manner, decarbonize Europe at the scale and speed that is needed to achieve our climate goals. As an ecosystem of 20 sectors—and growing—the initiative connects technologies, policies, and markets in a cross-sector roadmap towards a low-carbon economy. Partners of DecarbEurope commit themselves to the common values that are driving this transition: decarbonization, cost-effectiveness, circularity, sector-coupling, and consumer engagement.

DECARB EUROPE

Connecting technologies for a cleaner future

#DecarbEurope

www.decarbeurope.org

Leonardo ENERGY

European Copper Institute
Copper Alliance

Technology Partners

AEBIOM
EUROPEAN BIOMASS ASSOCIATION

APPLiA
Home Appliance Europe

EASE
European Association for Storage of Energy

EUROHEAT & POWER

Hydrogen Europe

REScoop.EU

smartEn
Smart Energy Europe

TRANSPORT & ENVIRONMENT

Strategic Media Partners

REVOLVE

ENERGY EFFICIENCY in Industrial Processes

Adnan Z. Amin

Director General of the International Renewable Energy Agency

For more than two decades, Europe has been a front-runner in renewable energy deployment. Renewable energy moved from the fringes to the mainstream globally, largely thanks to Europe's role as a first mover in developing renewable energy technologies and markets. As a result, we are witnessing a truly global transformation of the energy system characterized by fundamental shifts in the way we generate, distribute and consume energy, with renewables at the heart of this change.

Today, the European Union (EU) finds itself at a critical juncture. Its policy-makers face key decisions that will not only shape the future of energy across Europe for decades, but that also carry profound long-term economic and social implications. To make informed decisions, there must be an evidence-based dialogue on the opportunities and challenges associated with the available paths. To this end, IRENA is pleased to have collaborated with the European Commission in the development of a Renewable Energy Roadmap study (REmap) that provides a cost-effective roadmap towards European decarbonization.

The report finds that the EU can increase the share of renewable energy in its energy mix to 34% by 2030 – double the share in 2016 – with a net positive economic impact. Our findings also highlight that achieving higher shares of renewable energy is possible with today's technology, and that doing so would trigger additional investments of around €368 billion until 2030 – equal to an average annual contribution of 0.3% of Europe's overall GDP. There would also be a significant rise in employment across the sector in Europe, up from 1.2 million jobs today.

Europe can increase the share of renewable energy in its energy mix to 34% by 2030

Raising the share of renewable energy to 34% would also reduce emissions by a further 15% by 2030 – an amount equivalent to Italy's total emissions. These reductions would bring the EU in line with its goal to reduce emissions by 40% compared to 1990 levels and set it on a positive trajectory towards longer-term decarbonization. The increase would result in savings of between €44-113 billion per year by 2030, when accounting for savings related to the cost of energy and avoided environmental and health costs.

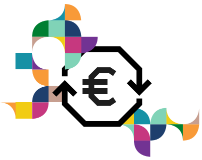
Much has changed since 2014, when the EU's current target of at least 27% renewable energy was set. Remarkable cost reductions over the last few years now make many forms of renewable technology competitive with conventional forms of power generation in much of the world. In fact, the average cost of utility-scale solar PV and onshore wind has fallen by 73% and 23% respectively since 2010, making renewables increasingly viable at scale without subsidies. And recent auction results for offshore wind, which has tremendous potential in Europe, suggest it could play an increasingly significant role in Europe's future energy mix. Cost reductions are expected to continue in the decade ahead.

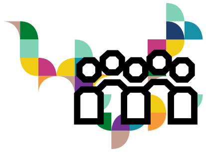
In terms of renewable energy power generation, nearly a quarter of global renewable energy capacity is in Europe, having added 24 GW of new renewables in 2017 and its share of renewables in power generation outpaces the global average. Yet the integration of renewable energy and renewable electrification into end use sectors such as transport, heating and cooling needs to be accelerated as we enter a new phase of low-carbon economic growth.

With an ambitious and achievable new renewable energy strategy, the EU can deliver market certainty to investors and developers, strengthen economic activity, grow jobs, improve health and put the EU on a stronger decarbonization pathway in line with its climate objectives. Indeed, turning to renewables is not simply an environmentally conscious decision, it is now – overwhelmingly – a smart economic one.

IRENA
International Renewable Energy Agency

CONTENTS





Bernard Respaut
Chief Executive of the
European Copper Institute

DECARBONIZING EUROPE

The language surrounding climate change can be strong. We need to fight climate change. It can be considered as a global threat. It drives species to extinction. Decarbonizing our economy has become a defining challenge of our generation.

At the European Copper Institute, contributing to the energy transition and decarbonization is among our top priorities. The question then becomes how it can be done in practice? Do we have what it takes to build a carbon-free Europe?

At first glance, the answer is a resounding yes. We have class A appliances, bioenergy, building automation, co-generation, demand response, district heating, electric motors, electrical furnaces, electric buses, ferries, trucks and vehicles, energy cooperatives, energy finance, energy management, heat pumps, hydrogen, solar heat, solar power and wind energy – in other words: the DecarbEurope solutions are at our disposal.

However, time is pressing to put the measures in place that will lead Europe towards its ambition of a fully sustainable economy by 2050 with 80-95% less emissions compared to the 1990 levels.

In addition to the need for speed, we have the daunting scale of the challenge. For starters, we need to decarbonize homes and buildings, for which there are plenty of solutions, but we can no longer use natural renovation rates. Industry, including our own, poses its own challenges because of its sheer volume of energy use and the process materials it needs. On energy supply, the European electricity sector has committed to full decarbonization well before 2050. In parallel to electrification, we have hydrogen, green gas and bioenergy. Finally, transport may represent the biggest decarbonization challenge of all, at least according to DecarbEurope partner Transport & Environment.

To build a sustainable Europe, citizens, cities, business, industry, regional and national governments and international organizations need to work together on multi-level governance. We need a smart combination of top-down incentives with a lot of bottom-up implementation. Intermediate actors, such as business, industry and cities are pivotal to make the bridge between political ambitions and citizen interests.

To organize these many actors, DecarbEurope adopted the following values to coordinate daily decisions made by end-users, manufacturers, regulators and other stakeholders:

• **Decarbonization:** we pursue solutions that provide a sizeable contribution and that are scalable to provide rapid and deep carbon savings. For this, we need policy stability, a long-term perspective and strict planning to achieve energy & climate objectives by 2050.

• **Cost-effectiveness:** we want solutions that are cost-effective, that compete in the market on merit. Minimum life-cycle costing should guide policy design. All cost-effective measures need to be pursued.

• **Circularity:** in the transition from a fossil fuel-based to a more capital-intensive energy system, we want products and systems to be durable, easy to repair and highly recyclable.

• **Sector coupling:** we believe in integrated energy systems and the use of digital solutions. We need a system approach combining renewables and energy efficiency with energy flexibility.

• **Consumer engagement:** we believe in full access to energy markets, green power purchase agreements (PPAs), guarantees of origin, long-term agreements and peer-to-peer energy transactions.

The DecarbEurope initiative now includes 20 sectors. As the convenor of the project, the European Copper Institute is encouraged and pleased to see how far we have already come: we have over a million electric vehicles on the road and over 10 million heat pumps installed. In 2016, Europe passed the 100 GW benchmark for solar photovoltaics, while 160 GW of wind power now supplies over 10% of the EU's electricity demand. These are just a few examples of the many encouraging developments that are part of the DecarbEurope ecosystem with solutions in which copper is a common conductor of efficiency and functionality.

We have the solutions at hand. Together, we will drive them even further this year.

Cu European Copper Institute Copper Alliance

The increase of energy efficiency standards in households plays a significant role in the reduction of carbon emissions.

Source: ALDECA Studio

Appliances

The standards of our modern life would have been impossible without the presence of home appliances. The warmth of our households, the conservation and the cooking of our food, our house cleaning are the significant advantages that have been provided through the revolution of home appliances.

Modern life would be impossible without the presence of home appliances.

Despite the significant value they offer to our lives, the amount of energy home appliances use has been steadily decreasing.

Since its introduction, the energy labelling brought new, more energy efficient products in the market. Nowadays, manufacturers have been improving the energy efficiency of home appliances even more than the current most energy efficient class, A+++. Energy efficiency through less energy consumption has a positive impact on the reduction of carbon emissions coming from electricity generation.

Connectivity will bring a series of positive changes in the optimization of energy consumption as well. Smart, interconnected and interoperable appliances provide users the ability to control the amount and the time in which they consume energy.

Industry's innovations in Heating Ventilation and Air Conditioning (HVAC) technologies have the potential to further reduce energy consumption by 30%-45%. Adapted to the energy needs of buildings, modern and automated HVAC equipment can contribute to the reduction of energy consumption, and therefore carbon emissions, making buildings much more sustainable.

The home appliance industry has been focusing its attention on energy efficiency, investing annually €1.4 billion in research and development activities. With the right policy framework that enables innovation, European manufacturers will be providing all the solutions for the decarbonization of Europe.

APPLIANCES

1. Over **11,000** patents are deposited by the appliance sector every year. This is almost **10%** of all patents deposited by industry.

2. The EU appliances industry invests **€1.4 billion** annually in R&D.

3. The combined installed stock of 9 appliance types is estimated to be **1.7 billion** units across Europe.

6. Recycling and recovery rates of large and small home appliances exceeded the targets established by the WEEE Directive.

7. The appliance industry creates nearly **1 million** jobs in Europe.

8. Today's refrigerators are **70%** more efficient than those used in the 1990s when the energy label was introduced.

Energy efficient appliances can contribute to the reduction of CO_2 emissions even by 50%.

4. The recycling rate of small and large home appliances amounts to **80%**.

5. Smart appliances help manage the variability of renewable energies. They can, for example, store energy when there is excess supply and get off the grid during peak load.

9. Dishwashers are much more efficient in terms of water and energy use than hand washing.

10. Within 3 years, the number of washing machines in energy class A+++ tripled.

Sources: CECED

1. **Increase the replacement of heating and cooling systems.**
The facilitation of modern, efficient, heating and cooling systems can make a decisive contribution to reducing energy consumption and environmental impact without sacrificing consumer comfort.

2. **Promote innovation in home appliance technologies.**
Sustainability starts at home. In this regard, there is a significant potential for home appliances to play a role in the demands of decarbonized energy systems. In doing so, innovation should not only be enabled, but encouraged and promoted in relevant policies.

3. **Increase connectivity on home appliances.**
Connectivity among home appliances improves energy efficiency of the energy distribution system; it contributes to using energy when it is available minimizes their environmental impact.

4. **Remove market barriers.**
Policies need to reduce the market distortion that comes as a result of over-regulation. At the same time, effective market surveillance should secure a levelplaying field.

5. **Correct valorization of innovative solutions in performance calculations.**
Industry is investing heavily in innovative solutions achieving significant energy savings. EU Member State should integrate the benefits of innovative technologies in building performance calculations by showing an increased energy performance of the building and as such valorizing the end-user’s investment.

Paolo Falcioni

Director General of Home Appliance Europe

How do home appliances contribute to the energy transition?

Home appliances have been playing an important role in the decarbonization of Europe. The sector has been contributing to the energy transition, by providing higher energy efficient products, designing and manufacturing more and more energy-efficient and environmentally-friendly products that can cut the resource use and save energy. Let's take the example of energy labelling. Through innovative industry developments, products on sale today are even better than A+++. As a result, consumers have the opportunity to choose products even more efficient than the best category provided by the legislation.

How can connectivity play a role in the decarbonization of houses?

How much energy do we waste when there is sunshine in Brussels and we cannot turn on the washing machines? In this context, connected appliances have the potential to bring a revolution in our households, providing us with more control over the energy consumption of our home appliances. Smart connected devices are able to assess their energy demand and use it at the right time. Cooling and heating systems are more sustainable providing us the right temperature at the proper time, in sync with the renewable energy generation.

According to studies (McKinsey, 2015), connectivity is estimated to save more than 20% energy in our houses and in our workplaces in the next decade, while more than half households will be having smart appliances in 2040 (Eurostat). Taking these predictions into account, our industry is engaged in continuing the research and development in the connectivity and interoperability of home appliances, which will be major contributors to sustainable and energy-efficient households.

What are the main challenges for the home appliance sector?

While new frontiers such as pervasive Internet of Things and Artificial Intelligence will help boost the developments of smart appliances, there are important issues like cybersecurity, e-privacy and safety that we are already taking into serious consideration. We are committed to have only safe smart appliances on the market. In this regard, we are already collaborating with policymakers and sharing our knowledge to build the best regulations that will further protect consumers and will enable a fair and transparent market functioning.

More than half households will have smart appliances in 2040.

How innovation increases energy efficiency?

Instead of the traditional on-off systems, the HVAC sector completely shifted to a new and innovative inverter driver technology. This means that the frequency of the compressor will be modulated when the maximum capacity of the technology is not required. The reduced compressor frequency, or part load operation, results in a higher energy efficiency (up to 30-45% energy savings). The delivered capacities are exactly matching with the actual demand of the building and increases the life cycle of the compressor/equipment. In short, better comfort, less energy consumption, more durable products.

APPLiA Home Appliance Europe

THE BLUE MOVEMENT
Netherlands

A new economic model in the use of washing machines can have a real impact on energy and water savings for every household and as a consequence, the reduction of carbon emissions. As a part of its Blue Movement strategy, Bosch gives the opportunity for the consumers to obtain the most energy-efficient washing machine (A+++) at their houses, just by paying a monthly fee.

Apart from their contribution to energy efficiency, this and similar initiatives have a positive outcome in the Circular Economy. Products are reused and as a result, their environmental footprint is being reduced.

OPTIMIZING ENERGY
Italy

As part of its goal to reduce carbon emissions by 50% by 2020, the Electrolux has been working intensely to reduce its environmental footprint by shifting to renewables and optimizing the use of energy and other resources throughout its operations, as well as improving the energy efficiency of appliances.

In manufacturing, the average level of carbon emissions per unit produced has decreased by 25% since 2015 and the company has set the goal that half of Electrolux energy will come from renewable sources by the year 2020.

GREENER PRODUCTION
Romania

With its corporate vision "Respects the Globe, Respected Globally", Arçelik nurtures its global growth story with greener production, better utilization of natural resources and more sustainable business processes. Arçelik actualizes pioneering practices in combating climate change and conducts studies to reduce its carbon footprint in accordance with both its sustainability strategies and the responsibilities of being a global player.

ISO 50001 certificated plant of Arçelik Romania factory, makes tremendous effort to minimize its carbon footprint and consistently reduce the energy consumption arising from its production processes. Thanks to 106 energy efficiency projects realized within the scope of Arçelik Romania operations, energy consumption per unit product has decreased by 44% since 2012. Arçelik's goal is to become completely carbon-neutral in manufacturing by 2025.

(Left) A washing machine. Source: stevepb
(Middle) Renewable facilities, Vallenoncello, Italy. Source: Electrolux
(Right) Arçelik factory in Ulmi, Romania. Source: Cenk

Volvo 7900 Electric Concept Bus.
Source: Simon Smiler

Passenger Transport

Buses are the backbone of public transportation systems and play a key role in our cities: in 2015, buses and coaches traveled 543.5 billion kilometers across European roads. Since most cities face air quality problems, electric buses offer realistic solutions for European cities. This is especially true since the total cost of ownership (TCO) of electric buses will be better than traditional combustion engine vehicle ownership. To be part of this transition to cleaner public transport, Europe needs to catch up: the total electric bus stock in Europe was estimated in 2017 to be around 2,200 while 160,000 electric buses were sold in China that same year.

30% of Europeans live in cities exposed to air pollutant levels that exceed EU air quality standards.

Electric buses reduce greenhouse gas emissions and lead to a drop in local air pollution, which is a major human health concern (up to 30% of Europeans living in cities exposed to air pollutant levels exceeding EU air quality standards). According to the European Environment Agency, close to 400,000 premature deaths occur in Europe every year due to air pollution. Given that conventionally-fueled road transport is the largest source of NOx (46% of total EU emissions) and particulate matter emissions, it is crucial to clean-up buses along with other vehicles. In addition to reducing local air pollution, electric buses offer more silent operations in cities than conventional buses, bringing additional health benefits to citizens.

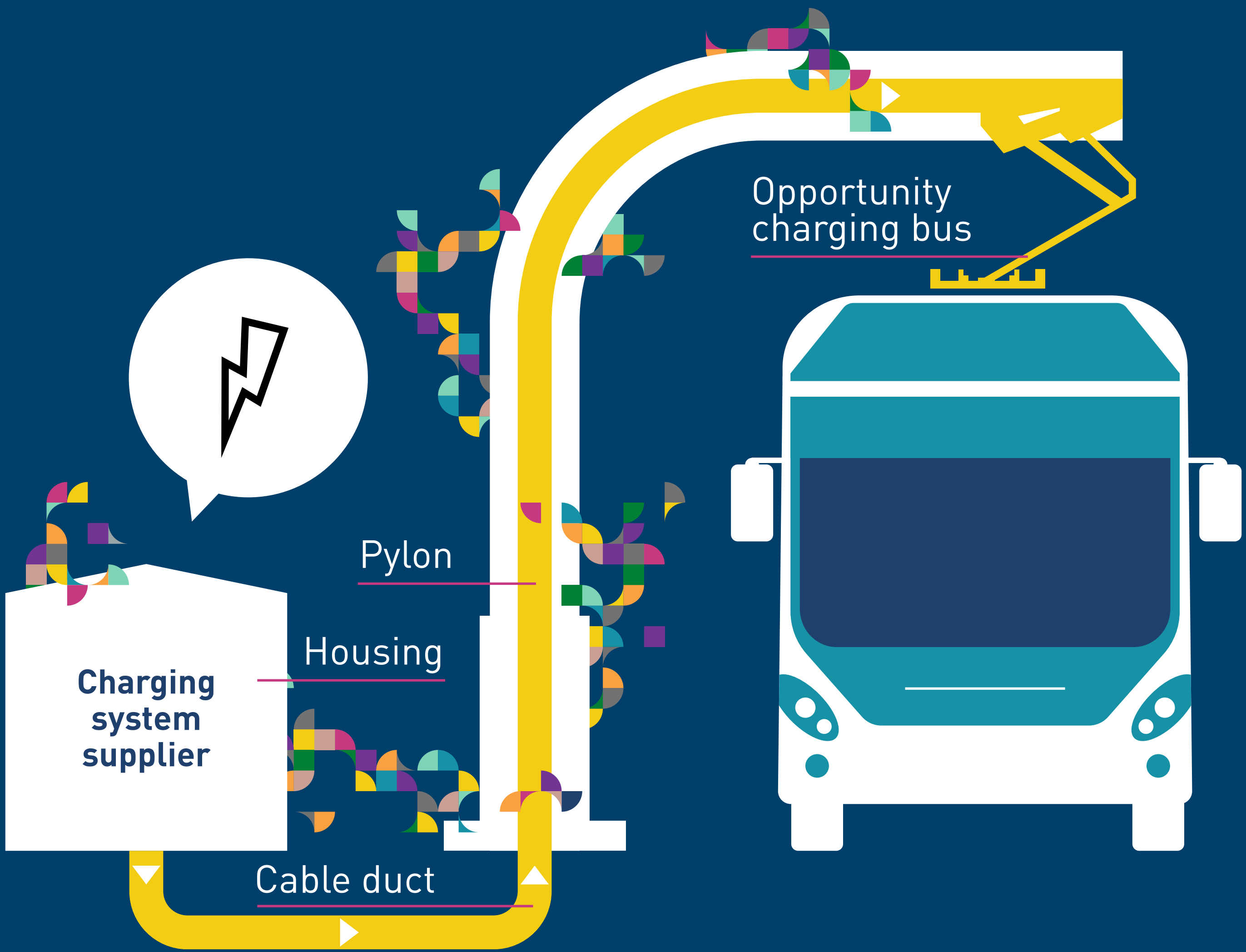
There are three main types of electric buses:

1) Full battery electric buses rely on an electric powertrain system powered solely by electrical energy stored in battery packs. These buses are classified in two categories depending on their charging systems: a) overnight charging buses with batteries that are large enough (typically more than 200 kWh) to ensure continuous daily operations and charge slowly during the night at the depot; and b) opportunity charging buses which charge at higher power (up to 600 kW) either at the bus stops or the bus terminals usually through a pantograph (from 30 seconds to about 10 minutes depending on the charging power and the size of the battery).

