DECARB EUROPE

Connecting technologies for a cleaner future

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2017

The goal of our DecarbEurope initiative is to engage decision-makers in policy and industry by showing cost-effective technical solutions that each reduce European greenhouse gas (GHG) emissions by several hundred million tons per year. This multi-channel media campaign includes 9 organizations and 2 media partners. Our role is to act as an ecosystem-builder that connects technologies, policies and markets to decarbonize the EU economy. This unique campaign provides a cross-sector roadmap for GHG reductions that is not limited to a single technology.

Each solution promoted by DecarbEurope is technology-based, cost-effective, market-mature, scalable and provides concrete solutions for a smart and user-centric energy system with ambitious targets. We recognize that these promising technologies each experience specific market, regulatory and/or technological barriers which hinder their full-scale activation. We therefore encourage policy and market instruments to remove some of the barriers in order to unlock the significant contribution these solutions can bring to reaching EU climate objectives.

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REVOLVE

ENERGY EFFICIENCY in Industrial Processes

Miguel Arias Cañete

Commissioner (2014-2019)
of Climate Action & Energy
at the European Commission

Six months after the entry into force of the historic 2015 Paris Agreement, countries across the world are getting on with putting their commitments into practice. Over 140 countries – and counting – have ratified the agreement in record time, and the 2016 Marrakesh climate conference showed that the spirit of Paris continues to ignite action around the globe.

What's more: governments that are committed to fulfil their Paris pledges through ambitious climate policies are joined now by a growing movement of businesses, investors, cities and citizens who see the potential of the sustainability transformation and are already busy building the new economy.

The direction of travel is clear, and the facts speak for themselves. Record levels of new renewable energy capacity are added every year, and costs are going down at an impressive rate. Last year, investment in renewables capacity was roughly double that in fossil fuel generation. Moreover, for the third year in a row, global economic growth in 2016 was not accompanied by an increase in greenhouse gas emissions.

Nevertheless, a transformation of this magnitude will not happen overnight and will require a stable regulatory framework that is flexible enough to adapt to the challenges ahead. In this context, in November 2016, the European Commission delivered the 'Clean Energy for all Europeans' package: a set of measures to help Europe implement the Paris Agreement, boost economic growth, spur investment and technological leadership, create new employment opportunities and enhance citizen welfare. The package will also help us meet our ambitious 2030 energy and climate goals: reduce our greenhouse gas emissions by at least 40%, achieve a binding 30% energy efficiency target at European Union level, increase the share of renewable energies in our energy mix by at least 27% and continue improving electricity interconnections between Member States.

In other words, Europe aims to modernise its economy, ensuring secure, affordable and climate-friendly energy and boosting job creation. The package will bring an increase of up to 1% in GDP over the next decade and the creation of 900,000 new jobs. These are in addition to more than one million workers already employed in the renewable sector in Europe and around one million in the energy efficiency sector.

But to create growth and jobs, the EU industry must be at the forefront of the clean energy transition. Accordingly, the Commission welcomes industry-led initiatives that might strengthen industrial links in the overall value chain and integrate non-economic actors such as social partners and consumer organisations. Initiatives like DecarbEurope, which engage decision-makers in industry and policy with cost-effective technical solutions, can help to promote the EU global leadership in clean energy and low-carbon technological solutions.

Overcoming the numerous challenges of the energy transition will require an active use of technologies and innovation, attract investments, accelerate growth and create new jobs. Research and innovation are vital to support Europe's global competitiveness and leadership in advanced renewable energy technologies and energy efficiency solutions. Industrial initiatives also have an important role to play in driving European innovation and global competitiveness. Some good examples of industry-led initiatives can be found in solar energy, energy efficiency, smart grids and energy storage sectors.

To achieve our goal, we need sustainable energy solutions and concrete actions to ensure that low-carbon innovation is deployed more widely and brought to the market more quickly. I am confident that DecarbEurope will help us in the transition towards a low-carbon society.

For the third year in a row, global economic growth in 2016 was not accompanied by an increase in greenhouse gas emissions

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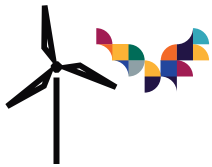


Bernard Respaut

Chief Executive of
European Copper Institute

The European Union's leadership on climate change relies on reducing greenhouse gas (GHG) emissions from energy-intensive sectors, and equally all the way down their respective value chains. To reach reductions that will keep us "well below 2 degrees Celsius" as stipulated at the CoP21 in Paris 2015, we need structured support for the full decarbonisation of technologies to foster economic growth and to consolidate EU leadership on addressing climate change globally.

The European copper industry is committed to maintaining a prominent role in this field. Since the late 1990s, it has pioneered strategies that trigger and support substantial carbon reductions in the downstream industrial, residential, service and transport sectors of Europe. When combined, these strategies can offer a comprehensive solution to profoundly decarbonising the EU's economy in the coming decades. The focus of these initiatives is on more efficient production and consumption of energy as it represents the bulk of Europe's decarbonisation potential.

Industrial companies can – and should – significantly expand their contribution to urgent climate action by taking responsibility for the energy consumption of their products, in addition to improving their own energy and carbon footprints. On the latter front, the European copper industry has shown strong commitment, reducing its own energy consumption by 60% since 1990. EU copper industry emissions are now equivalent to 4.5 million tons of CO_2 annually, which represents 0.1% of the EU's total emissions (4,550 million tons).

In the transition to a sustainable energy system, copper is the material of choice for more efficient production and consumption of electricity. The exceptional conductivity of copper makes it unavoidable when increasing the efficiency of equipment and vehicles or when integrating more renewable sources in the energy production mix. Using one additional kilogram of copper in a device (like a generator, transformer or motor) will reduce energy-related greenhouse gas emissions over its lifetime by 100 to 7,500 kilograms, depending on the application, generating energy savings of 24 to 2,400 EUR. Copper is also a highly sustainable material that can be fully recycled without any loss of performance and offers lifecycle benefits such as durability, safety, reliability, mechanical strength and corrosion resistance.

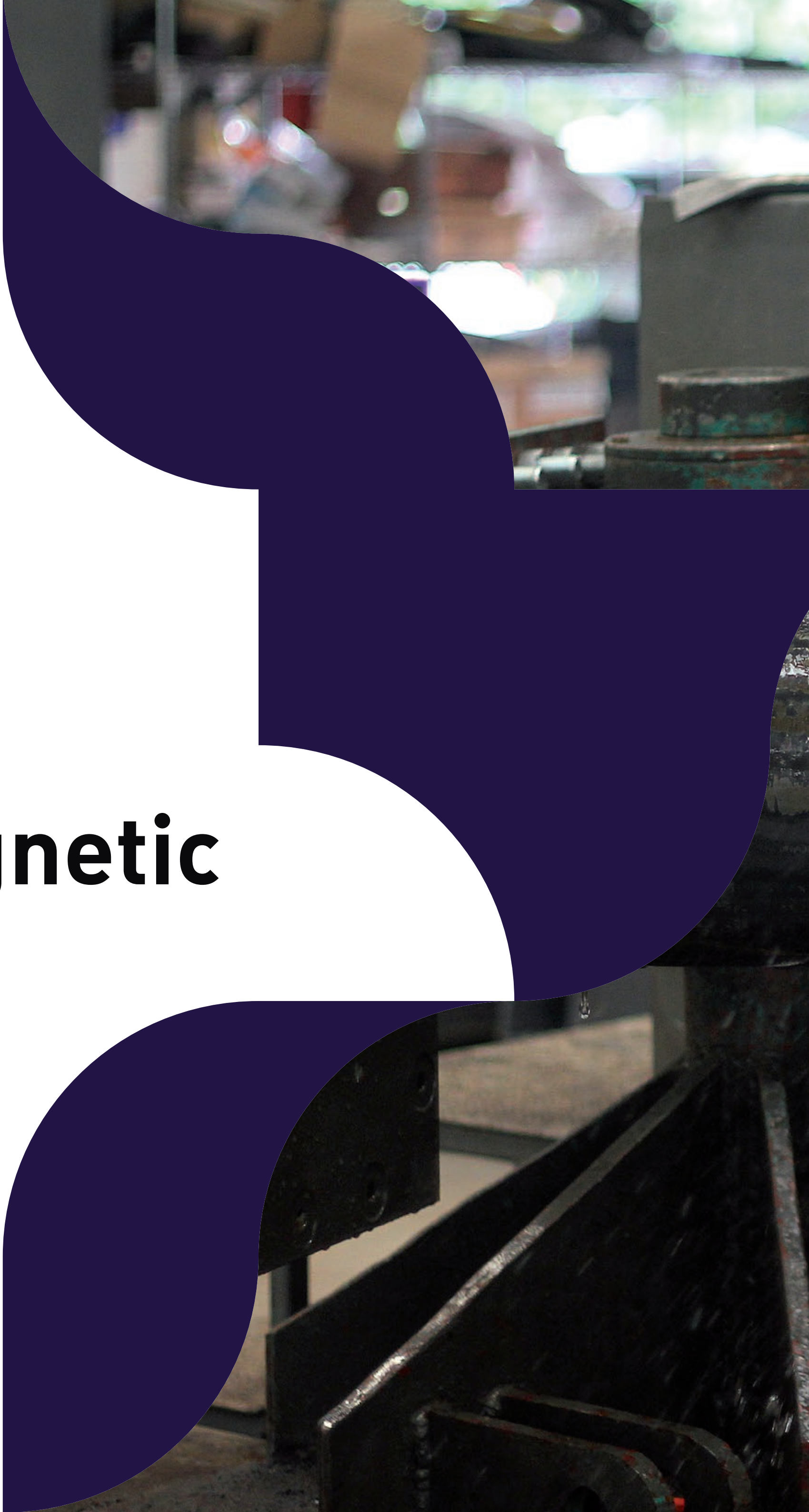
DecarbEurope goes one step beyond "technologies" (in the sense of "components") and also covers systems, because energy efficiency requires more than just efficient components. Systems need to be designed, installed, commissioned and operated with overall energy efficiency in mind, aiming at optimal energy management.

These are exciting times for the EU in its energy transition journey and at ECI, we believe that DecarbEurope can make a significant contribution to ensuring this transformation is a success. This is just the beginning of our journey to a cleaner world...

The goal of our DecarbEurope initiative is to engage decision-makers in policy and industry with cost-effective technical solutions that each reduce European GHG emissions by several hundred million tons per year.

Cu European Copper Institute
Copper Alliance

Electromagnetic Processing



Induction pipe bending at Barnshaw Section Benders, UK.
Source: Barnshaws Metal Bending Ltd

Electromagnetic processing technologies typically heat or melt materials that are used in everyday life. Process heating is central for the manufacturing of a vast array of consumer and industrial products. The conventional method is to heat the air in a furnace by combusting a fossil-fuel and transfer the heat to the work piece by convection. This convection method has major drawbacks such as lower thermal efficiency or heat transfer to the product, it requires larger space, is noisy and produces several combustion by-products such as CO, CO_2 and other particulate matters. Electromagnetic processing technologies use wavelengths in the electromagnetic spectrum that correspond to microwave, radio waves, infrared, and ultra violet to heat materials. Direct heating methods generate heat within a work piece, by either passing an electrical current through the material, or inducing an electrical current (eddy current) into the material. These technologies offer significant benefits compared to the fossil fuel alternatives and contribute to decarbonization by not producing on-site emissions. Depending on the way electricity is generated, these technologies will lead to an improvement in overall air quality. Other common advantages of electro-heat technologies, apart from the lower environmental impact, are:

Electromagnetic processing can potentially halve the final energy demand for EU process heat which is 20% of Europe's final energy demand.

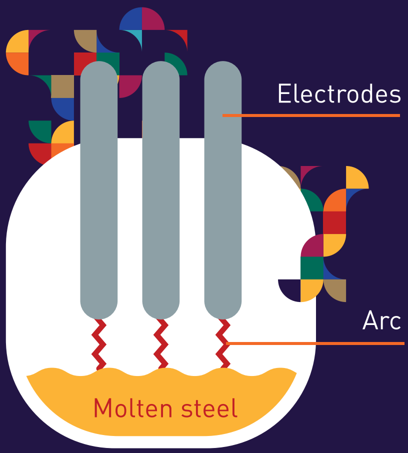
- A lower investment cost
- A compact installation relative to the production capacity
- No fuel transport and storage is required

The inherent power of most electro-heat technologies lies in the fact that they generate heat within the target material, leading to advantages in terms of process control and end-use energy efficiency. Typically, a factor two improvement in end-use efficiency can be observed, depending on the process. This means that electromagnetic processing can potentially halve the final energy demand for EU process heat which is 20% of final energy demand in the EU.

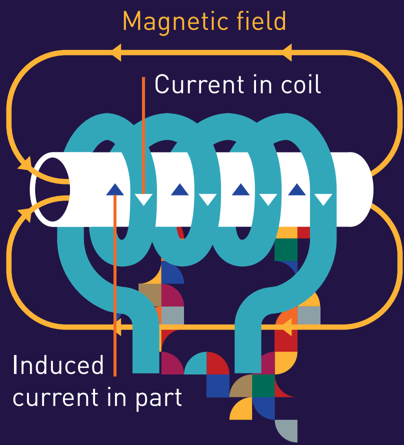
Another important difference in electrical versus fossil energy furnaces is in the oxidation losses of the materials processes. Typically, oxidation losses are 2-4% in fossil burners and 1% or lower with electromagnetic processing. While a few percentage losses of material through the chimney may not seem a lot, this difference is significant since it occurs every time a material is recycled, and the lifecycle environmental impact of the material lost has to be attributed to the process where the material is lost. Europe needs these technologies to meet its energy and climate objectives, and to achieve circular economy ambitions.

HEATING PROCESSES

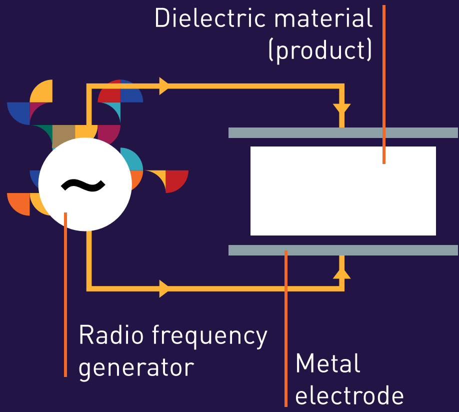
Electric arc heating



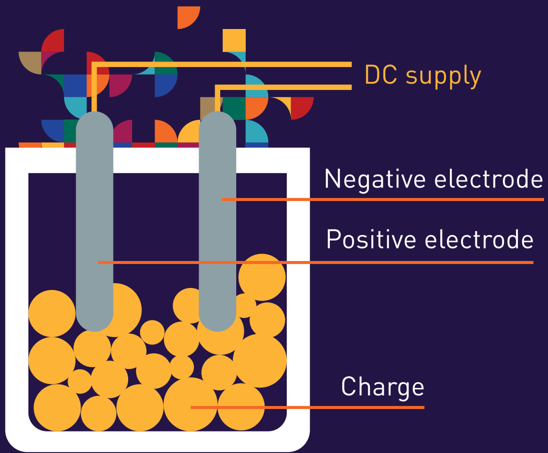
Induction heating



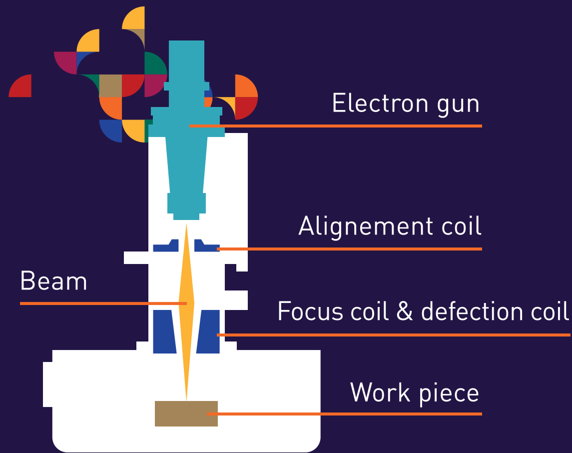
Dielectric heating



Direct resistance heating



Electron beam heating



1. An estimated **90%** of industrial thermal processes in Europe are powered by non-electrical energy carriers (gas, coal, oil).

2. Electrical heating methods **save final energy**, as the energy is used more effectively and in a more targeted manner.

6. It is possible to replace the major part of energy carriers (gas, coal, oil) currently used for process heat with electricity.

7. Electromagnetic processing technology offers the opportunity to **increase demand response** potential for industry.

Switching the most energy-intensive industries in Europe from fossil fuel to electricity would save 5 billion tons of CO_2 by 2050 (on average up to 150 million tons per year which is more than 3% of total EU annual emissions).

3. **Increasing renewables** in the energy mix means that the electrification of industrial heat processes becomes a cost-effective way of decarbonizing Europe.

4. From a lifecycle perspective, electromagnetic processing technologies exhibit significantly better results than local fossil fuel heating systems in terms of CO_2 emissions.

5. Process advantages are often the main driver for electro-heat technologies: higher productivity, high level of automation, high reliability, reproducibility, etc.

8. **Demand Side Management (DSM)** programs are of growing importance and are expected to play an important role in any electricity system of the future.

9. Electric furnaces and ovens in the EU is a growing industry with a high share of > **50%** export value.

10. Electromagnetic processing technologies facilitate the integration of electrical renewables.

Sources: Fraunhofer ISI, UIE, ECI, Institute of Electrotechnology, Leibniz University of Hannover

1. **Switch fuels to electromagnetic processing (EP) technologies.**
Switching from heating fuels to electricity produces net final energy savings as well as primary energy savings in an increasingly renewable electricity system. Such savings should be added to the list of options in Article 7(2) of the European Energy Directive (EED), provided that the 25% limit in Article 7(3) is increased accordingly.

2. **Provide a level playing field for all heating sources in the RED.**
An important bias towards combustion technologies in the heating & cooling sector can be observed in RED Article 23. The approach should be significantly broadened and equal footing needs to be provided for alternative technology options based on electricity.

3. **Increase the share of renewables in the heating and cooling sector.**
RED Article 23.3 on heating and cooling should provide an explicit focus on the case for replacing fossil fuel-based systems by electricity. The electrification of industrial heat processes can take place mainly through two routes: heat pumps and electromagnetic processing technologies.

Electromagnetic technologies use electricity to produce a useful thermal effect. They have the potential of largely displacing fossil fuels used in industry (~2,000 TWh/year). Significant efficiency gains of final energy are obtained, which requires the application of a multiplication factor to the amount of renewable electricity used.

4. **Widen the application and innovation scopes for EP technologies.**
While EP technologies are ready for market, their application to individual processes needs to be investigated and engineered on a case-by-case basis. While this is obviously a role for the market to play, a network of centers of competence could greatly facilitate technology adoption in this sector, moreover since many manufacturers of EP technologies are SMEs.

5. **Develop technology further for emerging electromagnetic processes.**
While many EP technologies have been available for decades and can be considered highly mature, many promising emerging technologies merit further development, such as plasma-arc, electron-beam and laser heating or microwave and radiofrequency heating.

Baskar Vairamohan

Senior Technical Leader at the Electric Power Research Institute

How do electromagnetic processing technologies contribute to the energy transition?

Electromagnetic processing technologies offer significant benefits compared to fossil fuel alternatives, such as not producing on-site emissions.

Induction heating generates heat within the workpiece, in contrast to conventional processes, and the location of the heating can be applied to a precise area on the metal component to achieve accurate and consistent results. Heat depth can be adjusted to the surface or can include the entire cross section. Temperatures can be controlled and because heat is generated internally, induction processes do not require a furnace enclosure or a large working area.

Microwave heating uses specific parts of the electromagnetic spectrum to heat non-conductive materials internally. The major advantages of using a microwave system for industrial processing include: rapid heat transfer, volumetric and selective heating, compactness of equipment, speed of switching on-and-off, and a pollution-free environment as there are no products of combustion.

How is electromagnetic processing a cost-effective solution to decarbonize industries?

Using induction heating as an example, the most notable advantages are:

Rapid heating of parts: induction heating of the workpiece provides much higher heating rates than the convection and radiation processes that occur in furnaces.

Fast start-up time: furnaces contain large amounts of refractory materials that must be heated during start-up, resulting in large thermal inertia. The internal heating of the induction process eliminates this problem and allows much quicker start-up.

Lower energy costs: when not in use, the induction power supply can be turned off because restarting is so quick. With furnaces, energy must be supplied continuously to maintain temperature during delays in processing and to avoid long start-ups.

Ease of automation: many manufacturers have completely automated their induction heating equipment. Automatic transfer devices, such as walking-beam conveyors pick and place mechanisms, and robots are used in conjunction with programmable controllers and computers. Parts can be washed, induction hardened, washed again, and tempered automatically.

Easier process control and monitoring: new and more precise methods of controlling the process variables are constantly being introduced. Because parts are heated individually, rather than in batches, it is much easier to control repeatability and monitor the process on a part-by-part basis. Some of the newer developments allow for real-time process monitoring.

Compact footprint: induction heating installations are generally much smaller than conventional gas-fired heating furnaces, and induction processes typically require no insulated enclosures, yielding a much smaller floor space requirement. Manufacturers can thus make more productive use of their floor space.