2) Fuel cell electric buses are buses that include fuel cells and a battery. Fuel cells provide direct electric traction or generate the energy needed to keep the batteries charged.

3) Trolley buses are electric buses powered by two overhead wires. Battery packs can be fitted to these buses, thus reducing the need to build the required infrastructure in cities.

PASSENGER TRANSPORT



1. In the EU, **55.7%** of all public transport journeys (32.1 billion passenger journeys per year) are made by urban and sub-urban buses.

2. In 2017, **386,000** electric buses were in circulation worldwide. According to Bloomberg, this number is expected to triple by 2025.

3. Electric buses emit less noise than conventional buses and can be driven smoothly, which makes them very popular for drivers and users.

6. Already in 2013, in the context of UITP's 3ibs project, **40%** of public transport authorities and operators asked were eager to switch to electric buses.

7. The zero-emission bus market is expected to reach **42%** in 2025 and **61%** by 2030 according to a forecast by UITP-based on a wide panel of bus industries.

8. If Oslo's bus fleet were to be converted to fully electric, the municipality will save **€80 million** over 10 years, compared to today diesel buses.

European electric bus production will reach full maturity by 2018-2020 meaning that demand and supply for e-buses are converging, paving the way for full-scale uptake of electric buses in European cities.

4. The ZeEUS project which tested various electric bus solution over 5 years observed **5.6 million** km travelled by electric buses in Europe (90 cities observed) preventing the emission of more than **3,000** tons of CO_2.

5. Starting in 2025, major EU cities, part of the C40 coalition, will only add zero emission buses to their public transport fleets: London, Paris, Barcelona, Copenhagen, and Milan. The Dutch Government has a similar procurement regulation for all municipalities starting from 2025.

9. There are **893,000** buses in circulation on Europe's roads today – their average age is over 9 years.

10. Schiphol Airport, in the region of Amsterdam, is home to Europe's largest electric bus fleet. Today this fleet is composed of **100** VDL buses (18 meters-long each) that are in operation 24 hours/day. By 2021, **258** electric buses are expected to operate at the airport.

Sources: Transport & Environment

1. **Require 100% of newly publicly procured vehicles to be zero-emission from 2030.**
   This should be reflected in the review of the Clean Vehicles Directive, which aims to drive clean vehicles uptake through public procurements.

2. **Stimulate the electric bus market with a zero-emission vehicles mandate.**
   Bus manufacturers will have to sell a minimum amount of emission-free buses, thus increasing the zero-emission bus offer on the market.

3. **Monitor and report carbon emissions and fuel consumption of buses.**
   Transparent information about the fuel consumption of buses will allow public authorities to make more informed choices based on total cost of ownership, favoring the most efficient technology.

4. **Develop a life cycle assessment methodology to assess the environmental performance of vehicles.**
   Thanks to more comprehensive criteria, going beyond tailpipe emissions and reflecting the environmental impact from a cradle-to-grave perspective would be beneficial.

5. **Promote the use of the green public procurement criteria for transport.**
   Define a set of voluntary criteria public authorities can follow to procure the cleanest buses.

Jeppe Juul

President of the Board of Transport & Environment

How do you see the future of bus operations between now and 2050?

By 2050, buses will be zero emission and will keep playing an essential part in providing reliable public transport on inter-city routes not covered by railways. Automated electric city buses in separate lanes have a good potential for lower cost while increasing travel speed, frequency and capacity. Buses will play a more significant role in city transportation, at the expense of individual car ownership.

How do electric buses contribute to the energy transition?

Changing from diesel fuel to electricity makes it possible to quickly introduce renewable energy in transport. With national and EU-wide targets for renewable energy, the energy used for electric buses will become less and less carbon intensive. Switching from combustion engines to electric engines results in a significant saving of carbon emission and greater energy efficiency.

What should be done to ensure that the EU becomes a leader in electric bus manufacturing?

We need ambitious targets on EU, national and city levels to ensure a rapid development of the home-market. While demand-side stimuli constitute a major driver for electric buses, manufacturers should also be incentivized to supply more electric buses, for instance through a zero and low emission vehicle mandate for buses. In the absence of ambitious targets, there's a risk that most electric buses will be imported.

What do you think is key to encourage public authorities to procure electric buses?

The EU must set ambitious targets in the Clean Vehicles Directive to ensure that most procured buses in 2025 and after are electric or hydrogen. And at the same time, fossil fuels (like concentrated natural gas – CNG) should not be considered sustainable transport alternatives. This is the only way to ensure public procurements are future-proofed and bring actual long-term benefits to cities.

Switching from combustion engines to electric engines results in a significant saving of carbon emissions and provides greater energy efficiency.

What other benefits for cities and citizens can electric buses deliver?

In addition to lower energy consumption, electric buses also contribute to making cities much cleaner. Less noise and air pollution will significantly improve public health and make cities more livable. And thanks to lower total cost of ownership, electric buses will bring long-term financial benefits to public authorities procuring these vehicles.

VDL ELECTRIC BUSES
Netherlands

Since December 2016, 43 18-meter-long VDL electric buses are in operation in Eindhoven, a Dutch city of about 225,000 inhabitants. When these buses reached the 1 million zero-emission kilometers driven in April 2017, it was estimated that NOx emissions were reduced by 4.7 tons and CO_2 emissions by over 1,000 tons. Thanks to their 180 kWh battery, the buses can drive for at least 3 hours. During the day, they are fully recharged in 35 minutes with 270 kW fast chargers while at night, buses can be charged more slowly with 30 kW chargers.

SOLARIS E-BUSES
Poland

Solaris, a Polish bus manufacturer, had a record year in 2017 with more than 2,500 electrified buses (including hybrid electric buses) delivered across Europe, mostly in France, Germany, Norway, Italy, and Lithuania. This comprises all electric, hybrid, and trolley buses. In Poland alone, Solaris sold 48 full electric buses. End of February, the Polish city of Stettin ordered 16 Solaris Urbino hybrid buses, following a bigger order by Warsaw for 130 full electric buses, which will be worth €95 million. These are very promising developments for e-buses, which will be complemented in Poland by a nationwide objective to procure 1,000 electric buses by 2020.

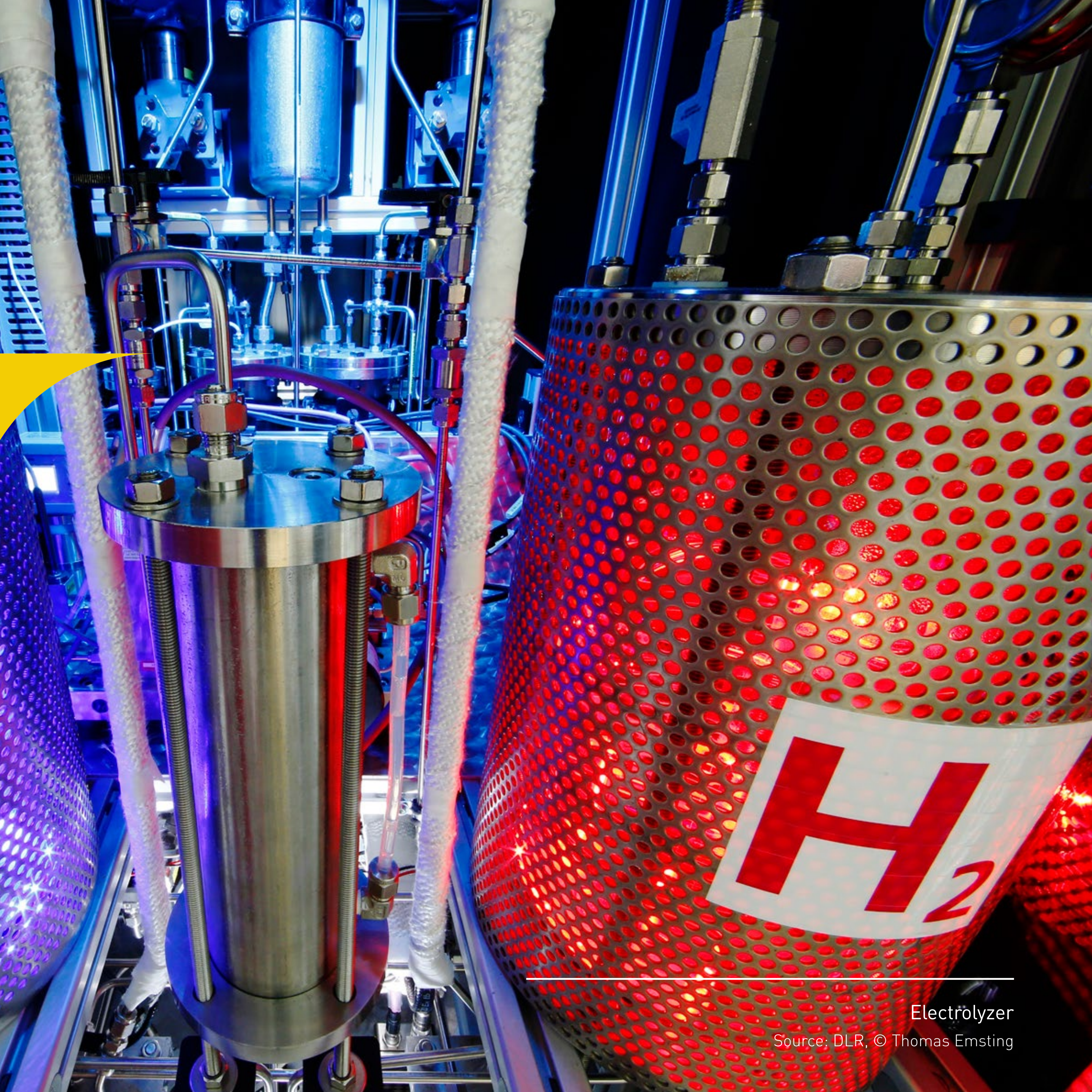
LARGE SCALE E-BUS OPERATION
China

The megacity of Shenzhen, China, has successfully switched 100% of its bus fleet to electric vehicles. In this city of more than 12 million inhabitants, around 16,000 electric buses are now operating. The city therefore reached its goal to move away from diesel engine vehicles in only 6 years. The switch is part of a program to cut air pollution and noise in the city. It is expected to save the equivalent of 345,000 tons of diesel fuel per year and cut 1.35 million tons of carbon dioxide emissions per year.

To support this transition, Shenzhen installed more than 300 bus chargers, allowing any bus to recharge in about two hours. The city also installed 8,000 streetlights equipped with a charging point that both buses and cars can use. Roughly 80% of the buses are provided by Shenzhen based electric automaker and lithium-ion battery manufacturer BYD.

(Left) The Eindhoven Hermes Bravo VDL SLFA E Citea. Source: Rob Dammers
(Middle) Solaris Urbino 8.9 LE electric at bus charging station. Source: Michał Kwaśniak
(Right) Electric vehicle charging station at BYD Headquarters, Ping Shan, Shenzhen, Guangdong, China. Source: Remko Tanis

Hydrogen



Electrolyzer
Source: DLR, © Thomas Emsting

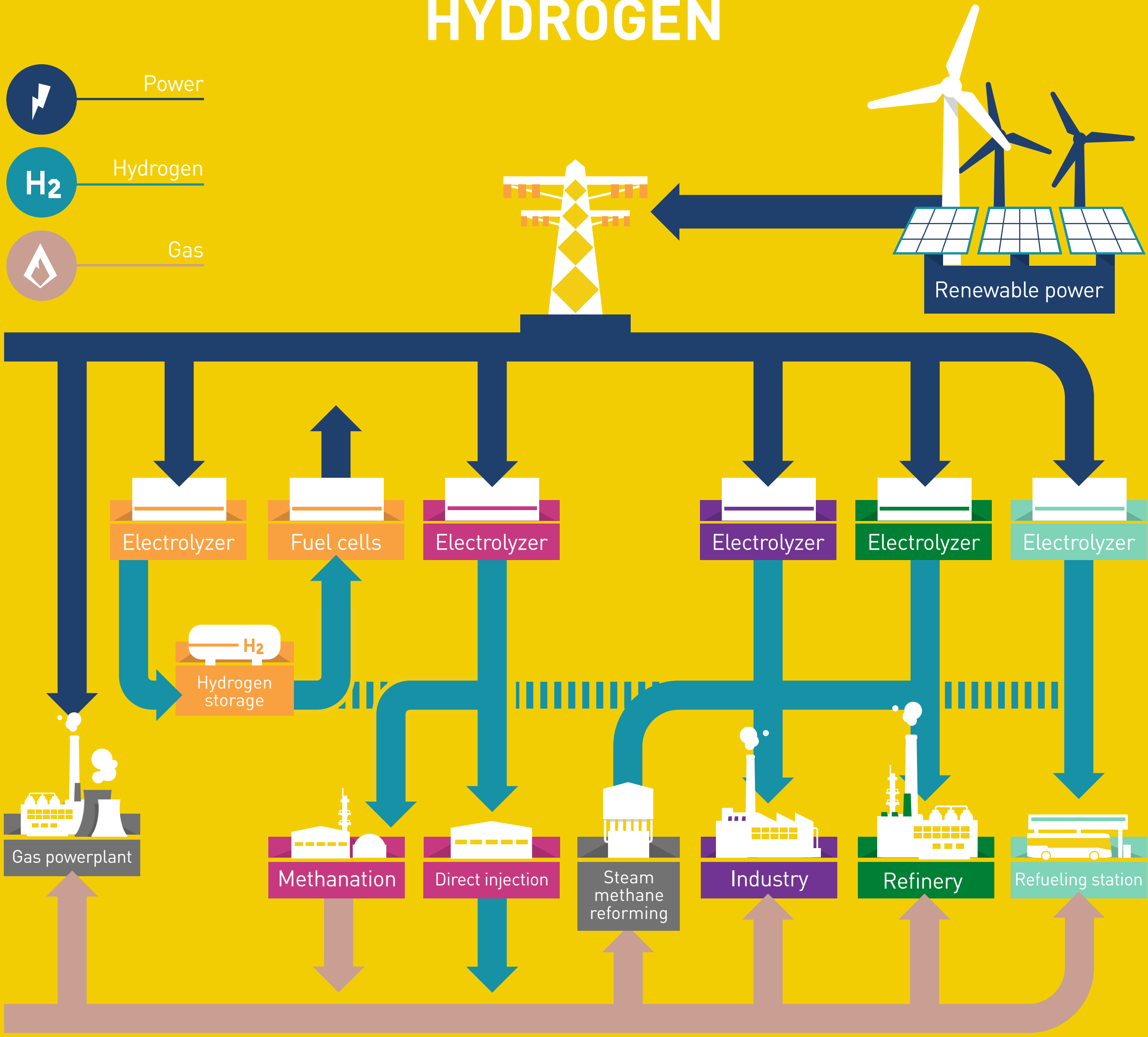
Hydrogen is an energy carrier, a fuel and a raw material. If produced from renewables, it can reduce GHG emissions, strengthen energy independence and mitigate the challenges posed by variability and intermittency of renewable energy systems. Hydrogen is an enabler for sectoral integration as it offers a clean, sustainable, and flexible option to convert renewable electricity into a chemical energy carrier for use in mobility, heat and industrial applications. Therefore, it is a key component of the future of energy systems that will accelerate the transition to a 100% decarbonized system. It also presents opportunities in terms of job creation, technological leadership, and environmental protection for Europe.

The hydrogen economy is already a $100 billion market worldwide.

The hydrogen economy is already a $100 billion market worldwide. Hydrogen is today mainly used for the production of fuels (50% of the market), fertilizers (43%) and various industrial processes (6%) such as the production of glass and iron, as well as for various food products such as margarine. Other uses of hydrogen exist but are still marginal on a global scale: the propulsion of vehicles (cars, buses, trains, boats); the production of electricity and heat for commercial and residential use; renewable energy storage in the form of hydrogen, or the substitution of natural gas with hydrogen in industrial and domestic applications. These uses are all growing.

The ability of hydrogen to access and integrate each sector of the energy system opens the opportunity for deploying renewables to a much greater extent. Power system with relying heavily on renewables can operate throughout long periods of non-consumption-oriented production of renewable energy by feeding hydrogen technologies into one or more energy sinks (for example in gas grids, storage tanks of hydrogen refuelling stations, and salt caverns). Stored hydrogen can be used on various timescales for satisfying demands for heat, transport, power or industry, thus achieving high utilization and absorption of energy. Whereas electricity derived from renewables provides the power sector with a profound decarbonization pathway, the heat and mobility sectors as well as the industry do not yet have decarbonization pathways of equivalent significance. The versatility of hydrogen enables these sectors to be integrated, deeply decarbonized thus contributing to Europe's energy transition.

HYDROGEN


Power
Hydrogen
Gas
Renewable power
Electrolyzer
Fuel cells
Electrolyzer
Electrolyzer
Electrolyzer
Electrolyzer
Hydrogen storage
Gas powerplant
Methanation
Direct injection
Steam methane reforming
Industry
Refinery
Refueling station

1. Hydrogen was the first element in the universe created after the Big Bang and is the most common substance (**75%**) and the richest energy source for stars.

2. Unlike electricity, hydrogen can be stored in large amounts for extended periods.

6. Electrolysis from surplus renewable power is seen as offering huge potential for the integration of intermittent renewable energy into the energy system.

7. Hydrogen fuel cell systems are suitable for virtually all means of transport.

Many of the opportunities offered by hydrogen have not been exploited, particularly because of regulatory barriers.

3. Hydrogen enables the deployment of renewables by converting and storing more than **500** TWh of otherwise curtailed electricity.

4. By 2030, **250-300** TWh of surplus renewable electricity could be stored in the form of hydrogen and more than **200** TWh could be generated from hydrogen in large power plants to accompany the transition to a renewable energy system.

5. Hydrogen has 7 major roles in the energy transformation: **1.** enabling large scale renewable energy integration, **2.** distributing energy across sectors and regions, **3.** acting as a buffer to increase energy system resilience, **4.** decarbonizing transport, **5.** decarbonizing industrial energy use, **6.** helping to decarbonize building heat and power and **7.** providing clean feedstock for industry.

8. By 2030, **10-15 million** tons of chemicals could be produced from such renewable feedstock. In the iron and steel industry, hydrogen can be used to reduce iron ore to iron.

9. Fuel cells are the leading conversion technology of hydrogen use for energy purposes. Fuel cells are used increasingly as alternatives to generators and rechargeable batteries and as a back-up power supply in the form of emergency generator sets or interruptible power supplies.

10. Hydrogen could account for almost **1/5** of total final energy consumed by 2050. This would reduce annual CO_2 emissions by roughly 6 gigatons compared to today's technologies.

Sources: Hydrogen Council, Wuppertal Institute/Shell, Chemicool

1. Level playing field between electricity and hydrogen.
The complementarity of hydrogen and electricity in decarbonizing transport must be acknowledged within the new RED. Article 25 must leave both technologies able to harness the full potential of integrating renewables through various schemes such as long-term power purchase agreements, guarantees of origin, in accordance with providing energy storage ancillary services for managing renewables in electricity grids and in direct combination with renewables.

2. Enable daster deployment of Zero Emission Vehicles (ZEV).
To achieve Europe's climate and energy goals, the swift decarbonization of the transport sector is necessary. The need for the rapid deployment of tailpipe ZEVs should be encouraged. Public authorities and private companies providing a public service are the ideal first-movers to deploy zero-emission solutions as the higher utilization rate of their fleets will enable the efficient usage of alternative infrastructures such as Hydrogen Refuelling Stations.

3. Legislation needs to harmonize fragmented regulation to introduce hydrogen into the natural gas network.
Hydrogen and hydrogen admixtures can be used as an alternative to natural gas for space heating, water heating and gas cooking thus making use of the large available infrastructure assets. Hydrogen can make a major contribution to decarbonizing the heating sector and decreasing our dependency on natural gas imports. Hydrogen must be acknowledged as a value-adding component for the energy infrastructure; and a remuneration mechanism for market players must be ensured.

4. Sectoral Integration via hydrogen needs to be recognized.
Hydrogen, as an energy carrier, can enable the decarbonization of various sectors, whatever the medium utilised (gas grid, storage tanks, etc.). This sectorial integration ability must be reflected through a European cross-sector hydrogen guarantees of origin certification scheme. Furthermore, the recognition of a premium value for green hydrogen for specific applications is also needed.

5. Develop financial engineering for next generation technologies and market activation.
To realise its potential hydrogen requires coordinated actions at the European level to tackle the remaining challenges for the sector to fulfil its promises. While Fuel Cell Hydrogen (FCH) technologies are very close to commercialization, there is still a cost gap with conventional technologies, and additional improvements in technology readiness must be further pursued. There is a need to further fund, in a coordinated manner, R&D and FCH technologies and the widespread deployment of hydrogen refuelling infrastructure across the EU.

Valerie Bouillon-Delporte

President of
Hydrogen Europe

Professor Capros, through the PRIMES model, states that using high amounts of storing capacity through hydrogen as an energy carrier could render this decarbonization economically affordable. Additionally, hydrogen helps integrate renewables further and facilitates the decarbonization of hard-to-electrify sectors, such as the steel industry. Hydrogen is an element *sine qua non* of the energy transition. **Hydrogen enables the electrification and decarbonization of all major sectors in the economy, while supporting the sector integration needed for the energy system transition.** In addition, it holds great potential to place Europe at the forefront of energy innovation technologies, helping cities improve air quality and creating new high-skill jobs.

Hydrogen is an element *sine qua non* of the energy transition.

How can hydrogen support in reaching the goal of a zero-emission society and help Europe accelerate the energy transition?

A deep decarbonization of the energy system is strongly facilitated by the integration of different energy sectors and specifically by linking power and gas infrastructures.

What is the market potential for hydrogen?

Hydrogen will play a necessary role in integrating large amounts of renewable power in the transport, energy-intensive, and heating and cooling sectors, which are today hard to decarbonize. In other words, hydrogen enables sectoral integration and the sector has very high ambitions to help boost the energy transition. Indeed, the Hydrogen Council[1], made up of 19 core members (of which 12 are Europeans) released their vision to 2050 stipulating that **up to €2.5 trillion annual sales and 30 million jobs globally are expected.** Projections **for Europe** indicate that **5 million vehicles and 13 million households could be using hydrogen by 2030**, while a further 600 kt of hydrogen could be used to provide high-grade heat for industrial uses. In this scenario, hydrogen would be abating 80 Mt of CO_2 and account for an accumulated overall investment of €52 billion and 850,000 new jobs. **It is the conviction of the European companies members of Hydrogen Europe that the hydrogen economy should be led by Europe.**

How is hydrogen placed internationally and what is Europe's position compared to other global actors?

Europe has much to gain by ensuring that its existing skills are promoted and expanded. The current EU supply chain of over 100 SMEs and other large industrial players must be strengthened over the coming years, as otherwise significant investments being made abroad will result in loss of competitiveness. As an example, over the last year China has invested an estimated €1.4 billion, most of it in production lines for hydrogen and fuel cell products. Japan is investing a total of almost €300 million in 2017 alone, and the Australian government has committed €15.6 million in grants and loans to finalize plans and commence construction of a Hydrogen Superhub that will potentially produce 20,000 kilograms of hydrogen daily. In California, FCEV are already a reality with 4,216 cars sold and leased, 21 in operation buses and 32 refilling stations. Against this background, European companies are successfully positioning themselves and exporting technology outside Europe. Considering that Europe recently lost its leadership in solar PV and battery technologies, it cannot lose its chance to lead the hydrogen economy.

What should be the next steps to allow hydrogen to fully deliver?

Achieving European targets for GHG reductions requires decisive policies that drive market entry of zero-emission solutions, with hydrogen and fuel cells being amongst the main ones. For hydrogen to take on its role as an enabler of the energy transition and see a substantial increase in its demand, there is the need to set an appropriate legal and regulatory framework. This is particularly necessary to enable a specific guarantee of origin scheme for hydrogen to emerge. Market participants must also be able to link with renewable energy providers through long-term power purchase agreements.

Hydrogen Europe

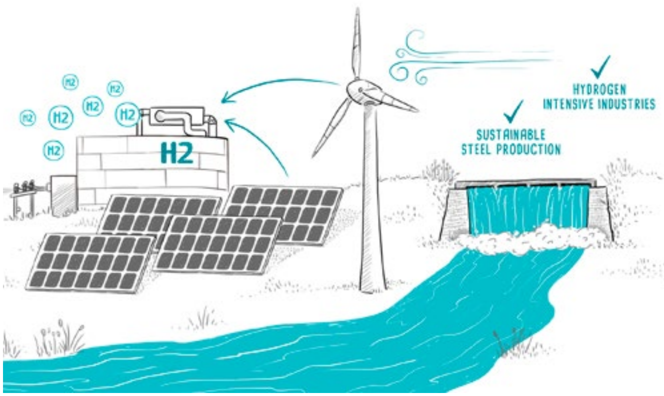
[1]The Hydrogen Council is a global initiative of leading energy, transport and industry companies with a united vision and long-term ambition for hydrogen to foster the energy transition.

FORDERINITIATIVE ENERGIESPEICHER
Germany

The energy transition requires a prompt advancement of environmentally-friendly technologies and processes to convert and store energy. In this context, the "Power-to-Gas" process will play a significant role. The Energie Park Mainz project stores wind and solar energy by converting it – via electrolysis – to hydrogen or methane. This energy park is the result of cooperation between different partners and has been designed to produce hydrogen using electricity from environmentally-sound sources of energy such as neighboring renewable energies. Around €17 million has been channelled into the project, which is funded by Germany's Federal Ministry for Economic Affairs and Energy within the framework of its "Förderinitiative Energiespeicher" (Energy Storage Funding).

TOWARDS 'GREEN' STEEL
Austria

The goal of H2FUTURE, a project coordinated by the Austrian Energy Utility VERBUND, is to produce green hydrogen for the steel industry. In one of the largest and most modern electrolyzers with proton exchange membrane (PEM) technology, hydrogen for industrial use and for balancing the power reserve market will be produced. The plant will be built and operated on the premises of voestalpine in Linz, and the hydrogen produced will be used directly as a raw material in steel production. Key questions about sectorial integration will be handled as well, such as evaluating potentials and possibilities for using green hydrogen in various process stages of steel production. In addition, the transferability of this technology to other industrial sectors which use hydrogen in their production processes will be investigated. This project is funded by the Fuel Cell Hydrogen 2 Joint Undertaking.



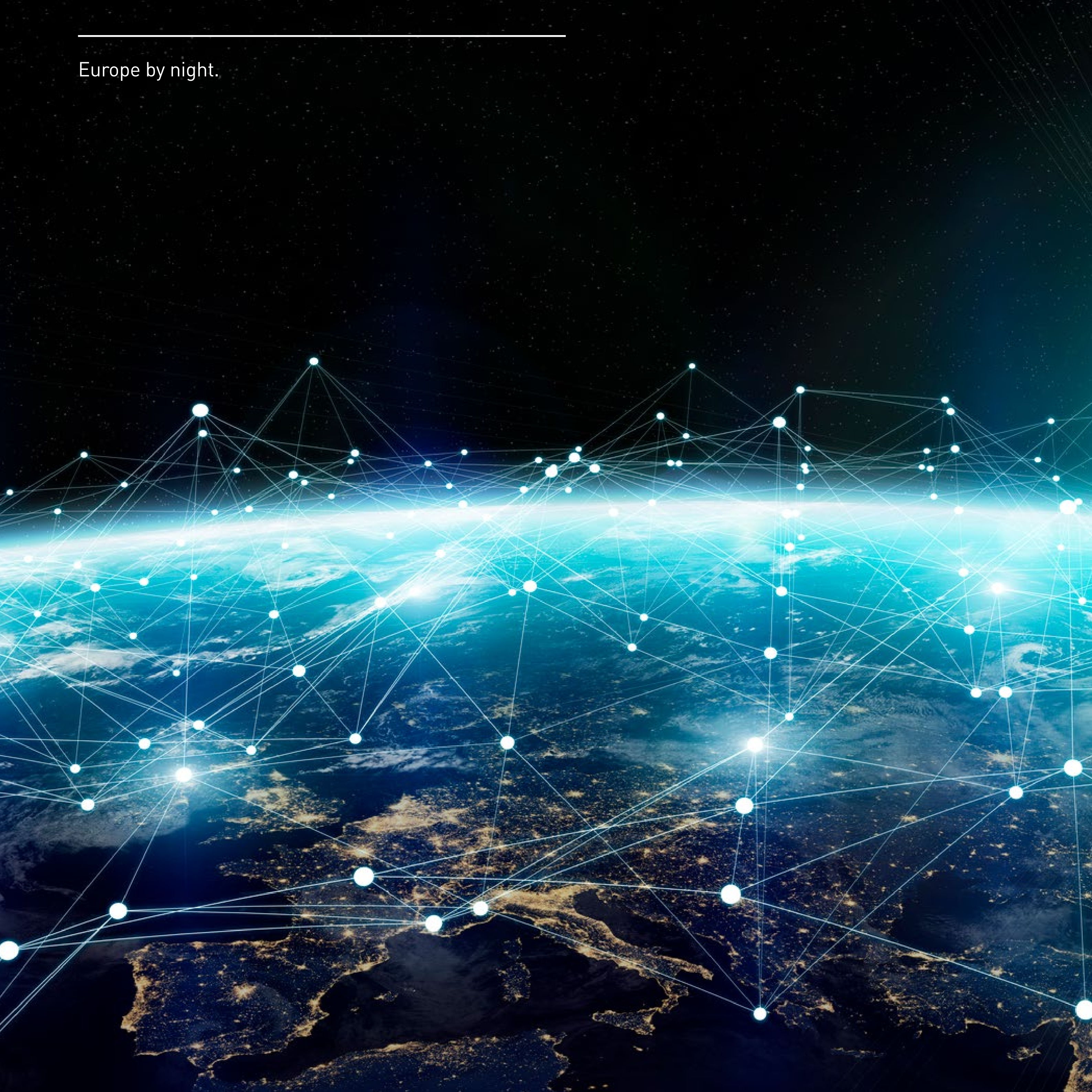
BOOSTING H2 MOBILITY
Across Europe

The JIVE and JIVE2 projects, which started in January 2017 and January 2018, will deploy nearly 300 zero-emission fuel cell buses and associated infrastructure in 22 cities across Europe by early the 2020s – the largest deployment in Europe to date. The buses will be deployed in cities in Denmark, France, Germany, Iceland, Italy, Latvia, Norway, Sweden, The Netherlands and United Kingdom. The main objectives are to:

- Achieve a maximum price €625-650k for a standard fuel cell bus thanks to economies of scale – or lower...
- Foster joint procurement processes, encourage manufacturers to develop and refine their fuel cell bus offers.
- Validate large scale fleets in operation and encourage further uptake, showcasing that fuel cell buses represent a viable alternative for public transport authorities, offering the same operational flexibility as diesel buses but without harmful tailpipe emissions.
- Deploy Europe's largest hydrogen refuelling stations with the capacity to serve fleets in excess of 20 buses and achieve near 100% reliability.
- Demonstrate routes to achieve low cost renewable hydrogen.

JIVE and JIVE2 have received funding from the FCH2-JU under grant agreement numbers 735582 and 779563. This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme, Hydrogen Europe and Hydrogen Europe Research. The project is co-financed by the European Union's Connecting Europe Facility.

(Left) Horizontal pressurized hydrogen tanks.
Source: Anna Durst
(Middle) Overview of sustainable steel production with green hydrogen. Source: H2Future project
(Right) ACC Aberdeen, Scotland H2 bus fleet.
Source: JIVE, ACC 10 hydrogen buses © ACC



Europe by night.

Demand Response

With increasing shares of decentralized and variable renewable energy sources, flexibility becomes even more important for an efficient, stable and cost-effective European energy system. The role of customer-empowerment is also moving to the foreground; thanks to advances in technology development and digitalization, people are starting to take an active role in the energy system: to make savings on their energy bill, to improve comfort or to contribute to the energy transition.

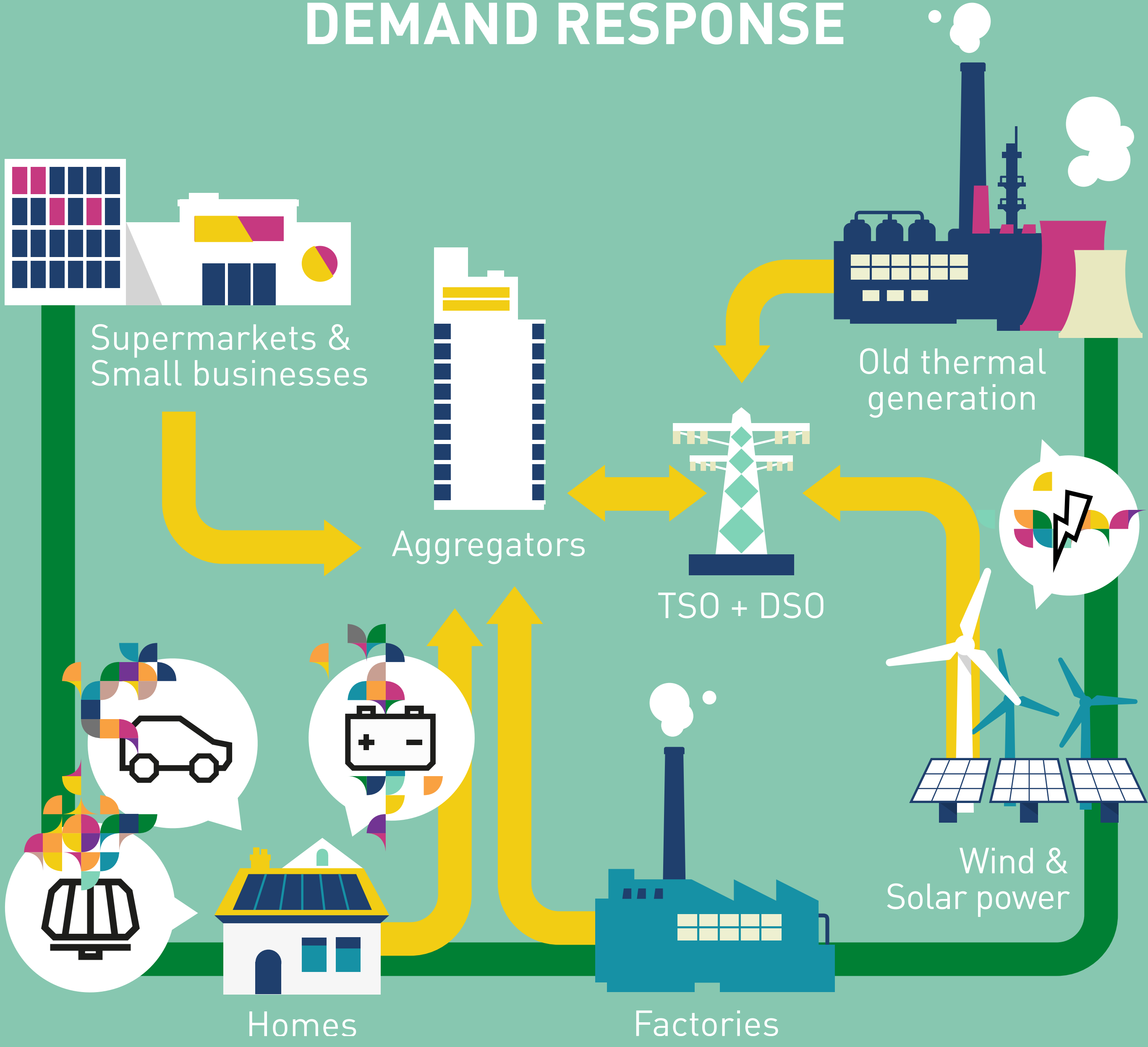
The potential for Demand Response will be 160 GW by 2030, according to the European Commission.

Demand Response is ideally suited to respond to these new challenges. As a key source of flexibility, it can provide effective system services to the electricity grid, replacing more expensive and polluting backup capacities. More than that, it also contributes to competition and effective price formation in a market that is increasingly dominated by renewable energy sources: in times of low renewable energy output, Demand Response contributes to balancing supply and demand and in time of high renewable energy generation, it makes effective use of excess generation, thus improving the business case for renewables. Finally, Demand Response gives consumers the choice to engage in the electricity system by selling their flexibility, usually with the help of an aggregator, or to react directly to dynamic market price signals.

According to a study by the Imperial College / NERA, a high implementation of flexibility would reduce the integration costs for renewable energy sources by £8 billion per year in the UK alone.