What are the challenges to adopting more electromagnetic processing technologies?

Short production runs: induction heating is the most cost-effective method for high-volume production of identical parts; induction coils are designed for a single part shape and powered to achieve a hardened depth. For short production runs on differing parts, the cost of induction heating may prove prohibitive because each part may require a different coil design.

Complex part geometry: induction coils must be near the metal to be effective, some complex parts are not suited for induction heating.

Diffusion processes: induction heating usually occurs in an ambient atmosphere and temperature whereby diffusion processes for altering surface metallurgy cannot be used. However, new methods that combine induction with direct heat such as vacuum furnaces promise to overcome this limitation.

Up-front cost: expensive material handling systems may be required before the advantages of higher throughput promised by inductive heating can be realized. Acquiring an inventory of induction coils may also be expensive.

Trained operators: while fewer person-hours may be required per part when compared to direct heat methods, induction heating operators need knowledge that requires specific training.

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

INDUCTION HEATING
Spain

At Porcelanosa in Spain, a GH induction ECOMOULD furnace improves the replacement and recycling process of so-called punches used in the press moulds for ceramic tile production. Punches—rubber or elastomer coatings on the steel plate—deteriorate and need to be replaced every certain number of tile cycles. With the innovative furnace, the ceramics manufacturer saved 75% on energy and tripled its production output. Where a traditional resistance furnace needed up to four hours to heat up 500 kg of steel moulds, the GH induction ECOMOULD technology achieves the same in just one hour. It is an environmentally friendly technology that improves labour conditions by avoiding contamination of burned elastomers.

ELECTRICAL FURNACE
France

With a new annealing and coating line, ArcelorMittal St-Chély d'Apcher is increasing its production capacity of high-grade non-grain oriented (NGO) electrical steel strips. In the line, the internal microstructure of the electrical steel strip is adjusted during the annealing process. The material is then coated with an insulating layer. The strip is heated up to 1,100°C by means of inductors and electrical heating elements in the horizontal annealing furnace of Drever International. The furnace can be operated with hydrogen up to 100%, helping to achieve a particularly oxide-free and clean strip surface, which is important for a high-quality material grade.

INFRARED
United Kingdom

A carbon infrared oven from Heraeus Noblelight is helping a UK company to achieve significant energy savings at its beverages plant. It has also saved factory space by allowing a single cold rinse line to be used both for juices and carbonated drinks. Since installation, the new medium wave infrared system has proved very successful, providing energy savings at the rate of £10,000 per year. As the manufacturing engineer comments:

"Heraeus explained that medium wave infrared was ideally suited for heating glass and then proved this in practice. Apart from helping us to save on energy costs, the new system also allows us to cold rinse bottles before heating. This is important as it means that the rinse line can now be shared with the carbonated drinks line without major modifications, and cost, as it is impossible to fill carbonated drinks in heated bottles."

(Left) Innovative ECOMOULD furnace. Source: GH Induction
(Middle) New annealing and coating line in St-Chély d'Apcher. Source: Drever International
(Right) Pre-heating of glass bottles prior to filling. Source: Heraeus Noblelight GmbH, Infrared Process Technology

Solar thermal water heating tubes, France.
Source: EEG Solution Energie

Solar Thermal

The basic principle common to all solar thermal systems is simple: solar radiation is collected and the resulting heat conveyed to a heat transfer medium – usually a fluid but also air in the case of air collectors. The heated medium is used either directly (to heat tap water for example) or indirectly by means of a heat exchanger which transfers the heat to its final destination (for instance in space heating or industrial process heat). Solar thermal systems are used in all continents, including the Antarctica.

Solar thermal must be clearly distinguished from two other renewable energy technologies using the sun directly – Photovoltaic and Concentrated Solar Power – both of which provide electricity, while solar thermal provides heating and cooling.

Solar thermal technologies are very flexible and can adapt to a wide range of situations and can be used on small and large scale. This technology is mainly used for: **1)** domestic hot water and space heating, **2)** district heating, **3)** industrial process heat, and **4)** air conditioning and cooling.

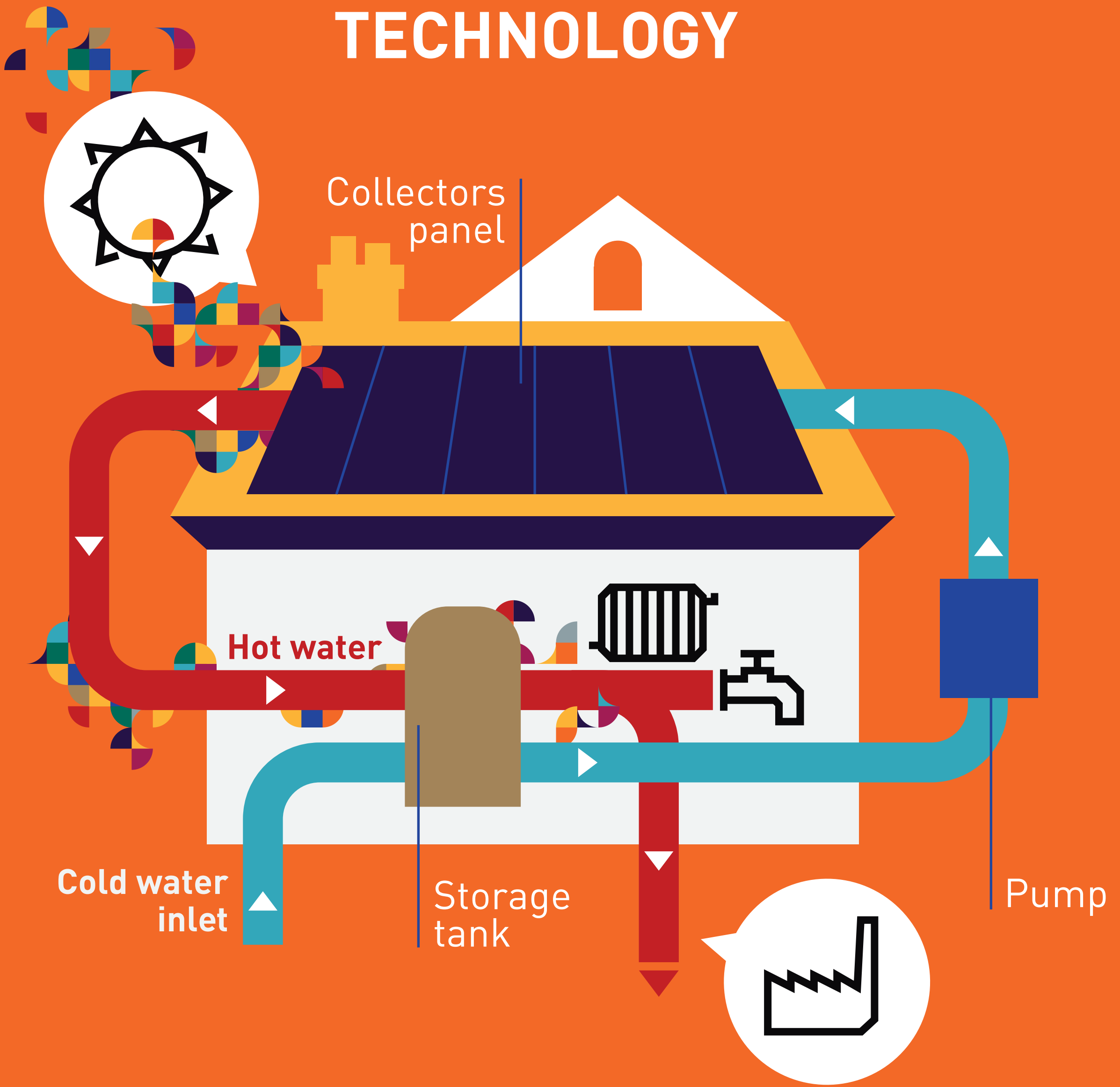
Solar thermal systems are used in all continents, including the Antarctica.

Most of the solar thermal systems in use today are related to low-temperature heat demand in buildings: providing **hot water** and **space heating**. The solar thermal heat can be produced on-site for individual houses or delivered via a **district heating** network. For **industrial processes**, solar thermal systems are well suited for generating low temperature heat up to 150°C. There are well-known applications of solar thermal heat in breweries, mining, agriculture (crops drying) or textile sector. Furthermore, over 150 large-scale SHIP systems are documented worldwide ranging from 0.35 MWth to 27.5 MWth (39,300 m²). **Solar cooling** is also suitable for residential, commercial, institutional and industrial use. One of the technologies used for cooling purposes are thermally-driven chillers which use thermal energy to cool down gases or fluids. This thermal energy can be provided by different technologies, including solar thermal energy.

DID YOU KNOW?

The largest solar thermal plant in operation at the end of 2016 is located in the Danish town of Silkeborg. This plant has a capacity of 110 MWth, using almost 157 thousand square meters of solar thermal collectors, enough to cover 22 football fields. This plant is operated by the municipal utility Silkeborg Forsyning and will cover 20% of the annual heating demand of the 21,000 clients connected to their district heating network. This solar district heating system is more than twice the size of the largest previous system (49 MWth), also located in Denmark.

SOLAR THERMAL TECHNOLOGY



1. Worldwide, in 2015, solar thermal employed some **730,000 workers** and generated a turnover of **€21 billion.**

2. Worldwide, in 2015, with **435GWth**, solar thermal had a similar installed capacity to wind, and higher than solar PV.

3. In Europe, there are currently **over 10 million solar thermal systems** installed.

4. The total installed capacity of solar thermal across Europe represents **47.5 million square meters**, equivalent to **33.3 GWth**.

5. The installed solar thermal stock represents around **250 GWh of storage capacity** in Europe.

6. Annual energy generation in Europe from solar thermal is estimated at **23.5 TWh_{th}**.

7. In 2015, the turnover of Europe's solar thermal sector was **€1.9 billion.**

8. **23,700 jobs** in Europe were provided in 2015 by the solar thermal sector.

9. In 2015, capacity additions of solar thermal across Europe was **1.9 GWth**, equivalent to **2.2 Mtoe** of energy.

10. By 2050, solar thermal could reach 133 Mtoe in Europe, covering **47% of low temperature heat demand.**

In 2015, Europe's solar thermal sector saved some 6.3 million tons of CO_2.

Sources: ESTIF, IEA-SHC

1. **Promote renewable heat.**
Decarbonising heating and cooling will be the main challenge for Europe's energy system, and renewable heat will be the main answer. The EU Clean Energy Package proposes specific measures to mainstream renewables in heating which is positive, but these need to be more ambitious, and binding for Member States.