According to the European Commission's Impact Assessment, as much as 160 GW of flexible capacity could technically be accessed through Demand Response by 2030, avoiding the need to build new generation capacity. Enabling a dynamic market with strengthened short-term markets, improved use of interconnections, and the inclusion of Demand Response and Distributed Energy Resources can lead to significant annual savings in wholesale supply costs of €50 billion in 2030. This would be expected to reduce the unit generation costs paid by consumer by more than 15%, "the largest part of which is attributable to the participation of demand response in the market".

DEMAND RESPONSE



1. All consumers benefit from demand side flexibility as it can increase the efficiency of the energy system and help bring down electricity costs for all consumers, whether they directly or indirectly participate in the flexible management of their loads.

2. Demand Response is as reliable or even more than generation plants. Aggregation builds up large resources out of many small loads. With only **70-80%** of an aggregator pool bid into the market, performance can be reached of up to **134%** higher than the originally committed capacity.

6. Currently, Europe is making use of only a fraction of its demand response potential, limited only to a few markets and services. The opportunity is enormous, however, with the European Commission placing the potential at **100 GW** today, rising to **160 GW** in 2030.

7. Providing consumers access to market-related dynamic pricing allows them to become relevant participants in the electricity market, profiting from altering their consumption in response to price signals and by reducing their electricity bills.

Demand Response can be more reliable than generation.

3. Explicit demand response – via aggregators or by large consumers directly – can provide dispatchable and reliable capacity, balancing and ancillary services to Transmission and Distribution System Operators, and thus drives competition and market effectiveness, while significantly reducing costs for energy and system services.

4. The introduction of an independent third-party aggregator into a market creates critical momentum around the growth of demand response, attracts private investment, and fosters competition between service providers.

5. Electricity demand-response programs have been proven to have a positive impact on the electricity grid. The UK Committee on Climate Change cites that savings in the operating and investment costs from the application of flexible technologies could reach **£8 billion** yearly in 2030.

8. According to the European Commission's Impact Assessment, demand response will increase by over 50% compared to today and could lead to system benefits of over **€1.2 billion** per year by 2030.

9. Creating a full-fledged smart energy system could reap **€10.6 billion** savings per year for energy users by 2030 a significant part of these savings would be attributed to demand side flexibility.

10. Finland and Estonia are the only countries in Europe to have advanced dynamic price contracts with around 2/3 of suppliers offering them to consumers: consumers can heat their homes at the cheapest hours and therefore are able to reduce their monthly energy bills.

Sources: European Commission, SEDC, UK National Infrastructure Commission, smarten, PJM

1. Guarantee access to all players to all markets.

IIn a new decentralized energy world, now actors and models will appear and evolve. To guarantee consumers can take the best tailored choice for their needs, all players must have access to all markets on equal footing with clearly defined roles and responsibilities. This is key to encourage and empower consumers to participate in the decarbonization of the energy system.

2. Provide the framework for flexible markets.

The regulatory framework needs to provide a clear direction for all players in the new energy system. This comes in the form of defined roles for prosumers and aggregators, and clear boundaries for retailers not to hinder the development of new business models. A new framework will include all the services that a fully decentralized and aggregated demand, storage and generation can offer.

3. Encourage dynamic pricing.

Smart meters will facilitate real-time pricing for end consumers. But smart meters are not enough, we need a wide availability for consumers to choose the dynamic contract best suited for their needs to take real advantage of the capabilities their smart meters offer.

4. Clear taxes and charges structures.

Following the importance of price signals, the design of taxes and charges must not hamper important price signals for effective markets and network management. The same applies for taxing on storage assets. Double taxation of storage must be avoided to enable the technology to unleash its true potential. To this end, dynamic options for levies and taxes should be explored, for example linking taxes to market prices or the point of fuel consumption, rather than final electricity unit.

5. Comprehensive and unified data formats.

Consumers should have complete access at all times to their data in order to be able to choose from the different services offered by the market. Data should be standardized to help correlate customers with their highest demand-side flexibility potential. The most comprehensive data will comprise historical interval data, real-time consumption data, settlement data and any other standing data on classification, tariff classes and networks to which the consumer is connected.

Andreas Flamm

Director of Corporate Functions at Entelios AG

What is Demand Response?

Demand Response is the way for end consumers to participate actively in the energy system and to help maintain a stable grid. They do that by offering the flexibility they have in their consumption, for example, by altering the production patterns in a factory or regulating the heating in a household, in reaction to a signal of the market. The most important participants in the demand side of the energy sector are flexible loads, storage assets and small decentral generation assets.

What are Demand Response aggregators and how do they work on residential level and on a commercial/industrial level?

An aggregator is an energy service company that helps valorise the flexibility of consumers. It identifies flexibilities, bundles them and sells it to the market on behalf of the consumer. Consumers on their side receive a payment for the services they provide to the electricity grid. In the case of Entelios, we work with energy-intensive companies, for example in the paper, aluminium and chemical industry, to identify flexibility potentials in their processes. Then, we pool the various companies' flexibilities and help activate their flexibility through automation equipment, while always allowing consumers to have final control over its consumption. An aggregator offers various services to the grid, ranging from the primary reserve/frequency control markets to all types of ancillary services and capacity markets. There are aggregators that work with industrial and commercial customers, but there are also aggregators that work with households. In this case they create a pool of households, set up with a smart meter bringing together their flexibility while optimizing their consumption and lowering their energy bill.

How will aggregators lead the way in the new decentralized energy system?

Aggregators are the perfect match for the new decentralized and variable energy system. They use technology to enable highly valuable consumer engagement. With a higher percentage of renewable energy in the system, we will need a way to guarantee the stability of the network while harnessing the full potential of these clean technologies. By helping consumers participate and unlock their flexibility potential, aggregators help integrate more renewable energy than would otherwise be possible. Since Demand Response uses existing infrastructure in households or industrial plants, it reduces the need to install new fossil fuel generation facilities.

> Consumers can contribute to the energy transition and earn money from their energy flexibility.

Why should a customer get involved in the energy system?

Consumers can contribute to the energy transition and earn money from their energy flexibility. The time has come for consumers to control how they interact with the electricity system. Not only will this bring a financial incentive, but it will also help interested customers to become an active participant and take control of their consumption patterns. This helps facilitate the integration of more renewable energy, avoiding the need to install more carbon intensive generation.

What are the main challenges for aggregators in Europe?

While the EU is taking big strides in making demand response and aggregation available for all consumers, there are still major barriers for aggregators to really have a European-wide role in the energy markets. Many markets are still closed or designed for the participation of conventional power stations only. Other challenges are in the way grid tariffs are designed – they often incentivise consumers not to provide flexibility to the system. And finally, it is important that third party aggregators are allowed to access all markets without prior agreement of the customers' retailers, which in many cases are direct competitors. This significantly increases competition for demand response services in the market, to the benefit of consumers. For this we need a clear regulatory framework, as it is currently being developed in some Member States and at EU level.

smartEn
Smart Energy Europe

STORAGE INSTEAD OF GENERATION
Belgium

The Ahold Delhaize Group is committed to a green and sustainable future. The company adheres to the UN Sustainable Development Goals and sets targets in accordance to the COP 21 Paris Climate Agreement. Currently, they are undergoing a project in Belgium to substitute 100 diesel generators used as backup capacity in their retail stores with batteries. These batteries guarantee a basic supply in case of blackouts. Delhaize wants to enhance the batteries to work as storage for renewable production, deliver extra power for recharging electrical vehicles and provide peak shaving abilities. Ideally, the battery provides a flexibility resource to the grid, becoming a multi-functional asset.

MONITORING YOUR DAILY CONSUMPTION
Belgium

Smappee provides energy management solutions for homes and businesses, monitoring appliances, batteries, PV and electric vehicles in real-time. The Smappee data allows for durable change in energy use. WWF uses Smappee's solutions to monitor solar power production and improve energy efficiency in fifteen offices around the world, with more offices to come shortly. The Smappee app allows them to visualize the energy use that goes unnoticed in everyday life, like leaving the lights on when exiting a room. WWF transforms this monitoring data into consumption recommendations. This awareness on energy efficiency has allowed some WWF offices to save up to 50% on energy consumption.

ENERGY EFFICIENCY AND MANAGEMENT DONE THE EASY WAY

Switzerland

The tiko Energy Solutions platform brings the power of a virtual power plant (VPP) and an award-winning Smart Home Energy Management system designed to connect Residential and SME assets to the energy market. With its active VPP deployments, tiko is one of the biggest real-time Smart Grids in the world, translating into more than 100 MW under control of the tiko network, and customers' energy savings above 1.6 GWh. tiko's customizable, future-proof technology has the life-expectancy of a physical power plant and enables the delivery of the full spectrum of energy services, including the most sophisticated such as fast frequency response. Avoiding the need to install new fossil fuel generation, tiko targets savings of 165,000 tons of CO_2 by 2020.

(Left) Sustainably renewed supermarket at Keerbergen. Source: Delhaize
(Middle) Smappee Energy Monitor being installed in WWF Myanmar. Source: Smappee
(Right) Manage your home with the Energy App. Source: Tiko

Wall Street at sunset, New York City, USA.

Finance

The energy transition guides us from a fossil-based to a low-carbon economy that will be significantly more capital-intensive. This requires changing the way we plan and manage energy systems. Security of energy supply will be replaced by security of material supply. From integrated resource planning across the energy supply chain, focus will shift towards sectoral integration between electricity, heat and transport. From a supply orientation, we will move towards supply and demand as equivalent pillars of a sustainable energy system. Rather than worrying about environmental emissions, circularity in a capital- and hence material-intensive system requires much more consideration.

Capital expenditure on existing and new projects between 2018-2025 amounts to $3.3 trillion in the Below 2 Degrees Scenario.

From a financial perspective, a capital-intensive sustainable energy system relies on the availability of abundant capital at reasonable rates of return. The return demanded by investors is closely linked to the perceived risk into a project. Such risk can be related to new technologies, policy or markets.

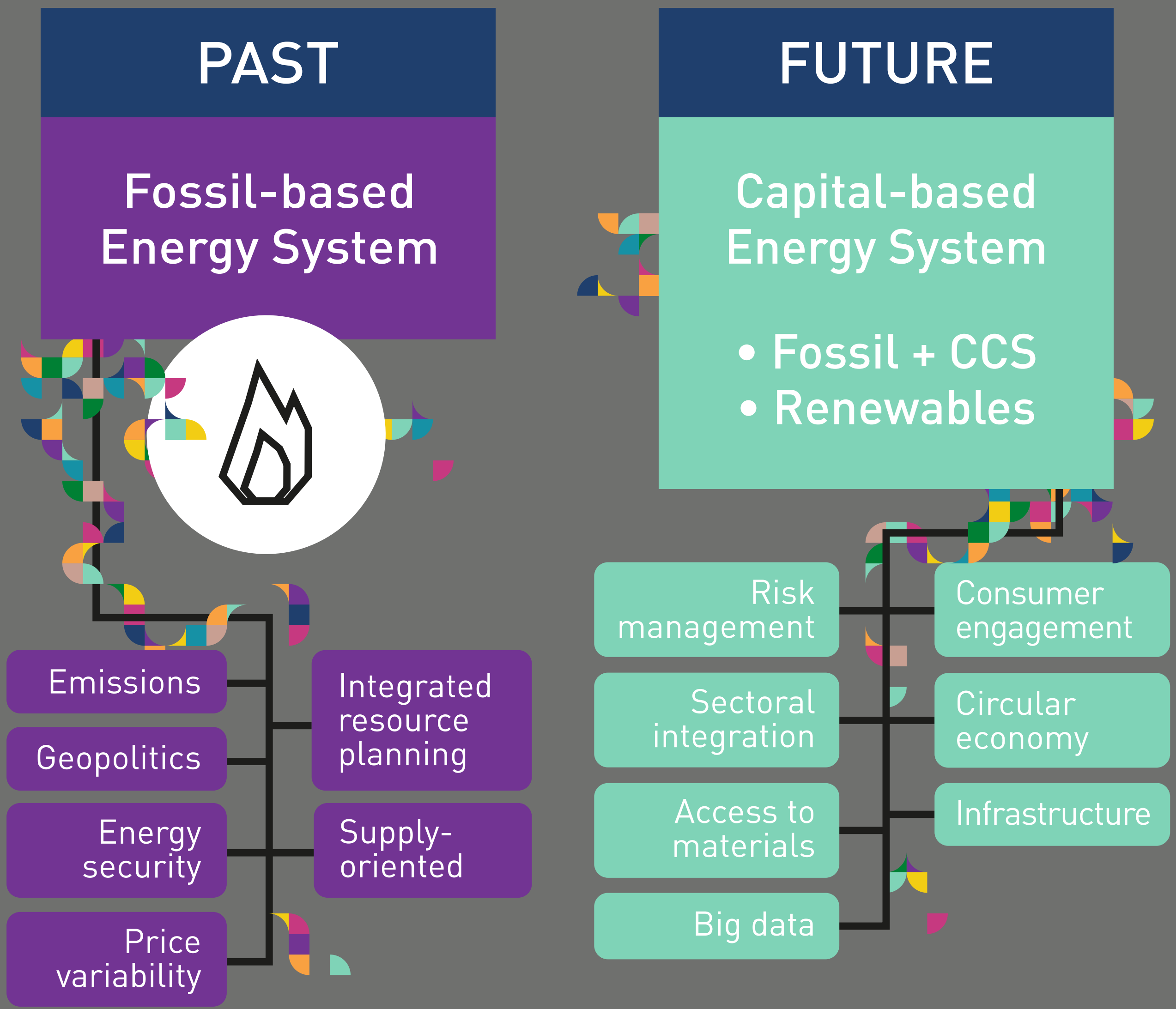
Technology risk occurs when a new technology is being introduced in the energy system. Its performance is still unknown and hence can deviate significantly from expectations. A mitigation strategy could be for a government - through its financial institutions or through a programmatic effort - to co-invest in demonstration to reduce this risk for market actors.

Policy risk happens because investments into energy technologies typically span decades, while the typical mandate for a government is limited to 4-5 years. Therefore, it is imperative to project a long-term future direction for the energy transition that is as clear as possible, despite relative inexperience with emerging technologies and new policy tools.

Finally, market risks arise because the future prices of new energy sources, such as hydrogen, green gas, CO_2 allowances or even renewable electricity are uncertain. Here, the best governments can do is not to distort markets, and to have a support and taxation mechanism in place that is in-line with long-term goals.

Besides the risk framework to facilitate investment by business, industry, municipalities and governments, a very promising trend is citizen participation into community power. In addition to the environmental and economic benefits of the energy transition, this addresses its social dimension by promoting public acceptance while reinforcing local communities. Last but not least, it taps into new streams of capital investment, enabling scaling-up to the trillions of euros that will be required according to IEA or IRENA.

FINANCE


PAST
Fossil-based Energy System
Emissions
Geopolitics
Energy security
Price variability
Integrated resource planning
Supply-oriented
FUTURE
Capital-based Energy System
• Fossil + CCS
• Renewables
Risk management
Sectoral integration
Access to materials
Big data
Consumer engagement
Circular economy
Infrastructure

1. In 2016, investment in energy efficiency in the EU increased by **10%**, at a sectoral level, buildings accounted for **58%** of incremental energy efficiency investment, followed by transport at **26%** and industry **16%**.

2. To achieve their "**66% 2°C**" scenario cumulative, global investment in energy efficiency between 2016 and 2050 will need to reach **$39 trillion**, of which **$30 trillion** would be in the G20 economies.

3. In EEFIG's De-risking Energy Efficiency Platform (DEEP) database, which includes over **7,500** projects, the reported median paybacks are 5 years for buildings and 2 years for industrial projects.

6. To date about **85%**, of all energy efficiency investment has been financed with existing sources of finance or self-financing rather than specific energy efficiency products or programs.

7. The projects in EEFIG's DEEP database suggest that the median avoided cost of energy is 2.5 Eurocents/kWh for buildings and 1.2 Eurocents/ kWh for industry, which is significantly lower than consumers' energy costs.

8. The global market for Energy Performance Contracts, which are most often associated with external financing, was **$24 billion** in 2015 and of this **$2.7 billion** was in Europe.

Around €100 billion/year is needed to meet Europe's 2020 energy efficiency target. (European Commission)

4. Around **€100 billion/year** is needed to meet the EU's 2020 energy efficiency target.

5. To achieve our climate goals, investment will need to grow to **$1 trillion/year** by 2050 and the provision of finance can help overcome some of the barriers to energy efficiency investment. Reducing risks can take place in two ways: **1)** increasing energy efficiency improves the cash flow of clients, thus reducing their risk; **2)** there is the risk of financing assets that become stranded as energy efficiency regulations are tightened.

9. The energy renovation market in the EU is estimated to be worth about **€100 billion/year** and is employing around **880,000** people.

10. Driving investment and job creation is an important driver for investment in energy efficient building renovations around **€40 billion/year** are triggered by policies implemented as a result of Article 7. For each **€1 million/year**, 19 jobs are supported meaning that Article 7 supports almost **800,000** jobs in the building renovation sector alone.

Sources: IEA, EuroAce, Eurima, European Commission, EEFIG, EEFIG Underwriter's Guide,

1. **Long-term policy stability to reduce financial risks.**
   Considering the capital-intensity of the future EU energy system, the cost of energy will be increasingly determined by the cost of capital and hence by risk perceptions of long-term capital investments into the energy system. Governments can reduce risk by projecting a clear and stable policy environment.

2. **Lifecycle costing in public procurement.**
   Governments, government agencies, development banks and national as well as multilateral financial institutions need to continue and expand the consistent, rigorous application of life-cycle costing in their procurement and tendering procedures, using capital hurdle rates that take into account social benefits and the avoidance of externalities.

3. **Enable investments in energy transition.**
   Policy needs to create an attractive investment climate. Innovation funding can reduce the risk of first movers for promising technologies that require large-scale demonstration. For smaller-scale projects, benchmarking tools and bundling of projects help in de-risking. Support is needed for the development of innovative, entrepreneurial business models based on emerging energy technologies such as electro-mobility, heat pumps, building automation systems or storage systems.

4. **Industry competitiveness at international level.**
   Energy and climate costs are likely to increase, certainly during the transition. Safeguard industry competitiveness by ensuring a level-playing field. This can be done for example by introducing strong sustainability considerations in international trade agreements or by providing innovation support for industry that develops the materials, products and services for the energy transition.

5. **Engage consumers into the energy transition.**
   The energy transition will affect final consumers. To improve public acceptance, financial and ownership participation into sustainable energy projects should be facilitated, for example through favourable tax regimes, so that citizens can have a direct stake in the energy transition. Green investment funds, when held to strict standards, can also play an important role.

Steven Fawkes

Founder and Managing Partner, EnergyPro Ltd

What is the potential for investments in energy efficiency?