2. **Exploit synergies between renewable heat and energy efficiency.**
The EU Clean Energy Package offers several opportunities to promote such synergies, be it in the efficiency obligations schemes, or in the Smart Financing Initiative (SFI). Rather than playing one against the other, the two must be seen as complementary, while removing fossil fuels from our energy system.

3. **Increase the replacement of heating systems.**
When replacements are planned in advance, renewable heating technologies such as solar thermal are easier to be integrated in the systems. Promoting the labelling of existing heating systems would encourage citizens to shift to more efficient and renewable appliances.

4. **Increase the renovation rate of buildings.**
Accelerating the rate of building renovations, along with advancing nearly zero-energy buildings (nZEB) standards, plus integrating minimum levels of renewables, would greatly help to promote a more decarbonised heating supply. Building renovations are the perfect opportunity to take advantage of the synergies between energy efficiency and renewable heating, and solutions, such as prefabricated building façades with integrated solar thermal collectors, already exist in the European market!

5. **Adopt efficiency as a systemic approach.**
The transformation of the heating sector can take many forms, not all leading to real decarbonization: the debate on heating electrification must take into careful consideration the difference between efficient electrification (where it makes sense, and only using efficient appliances and processes) and a wilder one aimed at keeping alive the utilities' dirtiest fossil fuel assets, thanks to increased demand, by promoting the most inefficient solutions.

Robin Welling

President of the European Solar Thermal Industry Federation

Why should solar thermal be promoted?

Solar thermal technologies are highly efficient and reliable, and have been used in European households for decades: there are now around 10 million systems installed in Europe. Solar thermal is cost-competitive against traditional fuels and can work in combination with all other heating technologies to integrate and upgrade different heating sources. The European industry is dominated by SMEs and is the worldwide technological leader for solar thermal. The large majority (over 95%) of the systems sold in Europe are manufactured within the EU. With 33.3 GWth of installed capacity in Europe, corresponding to covering domestic hot water needs of more than 10 million households, the sector represented in 2015 a turnover of €2 billion, employing almost 25,000 workers and replacing more than 6 million tons of CO_2 (worldwide, these numbers are tenfold). For solar thermal, nearly half of the jobs are in retail, installation and maintenance. This work is local and creates jobs mainly in European SMEs. For society, it is even better: solar thermal replaces imported oil and gas with local labor in a healthy sector.

What is the market potential of solar thermal technology by 2050?

Solar thermal technology can play a crucial role in the 2050 European energy mix. Since solar thermal technology can cover up to 47% of low temperature needs by 2050 with a favorable policy framework, which represents 133 million tons of oil equivalent, one can imagine how households and industry could save yearly on their energy bills.

Solar thermal is growing in specific sub-sectors, such as industrial process heat and district heating where it is being used to upgrade systems at a better price to reduce carbon emissions and air pollution impacts, as well as to provide or complement seasonal storage solutions. For industrial process heat, the potential is tremendous: now there are just a few solar process heat systems in operation, while around 40% of the industry's heating needs lie in the range of temperatures that can be delivered with solar thermal.

How can solar thermal contribute to Europe's decarbonization agenda?

The heating sector is among the highest emitters of greenhouse gases. While electricity is far from being decarbonized now and cannot provide a decarbonized supply alone to cover the entirety of the space heating and hot water demand, solar thermal is a quick win to shift from fossil-based heating supply, to a cheap, abundant and clean source of heating. The solar thermal sector saved between 6.3 and 7.9 million tons of CO_2 in 2015 in Europe – a number which could reach 687 million tons of CO_2 per year in 2050 with the proper incentives of policy-makers. Worldwide, solar thermal is already delivering a CO_2 reduction of more than 120 million tons.

What are the challenges to deploy solar thermal in Europe?

Most challenges are great opportunities for our sector: with the legally-binding European renewable energy targets for 2020 fast approaching, solar thermal constitutes a good opportunity for Member States to deploy a renewable energy source that can contribute to the fulfillment of their 2020 targets. Solar thermal is a technology that could be easily deployed further if adequately supported. A properly designed support scheme can activate investments from households to industry. Regarding the design of support schemes for renewable heating and cooling, the report prepared by a European project "Fair RHC Options and Trade" (FROnT) shows that investments provide a return in the short-term in taxes, job creation and the overall reduction of energy imports.

How can European policy-makers facilitate the deployment on the market of this technology?

There are several steps policy-makers can take to boost the deployment of solar thermal technology:

First of all, a proper implementation of the 2020 Renewable targets by Member States is needed and Member States must push forward their efforts to decarbonize the heating & cooling sector.

Then, European policy-makers must shape the European Clean Energy package in line with our ultimate common goal which is to achieve the 100% decarbonization of our societies by 2050.

Additionally, there are obvious synergies between renewable heat technologies and energy efficiency: together they can contribute more efficiently to removing fossil fuels from our energy system.

Finally, we need to increase the rate of building renovations and encourage citizens to replace their old heating systems with more sustainable solutions, by promoting for instance the labelling of existing systems.

ESTIF European Solar Thermal Industry Federation

SOLAR BREWERY
Austria

The system installed in the Heineken Göss Brewery, is an interesting example of the use of solar heat for industrial processes in the framework of the project SolarBrew with EU support. To enable the use of solar heat, it was important to optimize the brewing process, including the development of new heat exchangers for mashing. This led to a more efficient system, as it is possible to use hot water at lower temperatures, while steam was required previously. Mashing only needs an actual process temperature of around 60-78°C, which can be provided by solar thermal. The €320,000 investment included costs for solar collectors, piping, support construction, storage, design and commissioning, minus 50% subsidies. The Göss Brewery won the EU Sustainable Energy Awards for integrating innovative technologies in the brewing process.

WATER, BEER & WHISKEY
Ireland

The Great Northern Brewery in Dundalk, the second-largest brewery in Ireland, owned by the Guinness Company, was looking for a sustainable and cost-effective way to heat water for use in the changing and washing rooms, as well as in its canteen facility. Initial consultations pointed towards solar thermal as the technology capable of fulfilling the needs for hot water and simultaneously reduce the running costs and the carbon footprint. As a result, 80 Thermomax Heat Pipe evacuated tubes were installed to help provide hot water to the facilities from dawn till dusk, all year round, cutting greenhouse gases emissions in the process. Since then, the brewery has been subsequently acquired by the Teelings Whiskey Group and converted into a distillery, with solar thermal still forming a part of its water-heating system.

SUNNY RENOVATION
Austria

In Austria, at Graz, a series of houses built between 1950 and 1970 needed serious refurbishing as well as all the 204 flats of the Dieselweg Residential area. These flats had poor insulation and an outdated heating systems, which jointly resulted in high heating costs. On top of this, the buildings also needed other amenities, such as elevators. A refurbishment project has been launched to improve these buildings, while trying to minimize any disruption to the life of the inhabitants, allowing them to stay in their homes and reducing the time for onsite work.

To increase the energy efficiency of the building, the refurbishment process focused on the reduction of energy demand. This was achieved by improving the building insulation with prefabricated façade modules with integrated solar thermal collectors. Feeding 40m³ heat storage tanks, this new system has allowed the building to reduce its energy cost by 90%, as well as to reduce its CO_2 emissions by 80%. A great improvement for a building dating from the 1950s.

(Left) Solar facility at the Göss brewery. Source: AEE INTEC
(Middle) The Great Northern Brewery in Dundalk.
Source: Kingspan Environmental Ltd
(Right) Dieselweg Residential area, Graz, Austria. Source: AEE INTEC

Electric Motor Systems

Siemens will support the city of Vienna in optimizing its main sewage plant in terms of energy.
Source: Siemens

The role of motor systems in the energy transition

Electric motors are a major component of the technological world in which we are living. Even the most modest European households today contain easily ten electric motors. Apart from the obvious ones (the washing machine, vacuum cleaner and kitchen mixer), there are the pump systems in the heating boiler, hot water boiler and dishwasher, as well as fan systems in bathroom ventilation, computer and microwave. In industry, electric motors are even more widespread and often hidden in closed systems such as fans, pumps or compressors.

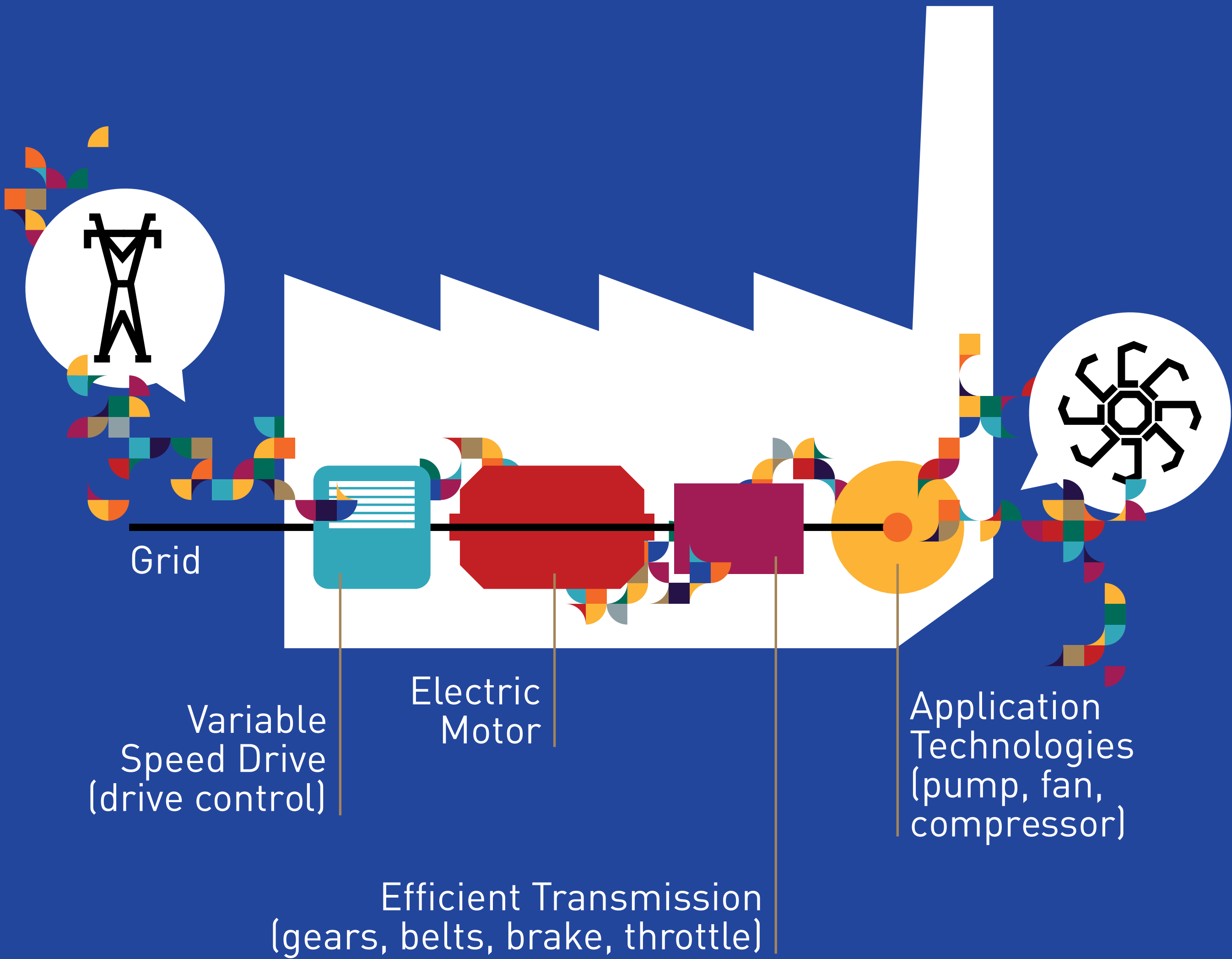
Electric motor systems currently use 53% of global electricity and 8% of global energy consumption.

In the transition towards a zero-carbon energy system, the role of electric motors will grow even further. A large part of the transition away from fossil fuel end-use to electricity-generated by renewables will occur by adopting heat pumps and electric vehicles. Both are approximately three times as efficient as their fossil fuel counterparts and driven by an electric motor. In the zero-carbon economy scenario, the estimated total share of motor systems will quadruple from 8% to 32% of all energy end-use. Therefore making those systems highly energy efficient is imperative.

The technology to make motor systems more energy efficient is available on the market and its adoption is mostly beneficial from a life-cycle costing perspective. Good work has been done: since 2011, minimum efficiency performance standards (MEPS) for the major motor categories are mandatory in the EU. Nevertheless, there is a large savings potential that could be tapped into through better adoption of existing standards, the extension of MEPS towards other motor categories, and more emphasis on an overall electric motor system's approach.

Indeed, the electric motor does not function in isolation: the motor driven unit (MDU) consists of the electric motor, sometimes controlling equipment such as a soft starter or variable speed drive (VSD), supporting mechanical equipment (gear, belt, clutch, brake…) and the application it is driving (pump, fan, compressor). The motor system also includes all other components that suffer from energy losses while executing its function (water or air ducts, throttles, valves). Optimizing this entire motor system is the best way to minimize energy use and CO_2 emissions.

MOTOR DRIVEN UNIT



1. Electric motors and the applications they drive (pumps, fans and compressors) are the single largest user of electricity, consuming > **2.5 times** as much as lighting.

2. Electric motor systems use over **50%** of global electricity and around **70%** of global industrial electricity.

5. Electric motors are everywhere - a modern home contains at least 50 motors; a luxury car has over 100 motors of different sizes.

6. By 2040, the annual global electricity savings for motors and motor systems could reach up to **3,050 TWh** per year.

Energy efficient motor driven systems can save Europe over 100 Mt GHG emissions a year.

3. Better energy efficiency regulations could reduce global electricity demand for electric motors by **24%** in agriculture, buildings, and industry.

4. Electric motor-driven systems used in heat pumps and electric vehicles save a factor three in final energy compared to combustion technologies.

7. New and existing technologies offer the potential to reduce the energy demand of motor systems across the global economy by **20% to 30%** with short payback periods.

8. Over **50%** of all electric motors are almost twice as old as their operating life expectancy which is between 20-30 years.

9. The global market for electric motors is expected to expand by **2.5%** per year until 2019, primarily driven by growth in developing countries.

10. **40-60%** of all motor systems would benefit from the proper use of Variable Frequency Drives (VFD) to improve the energy efficiency of industrial motor systems.

Sources: OECD, IEA, 4E EMSA, Swiss Topmotors Program, ECI, Dutch Green Deal Efficient Motor Systems.

1. **Reinforce market surveillance of existing regulation.**
There is a lack of capacity in the EU to check motor compliance. Given the number and variety of motors, certifying existing labs of manufacturers seems the most pragmatic way. The US system for market surveillance can serve as a good example that includes fines for non-compliance, a website for reporting non-compliant motors, random compliance testing, and manufacturers who can take action to measure motors of competitors in their labs (if a motor is non-compliant, the result is verified by an independent laboratory).

2. **Reinforce policy-maker involvement in international standardization.**
Nearly all policy-making concerning electric motors (whether MEPS, labelling or energy audits) are directly or indirectly based on standards. Involving policy-makers in the process of standardization committees will facilitate the development of appropriate test methods, performance metrics and efficiency classifications, while keeping pace with government objectives. This will lead to standards that are sufficiently reliable, robust and fit for policy implementation and could increase overall harmonization.

3. **Expand MEPS to other motor categories.**
In line with IEC 60034-30-1, small motors (0.12-0.75 kW) and large motors (375-1,000 kW) should be included in the MEPS to combine motor and VSD to be equally stringent; motors without VSD should also be adopted.

4. **Promote a larger saving system's approach.**
Beyond the physical electric motor, assessing the energy efficiency of the motor driven unit or the entire motor system is difficult because it involves interactions between electrical, mechanic and electronic components and can depend on local circumstances such as the motor load. Harvesting the entire motor system savings potential could be achieved through mandatory motor system audits. A system's approach can also be promoted through propagation of energy management principles and through education and training initiatives.

5. **Connect energy and carbon emission savings with the principles of the circular economy.**
The energy transition leads to an increased use of material in electric motors (higher number of motors + material use in high efficient motors). This can be made sustainable through the principles of the circular economy, which have been defined by regulators around the world and notably in Europe. They translate into a reluctance to use rare earth materials, strong end-of-life requirements (recycling) and strengthened management systems.

Michael Björkman

Technical Director, Marketing, Danfoss Drives

Why are motors important to decarbonising Europe's energy system?

Motor systems utilize more than half of the world's total electrical energy so the efficiency of these systems is crucial when analyzing the possibilities to save energy in the future. The components of motor systems (motors and variable speed drives) already have decent efficiencies. Motors are required to meet or exceed the efficiencies defined in IEC 60034-30. The efficiency of variable speed drives is increasing to above 96%, and as higher efficiency for these power electronic devices implies lower losses, hence smaller and more compact products are possible.

The third main component of motor systems (the driven machine) offers at least an order of magnitude higher potential energy savings. Downthrottling is most often used as a regulation mechanism, but it wastes energy, that could be saved by simply slowing down the machine. Pumps and fans are the best candidates – if you can slow down your pump by 20% then the output flow will be reduced by 20% but the power required to drive the system can be reduced by almost 50%.

The extended product approach as defined in standards (IEC 61800-9-2/EN 50598-2) helps customers quantify the potential energy savings.

How can Europe ensure leadership in efficient motor systems?

Europe has been active in standardizing efficiency requirements for motor systems. EN 50598 series – a standard on how to determine the efficiency of motor driven systems – was published in 2016 and has now been converted into a global IEC standard: the IEC 61800-9 series. The foundation for a potential regulation of the efficiency requirements is now in place. The behavior of the driven machine is the subject of standards from ISO, and the first drafts of a standard for pumps will soon be published. The efficiency requirements in the forthcoming Lot 30 are a good start but they only address the motor and variable speed drive, not the whole system which is the key to energy efficiency.

How will the digital and circular economy will impact the motors sector?

The circular economy initiative will have some impact, specifically on the motor side. There the challenge is to achieve a balance between the efficiency requirements and the material requirements – as a motor designed for higher efficiency will contain more material. For a normal asynchronous motor, the efficiency can augment by increasing its size or by changing the magnetic material used. Alternative motor designs, such as permanent magnet motors, improve the efficiency at the cost of more expensive material and manufacturing methods. These alternative designs also require the use of a variable speed drive with some additional losses.

Motor systems utilize more than half of the world's total electrical energy.

The circular economy has a different impact on the efficiency of a variable speed drive. The efficiency losses of a drive determine, to a large extent, the physical size of the product. Reducing the losses can be achieved by using newer technology and is not material dependent in the same manner as in a motor. Decreasing the size therefore reduces material usage. The materials used are unfortunately not as easily recyclable as the materials of a motor. This requires more research into cost-effective methods of reclaiming the rare and expensive materials used. Variable speed drives are by their very nature digital and will perform as intelligent sensors very close to the process, opening possibilities for further system level energy optimization.

The use of variable renewable energy sources for power generation has created the need for a smart grid with increased flexibility. How can motor systems deliver flexibility in demand?

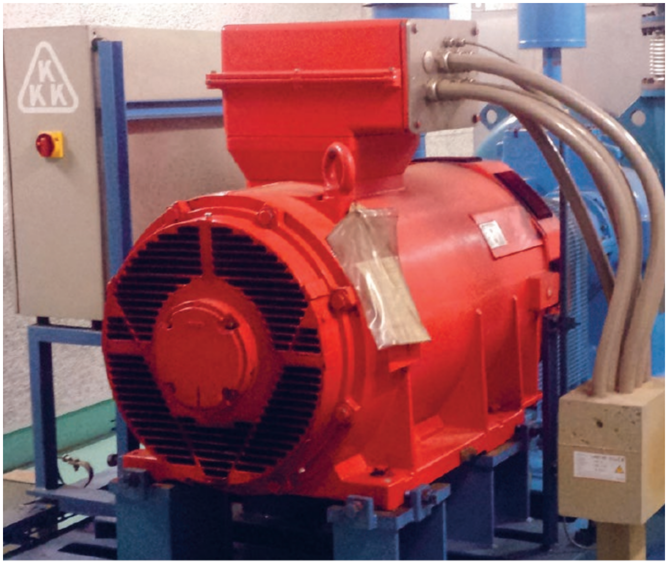
Most motor systems are controlled by some system parameter and, unless this is changed, the possibilities for demand flexibility are low. However, many applications exist where the requirements are not always carved in stone – for example it is possible to reduce the fan speed in a HVAC system if there is not enough power available without immediately impacting the comfort of people in the affected areas. Similarly, some pumping systems can be turned off, if the requirements are low, without impacting users (if there is sufficient water in a water tower, no new water is required for a period of time). In the final analysis, demand flexibility comes from the application (how much flexibility it can supply) and a motor-driven system offers an easy way to interface the controlled system with the demand side controller.

DAIRY INDUSTRY
Switzerland

Moving fluids is a key expenditure chapter in the dairy industry. Optimizing the pumping systems delivers important savings: in this case, 7% of the total electricity consumption. The key action concerns the replacement of old motors by new, high-efficiency motors equipped with an electronic regulation system (variable speed drive). This delivers energy savings in the range of 66% for this concrete application, with a payback period of about 3 years. The production volume and the quality of the product were not affected. This action didn't lead to any additional complexity in terms of operation and maintenance.