The IEA Energy Efficiency report showed that global energy efficiency investment in 2016 grew 16% to $231 billion, but it is widely recognized that in order to achieve climate-related targets we need to significantly scale-up the level of investment flowing into energy efficiency. The IEA and IRENA estimate that to achieve their "66% 2oC" scenario the investment required in energy efficiency would need to be ramped up to almost $3 trillion a year in the 2040s – a factor of more than ten increase on current levels. Approximately $1 trillion per annum of this would be in industry.

The critical question is "how do we increase the flow of investment into energy efficiency to the required levels?".

$3 trillion/year in energy efficiency investments will be needed by the 2040s to achieve the "66% 2°C" scenario for taking global climate action.

What are the challenges for energy efficiency investments?

One of the difficulties in discussing investment into energy efficiency is defining exactly what is meant by energy efficiency. Higher levels of efficiency in industry can be brought about by retrofit measures to existing processes, upgrades to process plant incorporating newer technologies, new process plant or new processes. It is important to be clear about these types of investment as they have different motivating factors – often with no explicit consideration of energy efficiency. These factors can include increasing competitiveness, increasing quality, increasing production output, and reducing labour costs.

What are the sources of finance for industrial energy efficiency investments?

When discussing investment into energy efficiency, it is often assumed that the issue is one of external, third party investment, often through the use of energy service contracts such as Energy Performance Contracts. The reality in industry is different because most investment is internally-funded from the company's balance sheet. The most likely source of external finance for an industrial company is its relationship bank.

Whatever the source of capital, the reality is that CFOs will always be a key decision-maker in any investment decision and CFOs within industrial companies often have similar issues around energy efficiency as external third party investors, namely a lack of expertise in appraising the value and risk of proposed energy efficiency investments, and ultimately a lack of certainty around the results.

How do we increase the flow of investment into energy efficiency to the required levels?

Increasing the flow of investment into energy efficiency in industry requires breaking down the problem into types of investment and understanding the driving factors for each type. Across all areas, there is a need to work to improve the quality of business cases and ensure they include all the benefits, especially the non-energy benefits that are often considered strategic. There is also a need to further de-risk energy efficiency projects through the use of standardized development and documentation methodologies, such as the Investor Confidence Project, and improve capacity to appraise value and risk of energy efficiency projects through tools, such as the EEFIG Underwriting Toolkit.

What is the role of banks?

Even though many industrial efficiency projects are financed on-balance sheet, the banks do have a role to play in helping to increase the flow of investment into energy efficiency. In the property world, banks such as ING have built in questions about energy efficiency into their lending process and taken decisions not to lend to low performing buildings in order to reduce the risk of financing assets that become stranded due to tightening regulations. By building in assistance on energy efficiency, banks can reduce the risk of stranded assets, reduce their counter party risk by improving their cash flow and lend additional capital. The same principles can be applied to industrial projects. The EBRD lending process has long incorporated assistance to borrowers to ensure that the optimum level of energy efficiency is built into refurbishment and new build projects, and represents a good model for commercial banks seeking to enhance their commitments to fund energy efficiency.

EnergyPro

KLIMAPROTECT
Germany

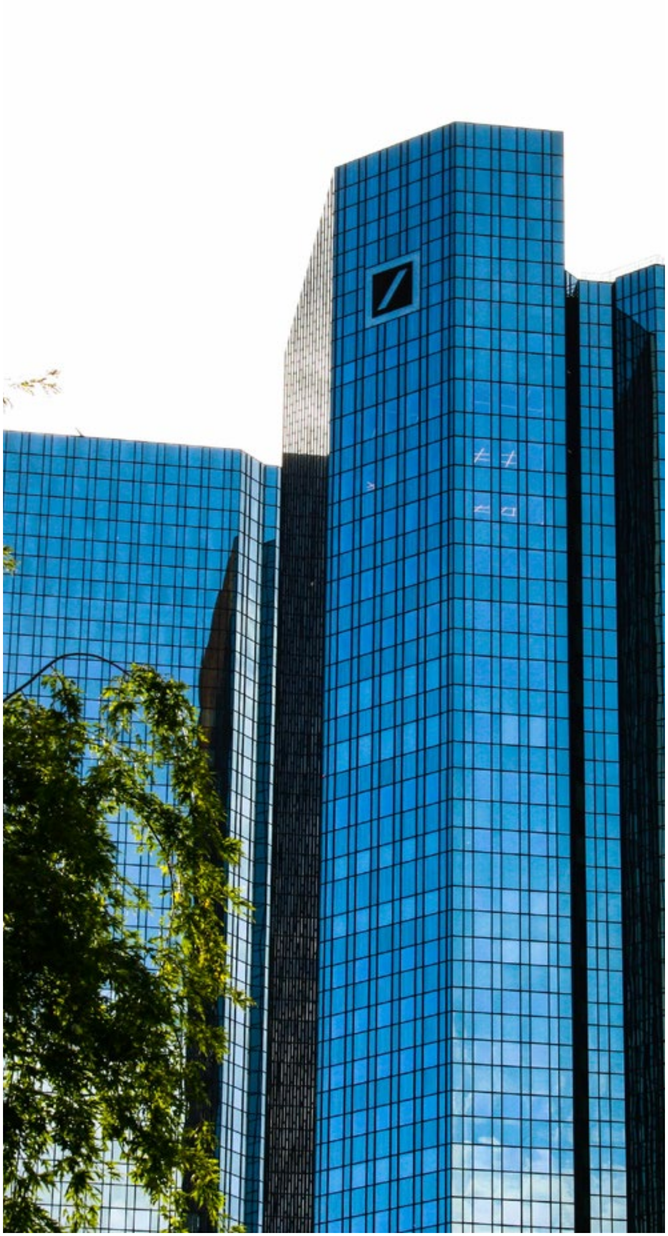
Hannover Re, in cooperation with KlimaProtect, has for the first time developed an energy savings warranty insurance product for industrial enterprises in Germany. This insurance solution enables providers of energy efficiency solutions to guarantee the potential energy savings offered by their retrofit activities. In the event that the promised energy savings fail to materialize, the company concerned receives deficiency payments from the contractor which are backstopped by the insurance coverage. Hannover Re reinsures these energy savings warranties covered by its primary insurance clients. Target clients for such warranty insurance include, for example, firms that improve exterior insulation, install heating systems and combined heat and power units or optimize lighting equipment.

INVESTOR CONFIDENCE PROJECT
United Kingdom

The Investor Confidence Project's Investor Ready Energy Efficiency™ certification has been awarded to a project consisting of a consortium of three NHS Trusts in Liverpool. This is a £13m project to improve the energy and carbon performance of the three hospitals, through the installation of a number of energy efficiency and low carbon measures. These include new gas-fired CHP energy centres, and a range of energy efficiency measures such as new variable speed drives for motors, plant optimiztion, and an extensive lighting retrofit program.

GREEN TAGGING
Europe

Green Tagging is emerging as the new strategy for Europe's leading banks to scale up financing of energy efficient housing and real estate. Green Tagging refers to a systematic process where banks identify the environmental attributes of their loans and underlying asset collateral as a tool for scaling-up sustainable finance. The Green Tagging of bank assets allows for easier access to green bond markets, better tracking of green loan performance and provides greater transparency of climate risks and portfolio resilience. While Green Tagging is in an early stage of development, the pace of change is striking. 10 European banks – ABN AMRO, BBVA, Berlin Hyp, HSBC, ING, Lloyds, SEB, Suedtiroler Volksbank, Triodos and UniCredit – are beginning to identify, analyze and promote green finance for housing and real estate through the direct attribution of environmental characteristics in their lending and debt capital markets operations.



(Left) Source: Pixabay
(Middle) Liverpool Women's NHS Foundation Trust. Source: EMA
(Right) Deutsche Bank, Franckfurt. Source: Brais CE

District Heating

City network technology.

District energy delivers sustainable heating and cooling, connecting local resources to local needs. District energy is a proven solution for delivering heating, hot water and cooling services through a network of insulated pipes, from a central point of generation to the end user.

District energy networks are also referred to as heat networks or district heating and cooling networks. They are suited to feed in locally available, renewable and low-carbon energy sources. Just to name a few examples: solar thermal, geothermal heat, sustainable biomass, waste heat from industry, from commercial buildings or from other urban facilities such as data centers, underground transport or water management systems. The ability to integrate these diverse energy sources means customers are not dependent upon a single source of supply.

District energy networks are inherently diverse and variable in terms of size and load; while employing similar operating principles, each network develops according to specific local circumstances and adapts to continuous innovation.

Heat networks are based on economies of scale, as the generation of heat in one large plant can often be more efficient than production in multiple smaller ones. A growing number of cities worldwide are adopting modern district energy solutions, as the best way to bring sustainable heating and cooling in dense urban environments.

The refurbishment, construction and expansion of district energy networks (combining district heating and district cooling, integrating and balancing a large share of renewable power, serving as thermal storage) are prerequisites for the smart energy systems of the future.

The constant evolution of district heating and cooling mirrors that of the broader energy transition.

District heating and cooling: connecting people, connecting communities, connecting buildings, connecting technologies.

We are on a journey to an integrated energy system through more efficiency and flexibility, increased use of renewable energy and waste energy sources, new business models and unleashing the huge potential of digitalization.

As more than half of Europe's energy is consumed for heating purposes, any policy initiative to decarbonize the energy sector would fail without addressing the topic of heat. Today, around 75% of Europe's heat demand is met with heat from fossil fuel-based sources, namely natural gas, oil and coal. An immense opportunity to decarbonize the European heating and cooling sector is therefore right in front of us.

DISTRICT HEATING

1. Currently just above **10%** of citizens are served by district energy systems in the EU28.

2. If urbanization continues and appropriate investments are in place, almost **50%** of Europe's heat demand could be met by district energy by 2050.

3. **1/4** of the population in the European Union lives in urban areas that could be reached by geothermal district energy systems.

4. Only **16%** of overall heating and cooling demand is covered by renewables – district energy can enable the integration of very large amounts of heat from renewable sources.

5. The share of renewables in the district energy fuel mix more than doubled from the year 2000 (from **11%** to **28%** in 2015).

6. District energy is often more efficient and cost effective in urban areas than natural gas networks.

7. There is on average **3 times** more renewable and excess heat available than is required to meet high levels of district energy supply.

8. District energy allows for a transition away from fossil fuel use and can result in a **30-50%** reduction in primary energy consumption.

9. A transition to district energy systems, combined with energy saving measures, could contribute as much as **58%** of the carbon dioxide emission reductions required in the energy sector by 2050.

10. Thermal storage is **100 times** cheaper than electricity storage (€0.5-3/kWh vs €170/kWh).

Around 60 million citizens are served by more than 6,000 district heating networks across the EU.

Sources: Aalborg University, Heat Roadmap Europe, Stratego project, International Energy Agency, UN Environment

1. Increase the recovery and reuse of waste heat via district energy networks.
All across Europe, tremendous amounts of waste heat from industrial processes and commercial activities are currently being dissipated unused in air or water. With a favorable policy and investment framework, this heat (directed to district heating networks) would significantly reduce demand for fossil fuels and supplement renewables in an effort to decarbonize Europe's heating market.

2. Maximize synergies between heating & cooling, electricity and transport sectors.
For future cross-sector integration, the issue of storage will be crucial to ensure the most efficient use of resources. Too often, energy is still uniquely identified with electricity, leaving out thermal storage solutions. Large-scale demand aggregation at city level is cheaper than individual storage of electricity and makes possible short-term storing and use of energy, as well as seasonal storage.

3. Boost the integration of renewable energy sources in heating & cooling.
Heating and cooling accounts for more than half of the EU's energy consumption; 84% of which is still met by fossil fuels. District heating networks help facilitate the integration of renewable heat, especially from bioenergy sources. In the long-term, we also need an increased share of geothermal and solar thermal energy as well as heat from heat pups powered by renewable electricity.

4. Cities hold the key to the energy transition: give them tools and resources.
Despite their significant share of energy demand, the role of cities in fighting climate change is still neglected when it comes to real action. To seize their full potential, cities must be involved in policy-making far earlier, while being equipped with all relevant resources – money, tools and legal freedom – to engage in pressing matters such as local energy planning and implementation.

5. Cooling needs far more attention: knowledge is key.
Often underestimated, tackling the cooling sector is an important part of Europe's efforts to achieve a decarbonized energy system by 2050. Sustainable technologies for example using natural cooling, integrated systems such as district cooling and the integration of the cold chain, deserve far more attention and resources for data collection, research and the roll-out of sustainable solutions.

Paul Voss

Managing Director of Euroheat & Power

What is district heating and cooling anyway?

District heating and cooling (DHC) networks are systems of pipes used to deliver heating and/or cooling to buildings, districts and entire cities. They can be supplied by many different sources including recovered heat from industrial or tertiary sector installations as well as various forms of renewable energy, including solar thermal, geothermal, biomass and even wind power. Since their viability relies on the density of demand, these networks are an ideal solution for dense urban environments where delivering low-carbon heat on a large scale is a major technical and economic challenge. At their best, these networks are by far the most effective route to market for a whole range of low-carbon sources of heating and cooling.

How does it fit in to the EU's energy policy?

One of the most significant developments in the EU energy debate over the past few years has been the emergence of the heating and cooling sector as a major policy issue. Long neglected by policy-makers in Brussels, it is now widely recognized as a key battlefield in the fight to deliver an effective energy transition in Europe.

In 2016, the European Commission published the first ever EU Heating and Cooling Strategy. This document makes it clear that as heating and cooling account for roughly half of the EU's overall energy demand, there can be no credible decarbonization plan which fails to explicitly address them. The strategy further emphasized the important role that DHC networks can play in delivering this transformation in the heating and cooling sector, specifically by delivering low-carbon thermal comfort to the heart of European cities, where the majority of the EU's energy needs must be met. Crucially, these principles are now slowly being translated into practice during ongoing negotiations on the EU's clean energy package in which DHC networks feature prominently as a tool to support the growth of renewables and the improved energy performance of Europe's building stock.

So DHC networks are a policy matter for cities?

The recognition of DHC's importance and potential at EU level is a major and necessary step forward. At the same time, their inherently local nature (as opposed to national or event pan-European gas and electricity grids) means that a European policy framework alone cannot be enough to deliver the needed change and development. As with the wider energy transition, cities will have an essential role to play. Against this background, cities around Europe, intent on playing a more active and effective role in shaping their own energy destiny, are beginning to take action. Perhaps the most exciting example of this tendency is the award-winning EU-funded CELSIUS project – an initiative designed to support cities in the process of getting their own DHC networks in the ground.

The recognition of DHC's importance and potential at EU level is a major and necessary step forward.

What does the future look like for district heating and cooling?

In a word, I would say 'promising'. DHC is such a good fit with Europe's various environmental, strategic and economic imperatives that it really should take off. And we're seeing signs of this at local levels all around Europe. That said, if this bright future for cities and DHC is to be delivered in practice, lots of things need to happen. Of course, an appropriate policy framework at EU, national and local level is a must, but policy is not the only thing that needs to evolve: our industry must also continue to adapt and develop, notably by switching to greener energy sources, improving network efficiency and exploiting the vast potential of digitalization and information technology to improve network performance and the customer experience. Some busy and exciting years lie ahead!

EUROHEAT & POWER

RECORD-BREAKING SOLAR HEATING SYSTEM
Denmark

The solar heating installation is part of a major conversion of the CHP plant near Silkeborg, Denmark. Its production covers the annual heat consumption of 4,400 households or 20% of the total heat demand of the city's district heating network. The solar district heating solution implemented reduces the CO_2 emission by 15,700 tons/year. The construction was pulled through in record time of just 7 months. This is a demanding project with regards to logistics and cooperation among the installation teams. In the busiest period, more than 6,000 solar collectors were installed in just one month. The installation comprises 12,436 solar collectors of each 12.6 m², totalling no less than 156,964 m².

EFFICIENCY AND DISTRICT HEATING
Spain

A complete retrofitting of the Torrelago district in Laguna de Duero, Valladolid (Spain), combined the buildings' façade renovation with an upgrade of the district heating system which now integrates renewable energy (biomass) and smart control solutions. This integrated demand and supply approach leads to 50% energy savings in the district. The project also took a cooperative approach with the district residents, raising awareness of energy challenges and empowering citizens through their engagement. Torrelago's district heating transition was integrated in the CITyFiED project – a smart city demonstration project supported by the European Commission. Praised for its approach, the project won a special award at the Global District Energy Climate Awards in 2017.

DISTRICT HEATING TO SHIPS
Sweden

Through a ground-breaking demonstration project, the Stena Line-owned passenger ship Stena Danica is now connected to the local district heating grid when it arrives to port in Gothenburg, instead of being heated by the light oil-fired boilers previously used. The application reduces the ship's CO_2 emissions by as much as 60%, SOx and NOx emissions by more than 90%, as well as significantly reduces noise levels in the neighborhood. The project is proof of how environmentally friendly shipping can be created, by combining logistics, industry and housing in central locations. Using these synergies means building a modern, sustainable community.

The challenge of the project was to develop a technical solution that enables daily connections to the district heating grid, which is very different from connecting a stationary building. It is also innovative in the sense that it is a new application for district heating, contributing to a low carbon local economy.

(Left) Silkeborg solar thermal field. Source: Arcon-Sunmark
(Middle) Torrelago district heating system operation. Source: Cartif
(Right) Stena Line ferry in the Gothernburg harbor. Source: iStock

Bioenergy

Outside a fully integrated pallet manufacturing facility, low value wood is chipped and supplied to the CHP plant that provides heat and electricity for manufacturing wood energy fuel in the form of pellets.

Source: AEBIOM

“Bioenergy” refers to all types of energy derived from the conversion of natural, biological sources, covering a vast range of feedstocks and conversion technologies. Bioenergy represents over 61% of the total renewable energy consumed in Europe and 10% of overall energy consumption. It is the only renewable energy that can provide the three forms of energy demanded by society – heat, electricity, and transport fuels – thus playing a key role in the decarbonization of Europe’s energy system.

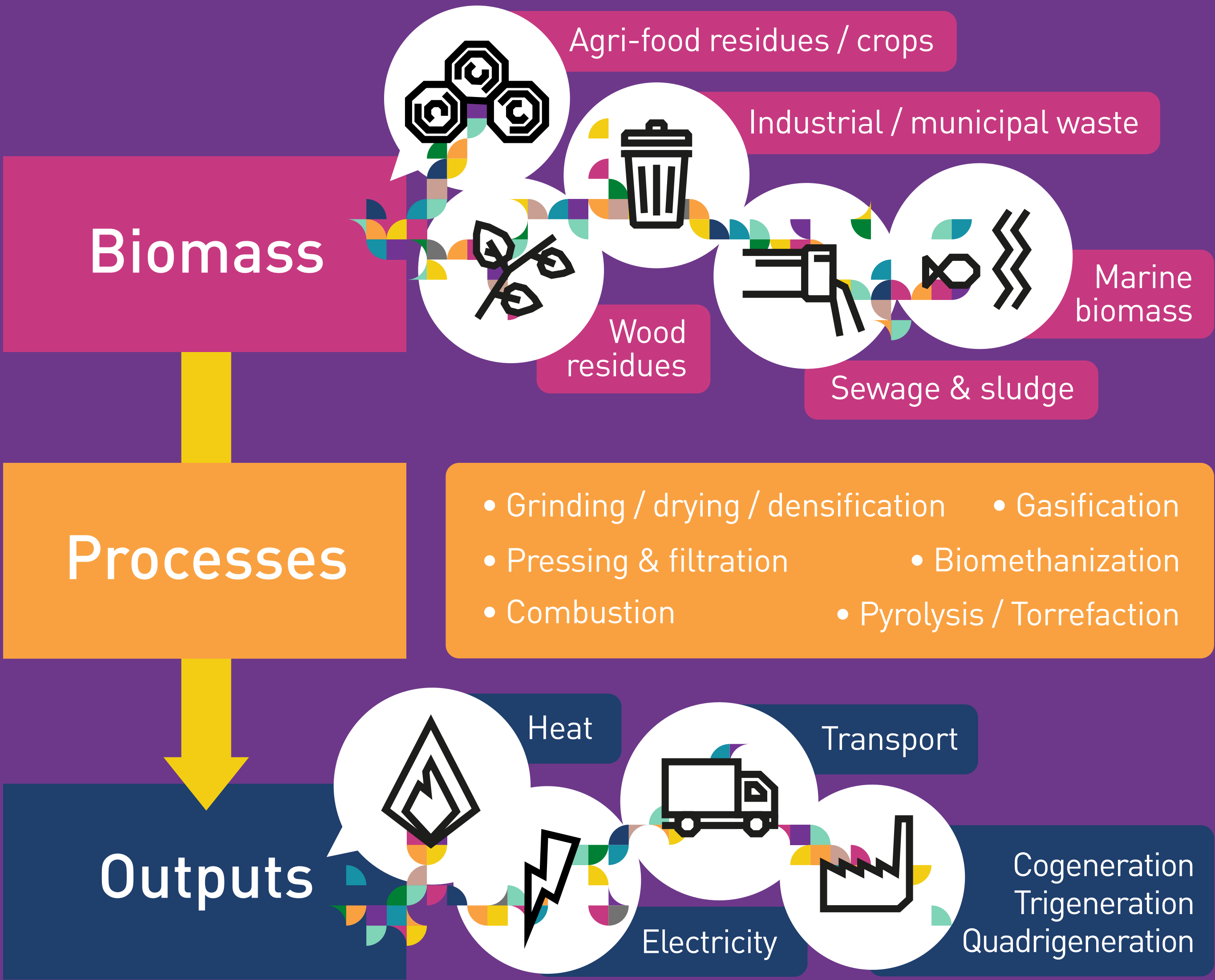
Bioenergy is the only renewable energy capable of providing heat, electricity, and transport fuels.

The feedstocks used to produce bioenergy are often referred to as “biomass” which exist can be found in 3 different states: solid, liquid and gaseous. When breaking down the EU’s consumption of biomass for energy, solid biomass (largely from wood residues) is the main source used, accounting for 70% of the total, while the liquid biofuel and biogas sectors account for 11.4% and 11.5% respectively. Municipal waste for energy makes up 7.1%.

Bioenergy is a European success story as a sector in which Europe is a clear leader in terms of production and consumption. The first developments of the modern bioenergy industry occurred in the 1970s with the production of efficient stoves, boilers, and new fuels, such as pellets and briquettes. It was not until the early 2000s, with the enforcement of the EU’s objectives on renewable energy, that the bioenergy sector established itself as a key player in the renewable energy field. Bioenergy consumption has more than doubled since 2000, rising from 55.4 Mtoe to 112.3 Mtoe in 2015. According to EU Member State projections, by 2020 bioenergy should account for 139 Mtoe in Europe, thus playing a major role in reaching the renewable energy target.

In 2015, more than 500,000 people were either directly or indirectly employed by the solid bioenergy sector, equalling the number of people working for the pharmaceutical industry. This success is mainly due to two reasons: first, 95% of all bioenergy consumed in Europe is locally sourced, mostly from local forest harvesting or wood and agricultural industry residues. As a consequence, the bioenergy sector is shaped by hundreds of SMEs that are deeply embedded in the local social fabric. This dimension is often forgotten in public debate regarding the future of the sector. With this in mind, AEBIOM launched a campaign in late 2017 dedicated to the “European Bioenergy Day” featuring success stories from all across Europe to highlight bioenergy developments.

BIOENERGY



Biomass
Agri-food residues / crops
Industrial / municipal waste
Wood residues
Sewage & sludge
Marine biomass
Processes
• Grinding / drying / densification
• Gasification
• Pressing & filtration
• Biomethanization
• Combustion
• Pyrolysis / Torrefaction
Outputs
Heat
Transport
Electricity
Cogeneration
Trigeneration
Quadrigeneration

1. In 2015, European wood pellet consumption replaced **6 billion** litres of imported oil while overall solid biomass consumption prevented **€32.1 billion** worth of fossil fuel imports.

2. Bioenergy represents **500,000 jobs** in the EU, which is equal to that of the pharmaceutical industry.

3. **50%** of the EU's renewable energy work force is employed by the bioenergy sector—a sector that in 2015 had a total turnover exceeding **€56 billion**.

4. As **95%** of all bioenergy consumed in Europe is locally sourced, bioenergy represents less than **1%** of Europe's annual energy imports.

5. Bioenergy represents around **90%** of the renewable energy used in heating, while **81.4%** of the overall heating sector is still powered by fossil fuels (a share far larger than electricity or transport).

6. Since 2000, the share of wood harvested in EU forests used in the energy sector has been steady around **20%** despite bioenergy consumption more than doubling over the same period.

7. In 2017, bioenergy alone sustainably fuelled the EU-28 for a total of **41 days** of the year.

8. **1/3** of Europeans cannot name a single renewable heating and cooling technology, proving communication efforts are still needed to promote them.

9. According to Eurostat, EU-28 forest coverage has increased by **322,800** hectares every year for the past decade, meaning that European forests are growing by the size of a football pitch every minute.

10. **78%** of all EU-28 forest removals go to the wood industry while only **22%** is used for energy, mostly coming from tree tops, branches and residues.

In 2017, bioenergy alone sustainably fuelled the EU-28 for a total of 41 days of the year.

Sources: AEBIOM

1. **Create a fair market for renewables by eliminating fossil fuel subsidies and introducing a carbon tax in the heating and cooling (H&C) sector.**
Fossil fuel subsidies prevail in the EU, creating an unfair market for integrating renewables. These subsidies should go towards renewable solutions to ensure coherence in EU policies. As most of the heating and cooling sector is not covered by the EU Emissions Trading System (EU ETS), no carbon pricing system applies to this sector at EU-level. A carbon tax should be introduced to the polluters, driving investment towards cleaner alternatives. Several EU Member States have already set a carbon tax at national level – this should be encouraged.

2. **Establish an EU framework allowing bioenergy to play its role in climate and energy goals.**
The future sustainability criteria that will apply to bioenergy after 2020 should be pragmatic, efficient and based on ground realities. This is key for maintaining and developing investment in the bioenergy sector to ensure its contribution to EU climate and energy targets.

3. **Promote synergies and complementarities between renewable sources of electricity.**
Recognizing the storable and dispatchable aspects of biomass, these characteristics allow for the stabilization of power grids by complementing supply when variable renewable energy sources cannot deliver, or during peak energy demand.

4. **Endorse renewable heat as part of the energy transition.**
The heating and cooling sector represents 50% of EU energy consumption that needs to be decarbonized. Modern and efficient direct sources of renewable heat should be promoted by accelerating the replacement of old heating installations while increasing the renovation rate of buildings to reduce energy consumption.

5. **Ensure coherence between EU policies (trade, industrial, energy and climate).**
To avoid counter-productive measures, this would allow for the development of a localized and innovative renewable energy industry, stimulating the economy and creating jobs in Europe. Investing in EU renewable energy industries not only prevents GDP leakage but also reduces our energy dependency.

Stefan Ortner

CEO of ÖkoFEN

What is bioenergy's unique contribution to the energy transition?

The average household that switches from oil heating to wood pellets reduces its CO_2 emissions by 8.5 tons annually—equivalent to replacing three fossil-fuelled cars with electric cars powered by 100% renewable electricity. Switching to bioenergy does not involve drastic change in consumer behaviour and is financially beneficial to homeowners and local economies. As biomass is widely available throughout Europe, society as a whole wins when independent from fossil fuel imports. Especially during winter, having enough renewable electricity on Europe's grid is a challenge all the more relevant with the adoption of electric transport. It's becoming increasingly valuable to have renewable energy storage on-site and to not produce peak electricity demand at the worst times.

As virtually all the fuel comes from within the EU, bioenergy creates local jobs. All biomass boilers are developed and produced in Europe with European boiler brands recognized worldwide as technology leaders.

What is bioenergy's greatest potential in replacing fossil fuels?

Bioenergy's greatest potential is replacing fossil-fuelled heating and electricity. The quickest way to reduce CO_2 emissions and increase independence is to replace fossil-fuelled boilers with the latest bioenergy technology. At ÖkoFEN, we combine this with solar energy to offer 100% renewable heating and electricity in one's home, meaning that all heat and electricity is produced on-site, every day of the year—even on a cloudy winter day. No other form of energy offers this kind of independence. These positive effects can be transferred from individuals to societies. Looking at electricity production in any given country on a cold, winter day makes certain that we cannot solely rely on electricity for all our energy needs if we want to reach our climate goals.

How do smart technologies help to decarbonize Europe's domestic heating and cooling sectors?

Smart technologies like machine learning and cloud data services offer higher efficiencies and optimized services. However, two related elements are even more important: first is the ability to enhance the user experience; with better visualization of energy usage and its sources we can build awareness and create a better image of bioenergy at consumer level. The second is offering better synergies between different renewable energy technologies. ÖkoFEN's integrated Stirling engine uses information from weather forecasts, electricity usage, production and battery data to decide when to produce heat or electricity from wood pellets.

How can we ensure that Europe leads in harnessing bioenergy technologies?

Although bioenergy is used widely in Europe, the carbon footprint of the heating sector is significant with change happening very slowly when compared for instance to the power sector. Germany still has around 6 million oil boilers installed (many old and at the end of their lifetime) which is also the case in many other countries. Numerous regions have good subsidy schemes in place, but greater political willpower is needed to replace heating systems at the end of their lifetime. It is normal that a car cannot be used when it does not meet emissions requirements; policies should also make people stop using their old, CO_2-emitting heating systems. Setting a carbon base price would also allow all CO_2-saving technologies a better economic chance against fossil fuels.

All biomass boilers are developed and produced in Europe with European boiler brands recognized worldwide as technology leaders.

We need to end fossil fuel subsidies and the use of incorrect emission statistics. In 2012, 1/3 of public money spent on energy went towards renewables. Statistics used for fine dust emissions from wood combustion in Germany are based on boilers installed before 2008, meaning no technological improvements of the last 10 years are reflected. Considering our climate goals, such an uneven playing field should be shocking for any European tax payer.

ÖkoFEN

BIOENERGY BLOOMS
Ukraine

Ukraine's goal to increase its share of renewable energy from 4% to 25% by 2035 has led to an uptake in biomass projects in the country where biomass accounts for 80% of the renewable energy consumption. Camellia, a flower company in Ukraine, is one example of such projects replacing fossil fuels with biomass. Having previously used natural gas to heat its 11 hectare greenhouse, Camellia switched to biomass by installing two 3.5 MW boilers, powered by local woodchips and agro-pellets. Switching from natural gas to biomass for heating has cut the production cost of its flowers by over 40%.

BIO-NATURAL GAS BUS FLEET
Germany

In 2017, Bavarian utility company Stadtwerke Augsburg (SWA) won the "International busplaner Sustainability Award" for reducing the particulate, NO_2, and CO_2 emissions of the city of Augsburg's bus fleet by switching to natural biogas buses using compressed natural gas (CNG). Back in 2011, SWA converted the 91 buses to use bio-natural gas made from agricultural waste, making the fleet CO_2 neutral with 95% less NO_2 emissions and almost zero soot particles when compared to diesel-engine buses. In 2016, SWA commissioned 23 new Mercedes-Benz Citaro natural gas buses with engines for even lower fuel consumption and lesser environmental impact.

MAKING THE INTERNET A GREENER PLACE
Luxembourg

The Internet consumes around 1,037 TWh of electricity globally, representing 609 million tons of GHG emissions—equal to that of all civilian flights over a year! Yet with bioenergy, the Kiowatt company is making the Internet a greener place. A joint-venture between Belgian bioenergy company Groupe François and Luxembourgish energy company LuxEnergie, Kiowatt's cogeneration plant is powered with over 35,000 tons of local waste wood yearly to produce green electricity, heating, and cooling. The plant's 17 MW boiler and turbine supplies electricity straight to the grid while the generated heat is used in 3 on-site applications: 1) to dry low quality wood for the manufacturing of wood pellets, 2) to supply the surrounding industrial park's district heating, and 3) two absorption machines convert the heat into cooling, which provides the data center operated by DataCenterEnergie Company with renewable cooling for its Internet servers. By 2020, Kiowatt will have saved 350,000 tons of carbon.

(Left) Flowers at Camellia's 11 hectare greenhouse grow in a comfortable climate. Source: Bioenergy Association of Ukraine (UABIO)
(Middle) An Augsburg bus driver refuels with bio-natural gas made from agricultural waste. Source: Stadtwerke Augsburg
(Right) The PM of Luxembourg, Minister for the Environment, and Mayor of Bissen celebrate the inauguration of Kiowatt. Source: Mediation

Energy Storage

Energy storage enables us to decouple energy generation from consumption, both geographically and over time. Energy storage can therefore provide valuable flexibility to the system at various time-scales, from seconds and hours to weeks and months. By providing a range of system and ancillary services, energy storage enables the integration of higher shares of variable renewables.

This flexibility will be vitally important once electricity systems are dominated by variable renewables, meaning that generation cannot be dispatched to match (predicted) demand. But even in the transition period, as we integrate more and more renewables into the system, energy storage can help the system run more securely and efficiently while extending the life of existing assets (for example grid infrastructure).

Energy storage is also important to help decarbonize the heating, cooling, and transport sectors through thermal storage, power-to-gas, and stationary storage devices that can help support the roll-out of electric vehicle charging infrastructure. Finally, storage can empower consumers to participate actively in the electricity market by generating, storing, and selling renewable electricity.

The term 'energy storage' refers to a diverse group of technologies that work according to different principles: mechanical (e.g. pumped hydro storage, flywheels, compressed air energy storage), chemical (e.g. power-to-gas), electrochemical (e.g. batteries), thermal (e.g. hot water storage), and electrical (e.g. supercapacitors). Some provide very fast responding, short-duration balancing power (such as flywheels or supercapacitors) while other technologies provide longer duration storage for balancing at a timescale of hours, days or even for seasons (for instance, pumped hydro or hydrogen storage).

Storage technologies are incredibly diverse, capable of providing a host of valuable applications at all levels of the grid. This makes them an essential element to support the transition to a decarbonized energy system.

Each storage technology is uniquely suited to a particular set of applications. Different storage technologies can be combined together to form a hybrid system that can be greater than the sum of its parts. Storage technologies are incredibly diverse, capable of providing a host of valuable applications at all levels of the grid. This makes them an essential element to support the transition to a decarbonized energy system.

ENERGY STORAGE

1. Limiting the average global temperature increase to well below 2°C above pre-industrial levels would require global installed energy storage capacity to double, rising from around **160 GW in 2015 to 380 GW by 2040.**

2. Currently, globally installed storage capacity amounts to only **2% of total electricity generation** capacity.

3. Deploying energy storage can lead to significant cost savings: in the UK, the **system-wide savings from storage deployment are estimated to reach up to £2 billion per year by 2030** by enhancing the efficiency of existing grid assets and deferring infrastructure investments.

4. **Energy storage reduces the costs of system balancing:** the Enhanced Frequency Response service in the UK is estimated to save up to £200 million in costs over 4 years since the extra-fast response reduces the volume of Frequency Response services that need to be contracted.

5. **Currently, 85% of heating & cooling demand is met by fossil fuels**, so thermal energy storage plays an important role in decarbonizing the heating & cooling sector

6. In the US, deploying an additional 35 GW of energy storage systems would lead to **estimated cumulative CO_2 emissions reductions of 3,666,200 mt-CO_2 equivalent** by 2025.

7. The European energy storage industry is experiencing rapid growth: **the market grew by 50%** in 2017.

8. Energy storage technologies provide **valuable applications for generation, transmission, distribution, and consumption**, delivering cost-effective flexibility at different timescales at all levels of the electricity system.

9. **The cost of many storage technologies is rapidly decreasing** due to R&D advancements and economies of scale: the battery price dropped from around 1,000 $/kWh in 2010 to 227 $/kWh in 2016.

10. Decrease costs for energy storage technologies vary by technology but are expected to be **between 1%/year and 15%/year** in the coming years.

The European energy storage market grew by 50% in 2017.

Sources: Carbon Trust/Imperial College London, Delta-ee, European Commission, IEA, McKinsey, National Grid, Navigant Research

1. **Define energy storage better in the EU regulatory framework.**
It must allow cross-sectorial interfaces, such as electricity "in" and heat, gas or fuel "out", to be considered as energy storage. The definition should reflect all types and applications of energy storage and not only traditional technologies and uses, such as pumped hydro storage or batteries, in order to allow for the development of new technologies.

2. **Establish clarity on the rules under which energy storage can access markets,**
in particular the perceived inability of transmission system operators (TSOs) and distribution system operators (DSOs) to own and operate energy storage.

3. **Eliminate unwarranted/double charging in a coordinated approach at European level.**
Whether and to what extent storage should finally contribute to grid costs merits a dedicated debate at European level, since energy storage usually supports the secure and efficient operation of the grid.

4. **Ensure that the procurement of all energy and ancillary services is market-based, subject to a Cost-Benefit Analysis (CBA).**
System services are not all procured on market-based conditions in all EU Member States which creates a higher cost for the consumer and discriminates against technologies that are not allowed to provide these services, even if the services would be provided cheaper and more accurately.

5. **Consider establishing energy storage as a separate asset class.**
Energy storage could be recognized as the fourth element of the energy system (alongside generation, transport (transmission/distribution), and consumption). This would prevent energy storage from being classified as either generation or consumption – or as both. It would eliminate any ambiguity that results from the historical market design stemming from a centralized energy system where everything fit into one of the three categories. It would also allow for a clear framework specific to energy storage.

Eva Chamizo Llatas

President of the European Association for Storage of Energy

Why is energy storage essential for the energy transition?

Transitioning to a low-carbon energy system is impossible without firm and flexible assets that enable synchronization between variable renewable energy sources (RES) generation and energy consumption. Storage is paramount to providing flexibility services at all levels of the power grid, helping transmission and distribution grids function more effectively, and deferring potentially costly investments in cables and interconnections. In addition, storage can provide support during contingencies, reducing the amount of energy non-supplied to customers.