WASTEWATER TREATMENT
Switzerland

This water treatment plant processes 60 million cubic meters of waste water per year, from a city of 720 000 inhabitants. Motors driving pumps and compressed air consume 26 GWh of electricity per year. The optimization of the motor systems has delivered 15% energy savings, which allowed to recover the investment in about 2 years. This project was carried out in the context of a broader technical and energy renovation programme, which carefully analyzed the pumping systems and compressors. The actions included the integration of a smart control to better regulate the load of motors according to the waste water condition.



SYSTEM EFFICIENCY
Netherlands

Sugar manufacturing is an energy intensive process. An old pumping system based on 3 units was replaced by a new, high-efficiency system using only two motors (one in operation, the other is used as a backup). The new system delivered a 40% cut in operational expenses, which made possible to recover the investment within 2 years. Savings are in the order of 1GWh per year. Additionally, the factory worked on a more efficient pipe network where aspects such as friction loss in the pipe and the number of corners were investigated.

According to Green Deal Efficient Motor Systems, By implementing the new pump system, an annual saving of €105,120 can be realized. The initial investment might be high, however the break even point can be reached within a year or two depending on the initial investment. Assuming the new motor system has a life time cycle of 15 years, the total saving over a period of 15 year can be more than €1,000,000.

(Left) Redundant pumping system, a 7.5 kW motor.
Source: Topmotors and Impact Energy
(Middle) Motor and compressor. Source: Topmotors and Impact Energy
(Right) Sugar refinery of the Suiker Unie in Hoogkerk, Groningen, The Netherlands. Source: Wutsje

Cogeneration

BASF's cogeneration plant,
Ludwigshafen Verbund site, Germany
Source: BASF SE

Cogeneration (Combined Heat and Power or CHP) is the simultaneous production of electricity and heat, both of which are used. In conventional power plants, heat is not recovered when generating power, while in cogeneration plants the heat is put to effective use to provide comfort (space heating and hot water) or services (high temperature heat and steam) for homes, public buildings, businesses and industry. **Trigeneration means that the plants can also produce cooling in addition to heat and electricity.** Heating and cooling accounts for around half of the EU's energy use, hence the importance of saving energy in these sectors by boosting energy efficiency.

Cogeneration optimizes the energy supply to all types of consumers, with the following benefits for both users and society at large:

• Increased efficiency of energy conversion and use. **Cogeneration is the most effective and efficient form of power generation.**

• Lower emissions into the environment, in particular of CO_2, the main greenhouse gas. Cogeneration is a vital part of the EU's carbon reduction policies.

• Large cost savings, providing additional competitiveness for industrial and commercial users, and offering affordable heat for domestic users.

• An opportunity to move towards more decentralized forms of electricity generation, where plants are designed to meet the needs of local consumers, providing high efficiency, avoiding transmission losses and increasing and supporting the grids by providing balancing and ancillary services through electricity markets. This will particularly be the case if natural gas is the energy carrier.

• **Improved local and general security of supply:** local generation, through cogeneration, can reduce the risk of consumers being left without supplies of electricity and/or heating. In addition, the reduced need for fuel resulting from cogeneration reduces import dependency, thus helping to tackle the key challenge of ensuring a secure energy supply in Europe.

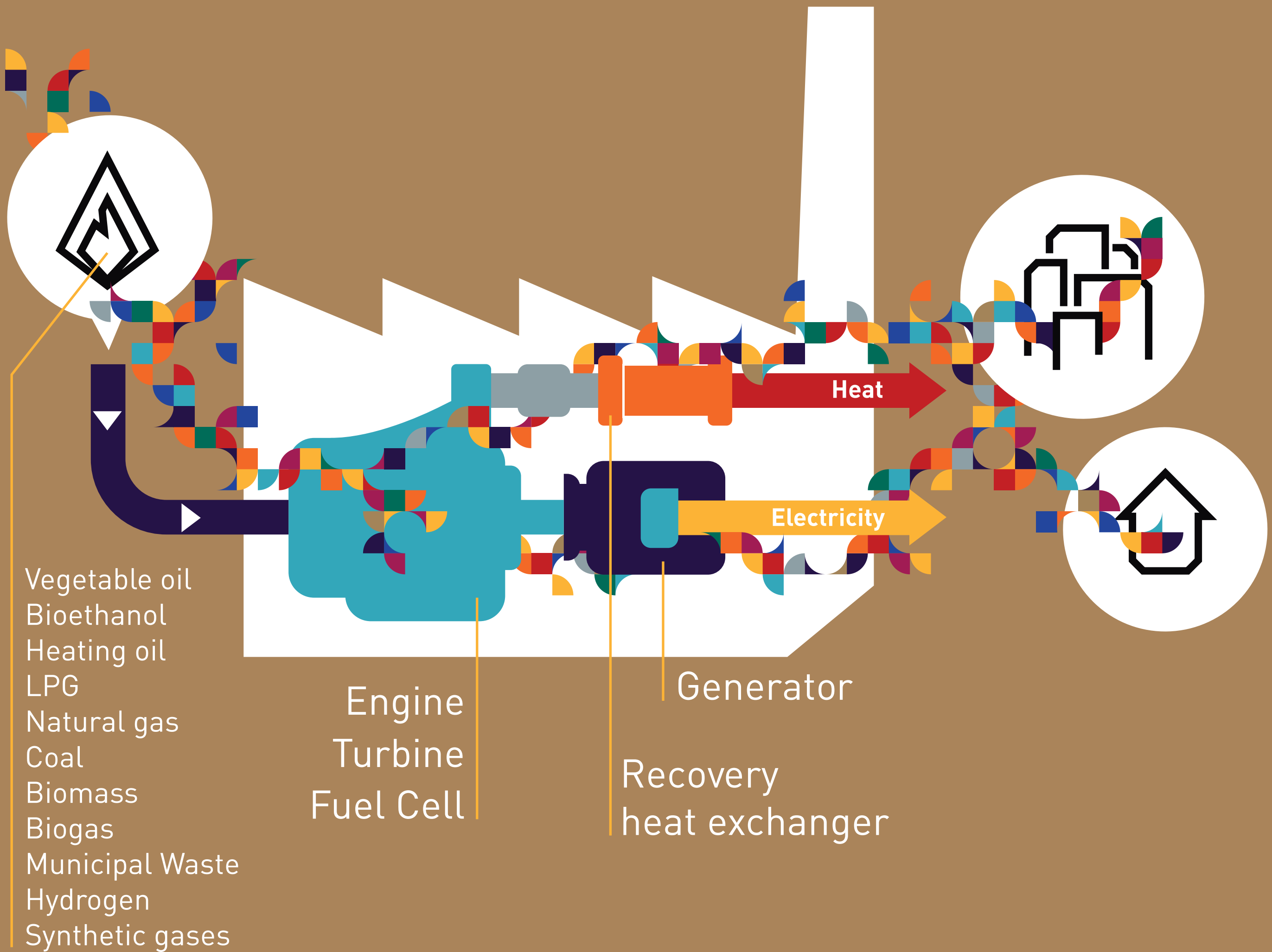
• An opportunity to increase the diversity of generation plants and provide competition in generation: cogeneration provides one of the most important vehicles for promoting efficient distributed energy solutions.

• Increased employment: numerous studies have concluded that the development of CHP systems is a generator of jobs.

DID YOU KNOW?

The world's first power plant, built at Pearl Street in New York City by Thomas Edison in 1882, was a CHP design. While the steam engines provided grid electricity, Edison made use of the thermal by-product by distributing steam to local manufacturers, and heating nearby buildings in the Manhattan area.

COGENERATION PLANT



1. **15%** of the EU's heat (850 TWh) and **10.5%** of its electricity today comes from high efficiency CHP.

2. In Europe, **Latvia** has the greatest share of cogeneration in total electricity generation (47.5%) followed by **Denmark** (44.3%).

6. Renewable fuels to cogeneration have more than doubled between 2005 and 2015 from **9% to 21%**.

7. As a flexible and dispatchable technology, cogeneration helps integrate more intermittent renewables on the grid.

Today, cogeneration already saves Europe around 200 million tons of CO_2 per year.

3. The efficiency of a cogeneration installation can exceed **90%**.

4. Cogeneration offers energy savings ranging between **15-40%** when compared to the separate supply of electricity and heat from conventional power stations and boilers.

5. **60%** of all bioenergy electricity is produced by cogeneration.

8. **70 million Europeans** use district heating; half of its heat is supplied by cogeneration today.

9. Around **100,000 Europeans** self-generate electricity and heat in Europe with on-site CHP, in homes, businesses and industry.

10. Cogeneration could generate **20%** of the EU's electricity efficiently with a range of increasingly renewable fuels.

Sources: Eurostat, COGEN Europe, Euroheat & Power, CODE2.

1. Take an integrated approach to the energy transition.

To engage consumers, policy should take a comprehensive perspective and break the silos between energy conversion, transmission, distribution and consumption, as well as harness synergies between different energy carriers (electricity, gas, heat), fostering consumer choice between different sustainable energy solutions. Taking an integrated approach to energy and climate policy, for example in setting objectives, energy planning, implementation and reporting, is particularly important for customers to reap the full benefits of cogeneration.

2. Allow investors and consumers to achieve real efficiency improvements.

Acknowledging the potential for demand reduction, supply side efficiency opportunities are equally important for achieving the energy efficiency objectives across the entire economy and can deliver significant savings in a more systematic way. Policy signals need to reflect when and how heat and electricity can be used and produced most efficiently. A robust and transparent methodology capturing these principles (within the Primary Energy Factor) will allow consumers to take informed decisions to achieve real efficiency gains.

3. Apply cogeneration to thermal generation for both conventional and bioenergy fuels.

Applying cogeneration to thermal power-only and heat-only generation technologies is key to achieve immediate energy savings and CO_2 reductions, helping to meet intermediary and long-term climate and energy efficiency goals cost-effectively. This means implementing the comprehensive assessments for heating and cooling in the Energy Efficiency Directive (EED). The incentive to promote biomass use in cogeneration plants in the latest Renewable Energy Directive (RED) review, in the EU Clean Energy Package, is a step in the right direction.

4. Enable innovation policy to boost cogeneration as part of new energy market designs.

There is significant potential for innovation in how cogeneration can be optimized to address the emerging needs of a decarbonised, high renewable energy system in the future. The policy framework for energy innovation should prioritize these aspects.

5. Unlock all available flexibility opportunities on the energy market.

Including demand response, heat and/or electricity storage, balancing services, aggregation of both demand and supply, the capability to provide grid support and ancillary services by cogeneration should be better recognised and rewarded. This will be achieved by facilitating the connection to the grid of cogeneration embedded in the local economy. In addition, the structure of the electricity tariffs should be based on the use-of-the-system, taking into consideration system costs avoided by having cogeneration installed.