Energy storage technologies are incredibly versatile. Short duration storage devices such as flywheels and batteries can respond to imbalances within milliseconds, while longer duration devices like pumping hydro or hydrogen storage can provide weekly, monthly, or even seasonal storage. On islands and microgrids, storage together with variable RES is replacing high emitting diesel-powered generators.

What role can energy storage play in the decarbonization of the heating, cooling, and transport sectors?

Electricity is the most effective sector in terms of integrating RES. In 2015, over 29% of the electricity in the EU was produced using RES, and the target is to reach between 45-50% in 2030.

Through storage, it is possible to link the electricity sector to the heating and cooling sector, as well as to transport. Roughly 85% of heating demand is still met by fossil fuels, so the electrification of heating is a very effective way to decarbonize the heating sector. Moreover, thermal energy storage has an enormous potential to provide power system flexibility, particularly at longer time scales.

Regarding the transport sector, 94% of energy demand is met by fossil fuels. Storage could potentially support the roll-out of electric vehicle charging infrastructure, since it can help smooth out peaks and valleys in demand. Meanwhile, in the long-term, power-to-gas storage is key to support clean hydrogen powered vehicles.

> Energy storage technologies are incredibly versatile.

What are the major challenges for the storage industry in Europe?

Since storage is a relatively new player in the energy system, the biggest challenge is the legal uncertainty about the role of storage in the system, since it is considered in some EU Member States as a generation or consumption asset depending on its operation mode. This leads to energy storage devices in some Member States being subject to double grid fees and charges.

And it is today undecided whether storage can be owned and operated by distribution and transmission system operators (DSOs, TSOs) for grid operation purposes (for any market service, property or management of storage devices by system devices is obviously out of question). Additionally, the lack of market-based procurement and the absence of long-term contracts for system services hampers investment security in the energy storage sector. From a research and innovation standpoint, there is a need to develop different storage services and applications, and to explore ways to combine and monetize these services.

How should energy market design evolve to value energy storage?

The market design must establish a level playing field for all energy storage technologies. First of all, we need a clear definition of energy storage in the regulatory framework. Secondly, we need to clarify the contribution of storage facilities providing efficient non-market services as additional grid elements. Finally, eliminating double charging and unwarranted fees and taxes will help energy storage compete equally with other flexibility options in trading schemes and offer market balancing options. Putting the right market design in place is a matter of urgency, without which we will not achieve the energy storage deployments necessary to support the cost-effective integration of RES into the system.

EASE
European Association for Storage of Energy

OPTIMIZING WIND POWER
Faroe Islands

SEV, the Faroe Islands utility, has commissioned Europe's first fully commercial Li-ion energy storage system (ESS) operating in combination with a wind farm. Saft's 2.3 MW containerized solution is helping to maintain grid stability so that the islanders can capture the full potential of their 12 MW Húsahagi wind farm. The ESS provides ramp control to smooth out sharp increases and decreases in power, as well as frequency response and voltage control services. The ESS also minimizes curtailment during periods of high wind and low consumption, as excess wind energy that cannot be injected into the grid is stored in the batteries.

UCAPS FIRMING' PV ENERGY
USA

Ultracapacitor technology projects from Maxwell Technologies such as the "Palisade project" installed in early 2017 in California, enables the renewable power to be stabilized or to "firm" the output power. Therefore utilities will be able to reduce or delay building additional standby power or regulation generated from other sources.

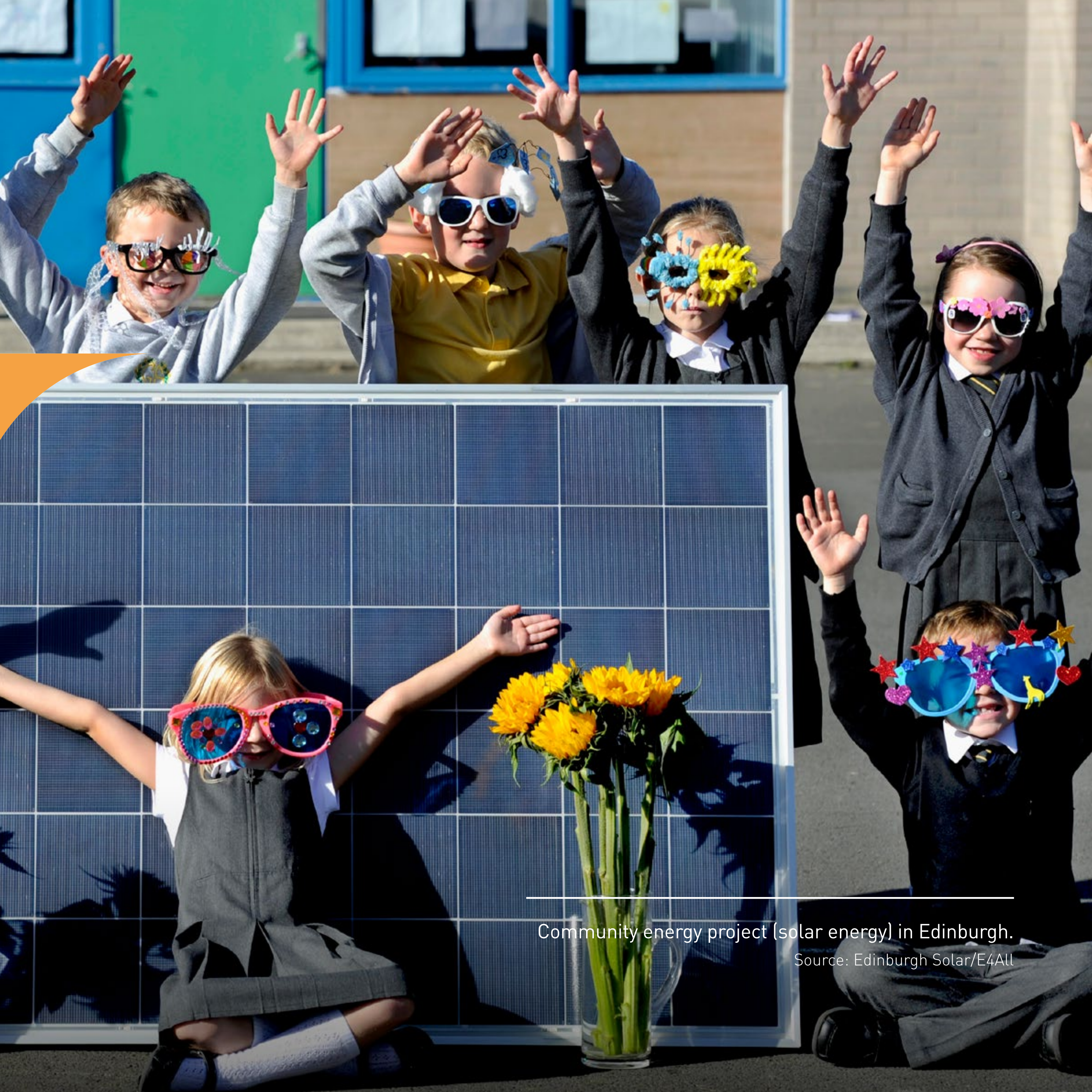
With an optimum sizing of an ultracapacitor energy storage for solar smoothing a power rating of 20% or more of the PV rated power and a reserve capacity can be achieved, while the maximum discharge time under full load can be 100 seconds or more.

MILESTONE FOR HYDROPOWER
Portugal

Portugal has been focusing for years on the flexible and dynamic potential of pumped storage to stabilize electricity grids. The new pumped storage plant Frades II has been in operation since 2017. Technology Group Voith supplied the plant with two variable speed pump turbines, two asynchronous motor-generators, the frequency converter and control systems as well as the hydraulic steel components. The key element of the plant is a special asynchronous motor-generator that offers three advantages: 1) it can respond faster and more flexibly to the active and reactive demand from the power grid; 2) it provides additional stability in the event of a drop-in voltage; and 3) it enables a fast restart if a power outage occurs. Following the successful start-up, the biggest variable speed pumped storage plant in Europe is considered the flagship project for further plants worldwide.

(Left) Saft Li-ion energy storage enables SEV to optimize wind power for the Faroe Islands at Husahagi. Source: SEV
(Middle) Maxwell ultracapacitors with cell management and monitoring. Source: Maxwell Technologies
(Right) Pumped storage power plant Frades II, north-west of Portugal. Source: Technology Group Voith

Energy Communities



Community energy project (solar energy) in Edinburgh.
Source: Edinburgh Solar/E4All

Energy communities – where citizens own and participate in renewable energy or energy efficiency projects – are a significant element in Europe's low carbon energy transition. By 2050, almost half of all European households could be involved in producing renewable energy, about 37% of which could come through 'collective' participation in an energy community. Europe's energy market is not only undergoing a fundamental transition from a system-based on fossil and nuclear power towards one based entirely on renewable, efficient and sustainable energy. It is also transforming from a centralized market dominated by large utilities to a decentralized market with millions of active energy citizens.

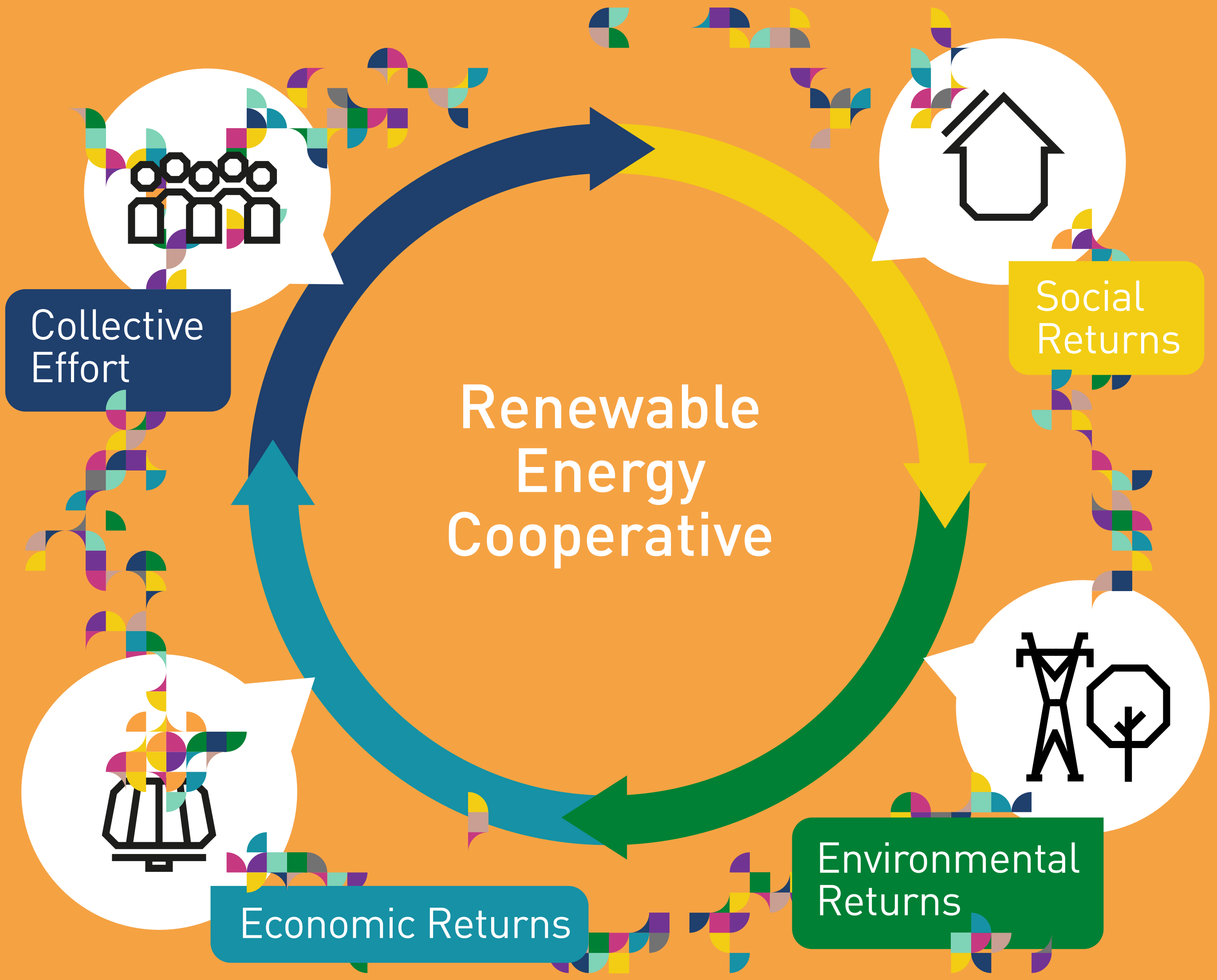
By 2050, almost half of all European households could be involved in producing renewable energy.

Putting citizens at the heart of the energy transition will be essential for its success. The energy transition requires considerable investments that are paid for by citizens: as consumers or tax payers. To ensure fairness, citizens should enjoy equal opportunities to use the grid and have control over how their energy is produced, distributed and supplied. Energy communities can aggregate their members to provide flexibility and other services that will help system operators to integrate more renewables, safely and efficiently. Most importantly, energy communities offer citizens something that is often overlooked in the energy sector: ownership, control, and a voice in how the business operates. Energy communities distinguish themselves by the way they do business in two important ways – governance and purpose. First, energy communities provide for open participation and democratic governance of the undertaking. Energy communities are open to all persons able to use their services and willing to accept the responsibilities of being part of the community, without gender, social, racial, political or religious discrimination. They are democratically controlled by their members, who actively participate in setting their policies and making decisions.

Second, instead of aiming to make profits, they exist to benefit, for example through the provision of services, their members and the local community. They harness the renewable energy projects not just to provide a modest return on investment to their members, but to fund social programmes, invest in energy efficiency in public buildings, create local employment, address various community development needs, and combat energy poverty. In this way, energy communities ensure that economic value generated by the energy transition is retained locally.

Already today, energy communities have transformed the energy market in many European countries while contributing to revitalizing the local economy and creating jobs. Energy communities deliver a significant share of renewables investment and promote their local development and public support. With the right European legal framework, energy communities could flourish and deliver an important share of Europe's renewable energy and therefore contribute in a significant way to the decarbonization of Europe.

ENERGY COMMUNITIES



1. There are around **3.000** Renewable Energy Cooperatives (REScoops)* active in Europe, most of them can be found in western and northern EU Member States.

2. The network of REScoop.eu represents **1,100** employees.

6. More and more municipalities and REScoops are cooperating to carry out local sustainable energy actions plan.

7. In 2016, REScoop.eu members jointly had an annual turnover of **€750 million**.

In the past years, Renewable Energy Cooperatives extended the range of their activities to work on energy supplying, energy efficiency, grid operations and e-mobility.

3. Most European REScoops started as renewable energy producers. In 2016, the members of REScoop.eu jointly invested **2 billion** euro in renewable energy sources production installations.

4. **1,500** REScoops or **50%** of the total REScoop population is represented in the European Federation for Renewable Energy Cooperatives (REScoop.eu). This number is steadily growing year by year.

5. REScoops are implementing programs to help their members to rationalize their energy consumption; members of REScoops are significantly lowering their consumption over time, up to **20%** a year.

8. In the past years, many REScoops are extending the range of their activities to work on energy supplying, monitoring, savings, grid operations, and e-mobility.

9. REScoop.eu members have a joint production capacity of about 1.250 MW. In 2016, the members of REScoop.eu jointly produced **1,500 million** kWh.

10. By 2050 half of EU citizens could be producing their own energy, either individually with solar PV or collectively through a RES cooperative.

Sources: REScoop.eu, University of Twente, CE Delft

1. **Acknowledge energy communities in national policy.**
Energy communities are social innovation tools that allow local citizens to cooperate on renewables, energy efficiency and other energy-related services. Due to their small size, democratic governance, and social purpose, they are different from traditional energy companies. National policies and regulations should acknowledge these differences and the benefits energy communities can bring the energy system and society, through a clear definition that promotes open participation while avoiding abuse from larger for-profit actors.

2. **Ensure an equal playing field across the energy market.**
Due to their unique characteristics, energy communities face distinct challenges competing based on rules designed for larger energy companies. National regulatory frameworks should ensure energy communities have equal access across the energy market, and benefit from non-discrimination and proportional treatment with regards to existing or future activities. They should also benefit from regulatory oversight to ensure their rights are enforced.

3. **Ensure support schemes do not exclude energy communities.**
The move from feed-in tariffs to competitive bidding support schemes for renewables poses significant challenges for energy communities. To the extent possible, energy communities should be exempt from participating in competitive bidding and be allowed to access direct forms of support. Otherwise, competitive bidding rules and procedures should be carefully constructed to ensure energy communities are not excluded.

4. **Provide citizens with easy-to-access information and guidance.**
One of the biggest obstacles to new renewable energy community projects is a lack of information on technical and financial matters, as well as complicated and uncertain administrative procedures. Simplification or streamlining of procedures (and ensuring that citizens have an easy reference point for technical or financial support) can be crucial to empower local citizens to develop new energy communities.

5. **Encourage the participation of vulnerable and energy poor consumers.**
All citizens, including low-income and vulnerable households, should be able benefit from participating in an energy community. Many energy communities already incorporate aims to support energy solidarity and address energy poverty by providing members with cheap access to renewables and ways to save energy. National policies for energy communities should encourage these types of activities.

Jim Williame

General Coordinator of Ecopower cvba

For Jim Williame, a green, sustainable, decentralized and democratic energy system is the future. He is putting these principles to practice in his job as general coordinator of Ecopower, the largest Belgian renewable energy cooperative with over fifty thousand shareholders.

Where and when did it all start for Ecopower?

Ecopower was established around a kitchen table in 1991. The origins of the Ecopower story date from 1985 when the watermill of Rotselaar was bought as part of a co-housing project. From there the idea for citizen energy production grew and led to the foundation of Ecopower.

Today, the cooperative is both an energy producer and a supplier; a successful cooperative business working on the transition towards a sustainable, democratic energy system. Projects include the development of wind turbines, solar, hydropower, cogeneration and a wood pellet factory. Together the installations produce about 90.000.000 kWh of electricity and up to 20.000 tons of wood pellets per year.

What drives you? What is your motivation?

Energy is part of an important public debate. Whether you talk economy, job creation, climate change or mobility challenges, energy is everywhere. We see in Flanders, but also in Europe and worldwide, that citizens are reclaiming control of their energy. Ecopower tries to answer this common need through its cooperative business model and through collaboration with other innovative, often cooperative energy players.

I am proud to be part of a movement not only demanding energy democracy but also actively working towards it. With Ecopower we offer a concrete solution for citizens who want to take ownership of their electricity use and who firmly believe there are alternative ways to organize the energy market.

What makes Ecopower unique?

The energy sector is transforming fundamentally from a fossil fuel-based system towards more renewables. All transitions create opportunities for new players. Through hard work, some well calculated risks and a little luck in timing, Ecopower acquired a unique position. In 2003, the Belgian energy market was liberalized and we became one of the first new suppliers. An asset that helped us grow because citizens reached out more easily to a cooperative that supplies a basic need. Our numbers increased our leverage in the debate around energy democracy.

All transitions create opportunities for new players.

When developing a project, Ecopower seeks local support, engagement and participation. This balances the NIMBY-reactions and assures that the profit of the locally-harvested energy stays within the community and thus stimulates the local economy and employment. This way of working activates citizens and is attractive for local governments. We notice and encourage the trend that local authorities include direct participation by local citizens as a criterium in public procurements, an advantage for cooperatives like Ecopower.

What does the future look like? What is your dream?

We work in a challenging and often complicated field. The path towards a new project can be very long and is often covered with administrative and political obstacles, the traditional big players still dominate the energy market and not everybody has the same view on the energy transition. But we firmly believe that the goal we pursue is possible: a 100% renewable and democratic energy system that puts planet and people first, with profit for the community.

Ecopower, together with its allies and partners, focuses on project development, lobby work at different levels, collaboration between energy communities, exchange of best practices and lessons learned, pilot projects to develop and test new technologies, and initiatives to raise awareness. By reinforcing the renewable energy cooperative model in Belgium, Europe and beyond, we work towards a green and sustainable energy landscape with citizens in the driving seat.

ICH BIN EIN STORFALL
Germany

After the 1986 Chernobyl nuclear disaster, some parents in the village of Schönau, in the Black Forest, decided to renounce nuclear was to take over the local grid. When this dedicated group bought the grid in 1991, the energy market was not yet liberalized and financial support systems were absent. They launched a crowd-funding campaign "Ich bin ein Störfall". With a double meaning in German of "I am a technical incident", referring to the disaster in Chernobyl, and "I am an annoyance". After years in and out of court, the ElektrizitätsWerke Schönau (EWS) today supplies clean power to over 100,000 consumers in Germany. They source their power directly from renewables and cogeneration producers, on a real-time basis, to be sure that absolutely no nuclear power is involved.

SOLAR ENERGY SOLIDARITY
United Kingdom

In Brixton, a disadvantaged area of London in the UK, many people cannot afford to have contracts with energy companies and instead have to be on more expensive 'pay-as-you go' tariffs. Brixton Solar community power project gives local people a limited amount of the electricity produced with solar panels on their own roofs for free. Through the project people can also take part in learning sessions to help them cut energy waste. This reduces energy poverty and means residents have more energy to heat their homes and cook with. The project is not only about renewable energy production or saving of kilowatt-hours; it is also about improving the resilience of a local community.

GENERATION KWH
Spain

In June 2015, Som Energia, a non-profit and renewable energy cooperative, launched "Generation kWh" as a response to the lack of support for renewable energy production in Spain. In response to the withdrawal of subsidies for renewable projects and legal barriers for self-consumption, the Spanish coop Som Energia came up with a creative and innovative way of investing in renewables: generation kWh. Energy shares, which are 100€ each, can be purchased by each of the 45,000 members to (partially) offset their specific annual consumption. After 25 years, the initial investment is to be returned. In the meantime, the investor had savings on his energy bill for 25 years. Generation kWh is based on small investments from lots of cooperative members making it possible to reach the big amount of money that is required to fund new renewable energy projects.

(Left) Ich bin ein Störfall"-campaign of EWS which means "I am a technical incident". Source: ElektrizitätsWerke Schönau
(Middle) Group of citizens with their solar installation. Source: Brixton Solar Community
(Right) Campaign image for Generation Kwh. Source: Som Energia

Electric heavy duty truck from TransPower used to move freight.
Source: Dennis Shreder / NREL

Goods Transport

Transport is the biggest sector in the ESD with a share of 34%, with heavy-duty vehicles being responsible for around 1/4 of transport emissions. Between 1990-2015, greenhouse gas emissions from heavy-duty trucks and buses rose 19% and this increase is projected to continue. Lorry emissions have been on the rise for decades and while more goods are transported by road, lorry fuel economy has been stagnant since the mid-1990s. EU Member States have a limited ability to reduce lorry emissions. Standards are a proven tool to overcome market barriers and improve fuel efficiency in a cost-effective manner.

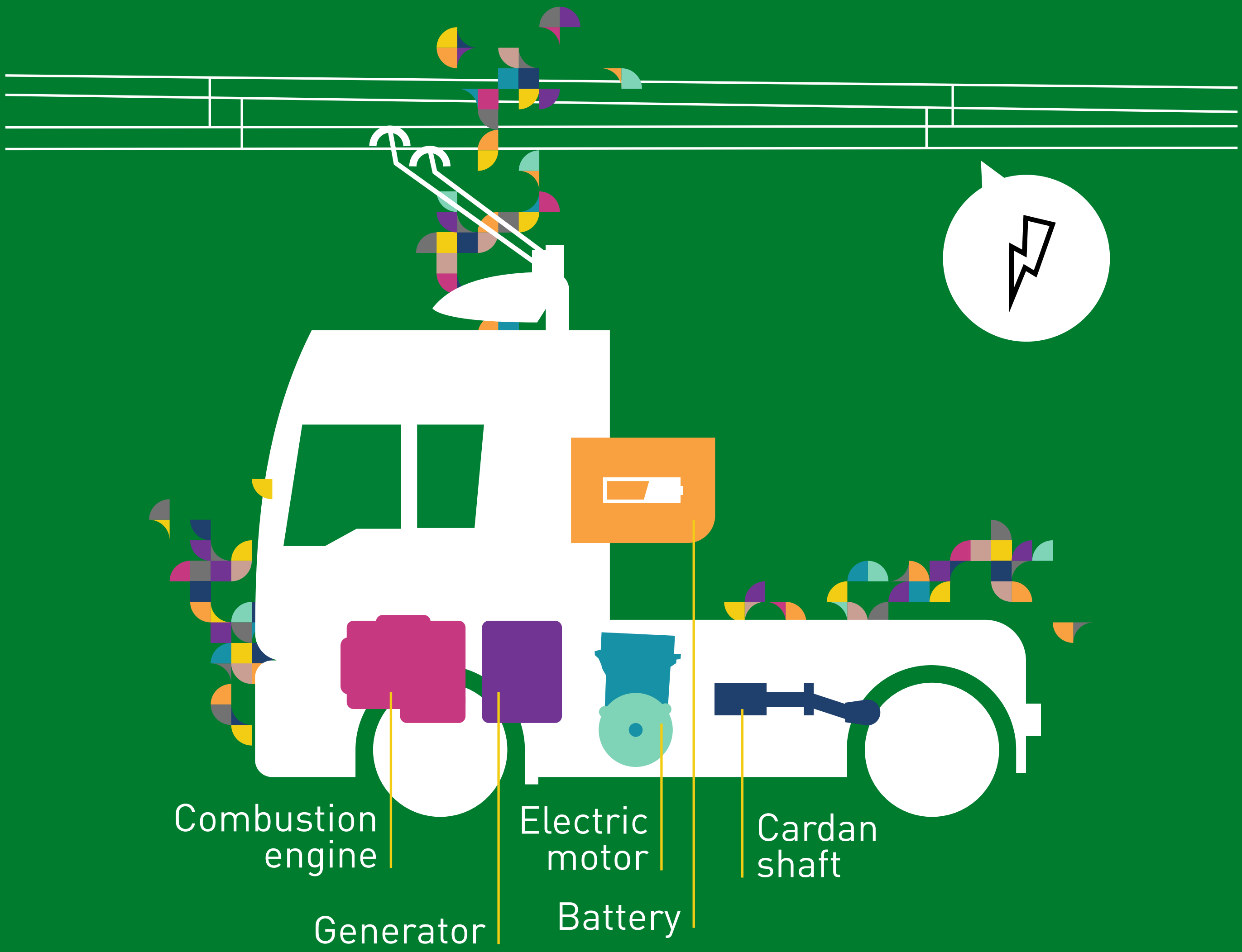
Diesel represents up to 1/3 of the lorry operating costs and diesel imports for road freight cost the EU €60 billion a year. According to studies for the European Commission, lorries could be at least 35% more fuel-efficient using existing technology without increasing operating costs for haulers. CO2 standards would ensure fuel-saving technologies are fitted as standard rather than as expensive options. The increased up-front cost would be quickly recovered through lower fuel bills and free up some €18 billion for new investments which would benefit the EU economy and create over 30,000 new jobs in the lorry manufacturing industry.

20 years of stagnating fuel efficiency and the introduction of fuel economy standards in other truck producing regions like Japan (2005), the US (2011) and China (2015) have eroded Europe’s leadership on truck fuel efficiency. The US announced updated truck fuel efficiency standards that will improve the fuel efficiency of trucks from around 36l/100km in 2014 to below 27l/100km in 2027. This will make US trucks the most technologically-advanced and fuel-efficient in the world. As a result, America will lay claim to the word’s most comprehensive regulatory framework, undermining Europe's current leadership in this area.

With the current average electricity grid in the EU, an electrified truck, either through battery or e-highways, would cut greenhouse gas emissions by a factor of 3 compared to a diesel truck.

Fuel savings can come from better aerodynamics, tires, and incremental powertrain improvements. A 2015 study by the International Council on Clean Transportation found that for US trucks fuel savings of up to 54% would pay back within 2.5 years. In coming years, electric trucks, either running on batteries alone or electrified through catenary lines, will bring more substantial benefits in terms of cost and pollutant emissions reductions.

GOODS TRANSPORT



1. Three quarters of EU freight is transported over roads. **13 million** heavy duty vehicles (HDVs) were on EU roads in 2015.

2. Every year, the EU imports around **500 million** barrels (**€60bn**) of oil to fuel its truck fleet, which makes the EU economy vulnerable to oil price fluctuations.

3. **450,000** medium and heavy trucks were produced in Europe: around **20%** of these are medium heavy trucks (3.5-15 tons) but the vast majority (around **80%**) of vehicles are heavy trucks (+15 tons).

6. Five companies account for **90%** of all the truck sales in Europe: Daimler (Mercedes), Volkswagen (MAN and Scania), Volvo-Renault, DAF and IVECO.

7. Air pollution from trucks costs European Union Member States **€43-46 billion** per year, according to the European Environment Agency.

8. Trucks make up less than **5%** of all vehicles on the road, they are responsible for **25%** of road transport fuel used with a **19%** of carbon emissions increase between 1990-2015.

With the current average electricity grid in the EU, an electrified truck, either through battery or e-highways, would cut greenhouse gas emissions by a factor of 3 compared to a diesel truck.

4. Fuel efficiency standards for trucks could reduce emissions by **35%**. One truck could save **€8,000-9,000** per year and Europe - more than €15bn per year, all while avoiding **37 million** tons of carbon being emitted annually by 2030.

5. Despite progress on reducing pollutant emissions (thanks to the EURO standards), new truck fuel consumption has remained stable for almost two decades.

9. Road transport is dominated by cost: in 2025, the cost per km of a battery truck (400 km battery) will be **2/3** that of diesel (0,72 €/km vs 1,07 €/km).

10. Charging infrastructure of 1 MW can be used during mandatory 45-minute stops every 4,5 hours driving (400 km).

Sources: Transport & Environment

1. Monitor and report truck carbon emissions and fuel consumption.
By obliging truck-makers to make information on fuel consumption available and transparent (to potential buyers and to the European Commission), purchasers get a better understanding of a truck's strengths and weaknesses (e.g. good aerodynamics, a very efficient engine).

2. Introduce ambitious CO_2 standards for trucks in the EU.
Binding standards for new trucks and buses would deliver the 30-50% fuel efficiency improvements and CO_2 reductions. The post-2020 truck standards would provide investment certainty to truck-makers and automotive-suppliers, while helping EU Member States plan policies to achieve the 2030 climate goals.

3. Incentivize public authorities to procure zero-emission trucks.
The revision of the Clean Vehicles Directive should require publicly-procured trucks to be zero-emission by 2030. As public companies usually rely on light or medium trucks in urban areas, they would have no economic reasons to procure other than clean vehicles by 2030.

4. Introduce a mandatory CO_2 differentiation of tolls for all vehicles.
With a 75% discount for ZEVs in the Eurovignette Directive… 75% toll discount for zero-emission vehicles would encourage the use of tolls as a smart taxation system promoting sustainable transport behavior.

5. Set a Zero-Emission Vehicle mandate for trucks.
Manufacturers selling trucks in the EU should be required to sell a minimum amount of trucks, as this will ensure a progressive transition to alternative powertrains. A ZEV mandate for trucks would also give the European truck manufacturing industry a competitive edge globally.

James Nix

Director of Freight and Climate at Transport & Environment

What innovations can we expect from truck manufacturing between now and 2050?

MAN is starting to build more than 100 fully electric urban delivery trucks a year at its plant in Steyr near the Austrian-German border. Daimler has committed to series production from 2021, again focusing on urban and regional delivery trucks. And a similar announcement from Volvo is expected shortly. Chinese firm BYD is already supplying ZEV trucks from its Rotterdam base; and Tesla, after launching its fully electric 40t long-haul truck last November, is taking orders from customers around the world including the EU.

How will truck electrification contribute to reaching the EU's climate goals?

E-trucks are not just desirable; they are necessary. The T&E model shows that, yes, more efficient internal combustion engines are necessary on the path to full decarbonization, but better diesel engines in trucks are not sufficient on their own. ZEV trucks are needed to meet the EU's 2030 target. Transport emissions need to get as close to zero as possible by 2050. That takes a staged approach in the decades leading up to mid-century. Europeans need to build, buy and use ZEV vehicles, all this increasing steadily, and with road transport accounting for 26% of emissions, e-trucks are a key part of this jig-saw.

How can the EU secure leadership in electric trucks?

It all starts with good standards which means a robust proposal from the European Commission in May 2018, followed by progressive changes by the Parliament and Council later in 2018 and early 2019. The starting point is a 24% emissions reduction by 2025; that's on a 2016 baseline: it would be 22% if a 2019 baseline is used. Moreover, we need a mandate that ensures 5-10% of new trucks are zero emission by 2025.

The interaction between renewables and sustainable mobility in the EU is growing ever stronger.

What do you think can accelerate uptake of electric trucks by haulers?

As knowledge of total cost of ownership (TCO) spreads, we can see haulers flocking increasingly to ZEVs. Already Alstom highlights a TCO for e-buses equal to that of EURO 6 diesel. McKinsey claims TCO parity is already here for some truck categories and very close for others. Lower maintenance costs play a big part.

What other benefits do you think electrification will bring to the EU?

Cleaner air; quieter, calmer streets; EU-generated revenue staying within the EU to purchase energy produced in Europe... Also, the share of renewables added to the grid each year: 80% of all new European power generating capacity is wind or solar. As older plants are retired or put on standby (typically coal-burning stations), Europe's energy grid is getting cleaner. Put very simply, the interaction between renewables and sustainable mobility in the EU is growing ever stronger.

TRANSPORT & ENVIRONMENT

URBAN DELIVERY TRUCKS
Germany

Daimler has started producing electric trucks for urban delivery purposes. The first 10 eActros trucks will be rolled out as part of an initial test fleet deployment, before the start of full-scale production scheduled for 2021. The drive system comprises two electric motors located close to the rear-axle wheel hubs. The eActros is be powered by two lithium-ion batteries with an output of 240 kWh. Its driving range averages 200 kilometers. A full recharge takes between three to 11 hours, depending on the power of the charging station. These technical specifications make the eActros suitable for goods transport operations in urban areas.

TESLA'S ELECTRIC TRUCKS
World

UPS reserved 125 Tesla trucks shortly after Tesla unveiled its new product. That makes it the largest public pre-order to date. Tesla expects the truck to be in production in 2019. Even if electric trucks will be more expensive to buy than conventional ones (the Tesla truck will cost around $200,000), UPS expects semi-trucks to deliver a lower total cost of ownership than conventional vehicles, at an estimated $120,000. Another major company, PepsiCo, pre-ordered 100 Tesla trucks, which illustrates that a solid business case backs up the transition to electric trucks.

E-HIGHWAYS GALORE
Sweden

Siemens has developed a catenary system for electric trucks, which is already running in Europe on two kilometers of road north of Stockholm. E-highway trucks are twice as efficient as conventional trucks and can provide substantial benefits in terms of reduced pollutant emissions, while contributing to diminish the carbon emissions from HDVs. The system works with a pantograph combined with a hybrid drive system. Thanks to a sensor on the pantograph the catenary system hooks up and disconnects automatically at speeds of up to 90 km/h. On roads without catenary infrastructure, the truck can either run on a battery or on its conventional powertrain. The advantage of the e-highway system is its high efficiency, its flexibility and the comparatively lower vehicle and infrastructure cost. According to the German environment agency, it is by far the most cost-effective route towards zero/low emission trucking. By 2050, 40-60% of highway trucks could be e-highway trucks.

(Left) The Mercedes-Benz eActros. Source: Daimler
(Middle) Tesla's new electric semi truck during a presentation in Hawthorne, California, USA. Source: Reuters
(Right) Catenary system for hybrid trucks in Sweden. Source: Siemens

As coordinators of this report, REVOLVE and the European Copper Institute would like to thank Tim Hurst and Damian Brady from the Communication team of the International Renewable Energy Agency for facilitating the Foreword by IRENA's Director General Dr. Adnan Z. Amin that contextualizes Europe's role in the global energy transition.

REVOLVE would also like to thank the industry leaders for taking the time to answer their respective interview questions and in particular those that helped provide content for their industries, notably: Yoann Le Petit, Clean Vehicles & New Mobility Officer from Transport & Environment (T&E) for the chapters on buses and trucks; Danielle Kutka, Project Officer at the European Biomass Association (AEBIOM); Sara Tachelet, Communications Officer from REScoop; Andrés Pinto-Bello, Policy Analyst at Smart Energy Europe (smartEn); Michela Bortolotti, Communications Manager at Hydrogen Europe; Doriana Forleo, Communications and Events Officer at the European Association for Storage of Energy (EASE); Dana Popp, External Relations & Communications Manager at Euroheat & Power (EHP); and Michał Zakrzewski, Smart Living & Competitiveness Director, Diana Yordanova, Communication Manager, and Romanos Antonopoulos, Junior Communication Specialist from Home Appliance Europe (APPLiA) that also participated in hosting the 1st DecarbEurope Forum on 4 June 2018 in Brussels at the start of the EU Sustainable Energy Week.

Contacts:

Stuart Reigeluth, Founder, REVOLVE:
stuart@revolve.media | +32 2 318 3984
Hans De Keulenaer, European Copper Institute:
hans.dekeulenaer@copperalliance.eu | +32 2 777 70 70

Disclaimer

This report is printed on 100% PEFC-certified recycled paper
Cover: Cocoon Silk 300gr
Inside pages: Cyclus Offset 90gr

ARTOOS | HAYEZ
communication production house
CO_2 NEUTRAL COMPANY
ISO 14001
100% GREEN POWER
SUSTAINABLE DEVELOPMENT
PRINTED CLIMATE NEUTRALLY
CERT. NUMBER : 53520-1805-1005

PEFC
PEFC/07-32-269
PEFC Recycled
This product is from recycled and controlled sources
www.pefc.be

NOTES

NOTES