Tim Rotheray

Board Member of COGEN Europe

How big is the European market for cogeneration?

Heat represents today more than 40% of energy consumption in Europe. There is a general need of security of heat supply in industry and there is an increasing need for energy independence, as homes and business will want to produce their own clean and affordable power and heat. The potential for expansion of the CHP market is very large. There is at least room for a doubling in the capacity of CHP across Europe, depending on the already existing installed capacity at Member State level. High efficiency cogeneration produces today 15% of the heat and 10.5% of the electricity generated in Europe. The EU-funded CODE2 project showed that the cost-effective potential for cogeneration in 2030 amounted to 20% of the total electricity and 25% of the heat expected to be produced in Europe.

Will cogeneration be phased out by 2050 as a transition technology?

Most commentators would say that this is unlikely. We may need more thermal capacity by 2050. If we need heat to make power, then we should not waste heat but capture and use it – whatever the heat source. By 2050, our energy system will have changed dramatically with almost entirely decarbonized electricity and significant share of renewables in the grid, the system will be smarter and more interactive between producers and users. Those users will need efficient and reliable heat and power. Cogeneration is reliable, can be used on demand and cuts energy waste. In a decarbonized energy system, with lower carbon energy inputs (sun, wind, low carbon gasses or biomass) we want to ensure we are not wasting any. If we want to ensure that consumers get a good deal from decarbonizing our energy then we must cut energy waste. That is why cogeneration has a strong role now, and will grow in the future.

Do smaller sources of energy like peat have an increasing role to play in cogeneration?

Cogeneration uses a range of fuels and can be an effective solution for rural and remote communities, such as with the use of LPG or local bioenergy. However, it is important that whatever fuel is used it contributes to the European energy transition. We are seeing a decreasing role for coal in Europe and peat is likely to face a similar fate but whatever fuels we use in Europe, fossil or renewable, we should do so with minimum waste.

Increasing renewable fuels. Renewable cogeneration has doubled in the last 10 years. Sustainably sourced bioenergy fuels, in wastes sites and local production are very valuable. We should burn them carefully and extract as much energy value as we can. Increasing renewable cogeneration improves the use of bioenergy and reduces carbon emissions even further.

The share of renewable fuels used in cogeneration has increased from 9% to 21% […] Cogeneration can be renewable and enable more renewables.

How can cogeneration continue to bring down its carbon emissions?

Today, cogeneration already saves more than 200 million tons of carbon per year. But industry is stepping up its efforts to do even better. The 2050 trajectory demands a great deal more work. There are three key areas for cogeneration reducing emissions:

Flexibility. Cogeneration plants can operate with increasing flexibility. Running at times of low wind and sun, thus displacing higher carbon coal and gas generation, but it can then slow and stop generation at times of abundant low carbon power. Flexible cogeneration is a key method for increasing the level of renewable generation on the power networks by managing renewable generation intermittency.

Decarbonized gas. In the longer term, there is likely to be a greater role for decarbonized gas. Europe's gas grid is a great energy store and we will need a lot of decarbonized energy storage if we are to achieve Europe's climate ambitions. Decarbonized gas will be hugely valuable, to address the flexibility and reliability challenge of electricity and heat supply.

COGEN EUROPE The European Association for the Promotion of Cogeneration

PROMINENT
Netherlands

Prominent consists of 26 members with 36 sprawling, high-tech greenhouse facilities that supply 20% of the Netherlands vine tomatoes. To meet their on-site power, heating, CO_2 and artificial lighting needs, Prominent's members use combined heat and power (CHP) systems that produce a total of more than 150 megawatts (MW). A majority of this power (up to 131 MW) is supplied by 50 of GE's Jenbacher gas engine CHP systems. With GE's myPlant 2.0 Asset Performance Management solution, Prominent can increase the gas engine CHP performance and reliability on the 50 Jenbacher units installed at the high-tech greenhouse facilities. GE estimates that the industrial Internet will bring productivity gains of $8.6 trillion for industrial companies in the next 10 years – more than double the future value of the consumer Internet. We are moving from reactive to predictive data solutions.

STADTWERKE KIEL
Germany

A gas-fired thermal power plant with an efficiency of more than 90% will set new national standards. The order for 20 Jenbacher (J920) FleXtra Gas Engines with a total of 190 MW is the largest in Jenbacher company history. In replacing the existing coal-fired community power plant, the environmentally-sound energy solution will supply the region with district heating. Due to the high proportion of wind energy reliance in the regional network, the power plant must be able to supply full power to the local network at short notice to compensate for volatility of available wind in order to ensure network stability.

WINDSOR CASTLE
United Kingdom

Like its London sister, Buckingham Palace – the 11th century Windsor Castle is using cogeneration technology to help heat and provide power.

The 200kW decentralized energy system supplies hot water and electricity to the Royal Household and has been in operation for 11 years. The vast scale of the castle with its many banqueting halls and entertainment rooms means it is a prime site to reap the benefits that Combined Heat and Power Systems provide.

The cogeneration system was installed under a Discount Energy Scheme whereby the Castle simply purchases the electricity generated by the system at a discounted rate while incurring no capital costs for the project. With no initial payback period, the financial savings for the Royal Household are immediate.

The cogeneration system reduces the Castle's reliance on energy supplied from the grid and will achieve annual carbon dioxide savings of 418 tons, which is equivalent to the carbon that would be offset by a 343-acre forest.

(Left) Source: GE
(Middle) The new gas engine heating power plant is being built on Kiel's eastern shore.
Source: Stadwerke Kiel AG/ Luftbildservice Bernot
(Right) Windsor Castle. Source: John 'K'


SEA POWER
A2SEA

Wind Power

Wind power is one of the fastest growing industrial segments in the world. Being once a niche market in Europe, wind has added more capacity than any other technology over the last decade. Now, wind power nears the 500 GW milestone, providing jobs and power to regions across the globe.

Wind energy is the most efficient solution to reduce emissions in the power sector. Onshore wind is now the cheapest form of new power generation on average across Europe. Its costs fell 60% in the last 10 years. And offshore wind costs fell 50% in just the last two years. Wind power emits no greenhouse gases or air pollutants during its operation and uses minimal water. Wind power is a scalable and reliable renewable energy source on- and offshore, which allows for hedging against fuel price fluctuations.

9 out of 10 Europeans are in favour of wind power in their country. This is because wind mitigates climate change and contributes to energy security and economic growth. With community ownership, wind also gives people a stake in their own energy. In 1985, wind turbines were under 1 MW with rotor diameters of around 15 meters. Today, 7.5 MW onshore turbines are the largest with a rotor diameter of 127 meters. And offshore, the industry installs 8 MW turbines with a rotor diameter of over 160 meters and a tip height of nearly 190 meters.

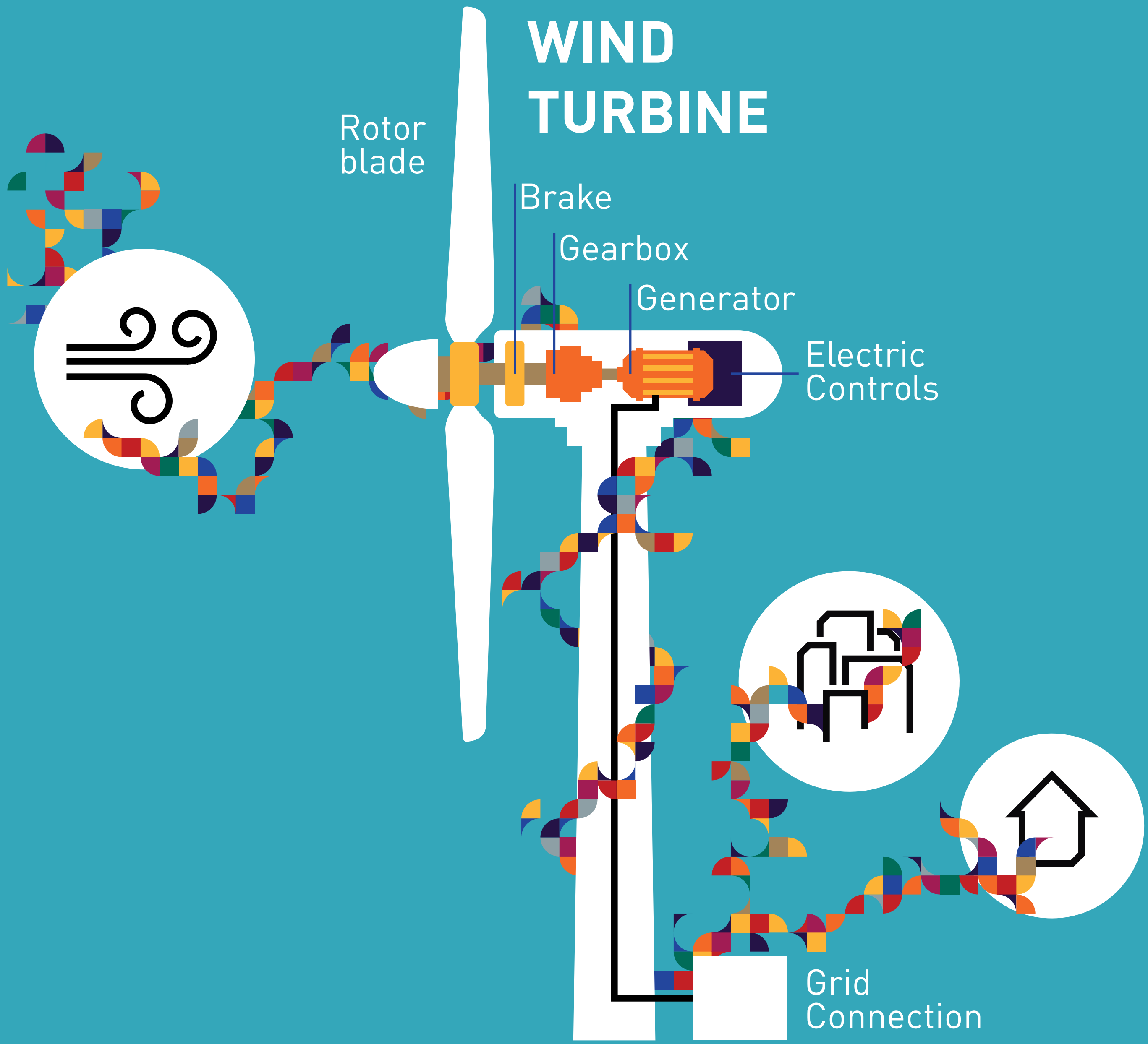
Grid operators can integrate large amounts of wind power. Wind covered 37% of Denmark's electricity demand last year and generates more than 100% on windy days. To make the energy transition work, governments need to reinforce and better connect the power grid, which would bring down prices for consumers.

More and more companies are turning green. Investors seek long-term, stable revenues in a low interest rate environment. The European wind sector has long been open to overseas investors, who look at Europe as a major infrastructure hub for onshore and offshore technologies alike. And industrial consumers are hungry for more wind energy as they look for green electricity that comes at stable and competitive prices. Europe today has over 1.2 GW of renewables capacity contracted through corporate power purchase agreements, 90% of which is in wind energy.

Europe still leads the world in wind technology. Three out of the top five global turbine manufacturers are European. Wind is an asset for Europe with €11bn exported in 2015 and €27.5bn invested in 2016. In comparison with the rest of the world, European wind energy markets are, however, slowing down. Regulatory factors, bad design or slow adaptation to market dynamics, are the main problem. The transition is not self-running but a difficult road leading to a prosperous destination.

DID YOU KNOW?

Check how much wind power was generated in your country with one click. See Europe's electricity mix and hourly wind power generation here: **windeurope.org/daily-wind**



WIND TURBINE
Rotor blade
Brake
Gearbox
Generator
Electric Controls
Grid Connection

1. Wind accounted for **51%** of the EU's new power capacity in 2016.

2. **154 GW** of wind power is installed in the EU today, which makes wind the second largest power generator by capacity in the EU.

3. In Europe, the average onshore turbine produces enough electricity for 1,500 households; the average offshore wind turbine can power over **4,500 households.**

4. Onshore wind is already the cheapest form of new power generation in many parts of the world. By 2025, IRENA sees a global cost reduction potential of **35%** for offshore wind and **26%** for onshore wind.

5. Almost every second turbine in the world is made in the EU. European manufacturers have exported **77 GW** or over **25,000 wind turbines** to other parts of the world so far.

6. Europe's wind industry's turnover grew to **€72.5bn** in 2015 and it invested €27.5bn in 2016.

7. In the run-up to Paris CoP21, **70 non-EU countries** highlighted wind power as a climate mitigation tool in their national determined contributions.

8. Europe's wind industry employs more than **300,000** people today.

9. A single blade of the biggest wind turbine is **88.4 m** long and exceeds the wingspan of an Airbus 380.

10. Wind turbines in the EU met **10.4%** of the EU's electricity demand by generating almost 300 TWh in 2016.

In 2016, wind power saved Europe an estimated 191 million tons of carbon dioxide emissions.

Sources: WindEurope, IRENA.

1. Show more ambition on renewables.

The 2015 Paris Climate Agreement was a landmark achievement but just a first step. The indicated deployment of renewable energy does not yet suffice to prevent a 2°C temperature rise. EU policy makers should therefore adopt an EU-wide binding renewable energy target of at least 35%. National governments should also provide clarity on future volumes to speed up the energy transition and slow down climate change.

2. Modernize our grid and make the market fit.

Energy is Europe's last commodity that cannot be freely traded and faces software and hardware problems. The rules governing grid and electricity markets were tailored to the power systems of the past, made up of centralised fossil fuel production with national boundaries. Europe's market design should become more flexible and fit a large share of renewables. Eventually, the existing grid infrastructure has to shift from old, fragmented grids to a smart, Europe-wide network.

3. Cut red tape and attract investors.

The investment climate in the European power sector is deteriorating. Projects become riskier and struggle to attract affordable capital as they lack visibility on their long-term revenues. This is particularly relevant for wind energy projects, which require large upfront investment and are highly sensitive to financing conditions. Governments can increase visibility with easier permitting and mechanisms that prevent abrupt policy changes. Fully implementing the guarantees of origin tracking and facilitating power purchase agreements would attract more investors.

4. Decarbonise transport, heating and cooling.

Transport, heating and cooling consume three quarters of EU's energy and account for the lion's share of emissions. By 2015, renewables grew fast to 29% in the power sector. But the others lag behind with an 19% share of energy from renewable sources in heating and cooling, and only 7% in transport. In order to further the energy transition, EU institutions should set trajectories for renewables in all sectors and promote electrification and hydrogen powered by green energy.

5. Facilitate world-class innovations.

The EU wants to strengthen its industrial base and become number one in renewables. This mission requires ongoing innovations and is at risk if Europe continues with business as usual. A dedicated EU strategy for research and innovation and aligning funding with the climate and energy targets leads to success, strengthens the industrial base and sustains the EU's leadership in both on- and offshore wind energy.

Giles Dickson

Chief Executive Officer of WindEurope

Why does the energy transition matter to Europe?

Europe is still recovering from an economic crisis and has entered unchartered territory. The energy transition is a tangible solution to kick-start the economy and mitigate climate change, one of humanity's most serious threats. The average global temperature in 2016 was almost 1.4°C higher than in the 19th century, and Europe is warming faster than other parts of the world. Energy accounts for almost 2/3 of greenhouse gas emissions but modernising our energy system brings more than environmental benefits.

Replacing fossil fuels with wind power and other renewables modernises our economy, renews business models, strengthens Europe's competitiveness and creates new jobs. Wind power is on a journey to modernise regions and make Europe a global leader in clean technologies.

What are the main challenges?

Information, technology and policies.

Plugging the economic benefits and busting myths is essential to ditch the fossil fuel addiction. A large number of people still perceives wind power as a nice add-on although 90% of Europeans want wind power because they care about their environment. Wind power is an indispensable mainstream industry, employing more than 300,000 people in Europe alone and producing enough electricity for 90 million European households. Thanks to ongoing innovations, wind is ready to become central to Europe's power system and continues to drive down costs.

Onshore wind is the cheapest form of new power generation in many parts of Europe, and offshore wind power is maturing fast. In 2015, the biggest offshore wind players issued a united pledge to make the technology fully competitive within a decade. Recent strike prices of €50-73 per MWh confirmed that we are on track in prime locations in Denmark, Germany and the Netherlands. Unleashing wind power's full potential, however, depends on a robust pipeline and supportive policies post-2020.

All EU Member States still import and subsidise fossil fuels at a high cost, and thereby risk a carbon lock-in. Policy-makers have started to modernise the existing energy infrastructure and make the market fit for renewables. These first steps should not lead to complacency but a momentum to decarbonise the economy further.

> Wind power is on a journey to modernise regions and make Europe a global leader in clean technologies.

How important is electrification?

Europe will not accomplish a competitive, low-carbon economy with business as usual. Electricity accounts for less than a quarter of Europe's energy demand, and the EU's reference scenario indicates that it will not change significantly over the next decade unless electrification increases.

Electrifying transport, heating and cooling is good for the economy and environment if powered by wind energy. Air pollution costs the European economy €1.4 trillion a year, which is why Member States need to step up their efforts on electro-mobility. The Dutch Parliament, for example, supports electric vehicles and voted for a motion to ban the sales of new petrol and diesel cars by 2025.

At the same time, the Netherlands aims at 6,000 MW onshore wind by 2020 and 4,500 offshore wind by 2023. Dutch wind turbines could then produce enough electricity to power 1,000,000 Tesla S in a clean way.

How do Europeans benefit from the energy transition?

Wind power re-energises regions, even those in decline. Like many seaports, Hull has a proud history. Shifts in the global economy however led to deindustrialisation and rising unemployment. This changed a decade later.

In March 2014, Siemens and Associated British Ports announced that they would jointly invest £310m into two wind turbine production facilities in the region. The Green Port Hull takes advantage of the offshore wind opportunities in the North Sea and established a world-class centre for emerging renewable industries.

The Green Port Growth Programme supported over 300 local companies, 400 employees and 600 apprentices in getting a skilled job with energy, manufacturing and engineering firms. The number of green jobs in the region climbed to 1,000, turning one of the UK's poorest towns into a bustling hive of commercial activity. The operation of the Hull plant began in December 2016 and recruitment is ongoing.

Wind EUROPE

MONKS TURN TO WIND ENERGY
Romania

The turbines of the largest onshore wind farm in Europe (600 MW), Fantanele–Cogealac, are everywhere around Casian, a village in south-east Romania. Father Iustin was the first monk in the Constanța region to power his monastery with renewable technology and now he gladly advises other monasteries to do the same. The renewable energy system at Casian supports the lives of the five monks at the monastery, powering their fridges, washing machine, stove, lights and one laptop computer, and perhaps most importantly, it powers the water pump that is responsible for pumping water from the 150 meter well. 10 monasteries in the Casian area have followed in the footsteps of Casian and have some sort of renewable energy system.

GIVING POWER TO THE PEOPLE
Germany

In June 2016, the Südliche Ortenau civic wind farm, about 50km south of Strasbourg, emerged on the territories of the municipalities of Ettenheim, Schuttertal and Seelbach. The wind farm comprises seven modern 2.75 MW GE wind turbines with a hub height of 139 meters. In a normal wind year, each of these turbines can power 2,000 households, and together they produce enough electricity to cover 30% of the demand in all three municipalities. Independent from volatile fossil fuel prices, locals can buy the generated power directly at a stable price. Ownership and information are the cornerstones of a strong community. In September 2016, The Bürgerwindpark Southern Ortenau won the Best Community Project Award of WISE Power.

LM WIND POWER OFFSHORE BLADE PLANT
France

The scale of offshore wind turbine blades requires special facilities and a location close to the sea. That was part of the reason for LM Wind Power to start construction on March 23 in the presence of French Prime Minister, Bernard Cazeneuve, in Cherbourg, Normandy, for its first dedicated offshore blade plant. The Cherbourg plant is LM Wind Power's 15th plant worldwide, and the company brings an initial investment of more than €100 million to the project including factory, equipment and start-up. The factory will serve all customers in the global offshore wind blades market. The plant is expected to grow to a capacity between 1.2 and 2.0 GW and employ around 550 people. LM Wind Power was acquired by GE for $1.65 billion in April 2017.

(Left) Fântânele-Cogealac Wind Farm, Romania.
Source: Sandri Alexandra Buzatu
(Middle)The Bürgerwindpark Southern Ortenau.
Source: Roland-Geisheimer
(Right) Source: LM Wind Power

Energy Management

Energy management standards ensure that senior management commits to energy efficiency and that all staff play a significant role in the process.

Source: Siemens AG

The development of effective energy management across EU organisations should be viewed as a strategic opportunity and priority. About 11% of all EU energy consumption can be economised cost-effectively through the adoption of more effective energy management.

Energy management is a structured process through which organisations seek to optimise their energy use, by reducing energy waste, increasing energy-efficiency and increasing the share of renewable energy. Energy management standards, such as EN ISO 50001, offer a comprehensive approach to address the various behavioural, technological and regulatory requirements related to energy efficiency. They help companies embed energy management within the entire organization.

In general energy management has five distinctive steps, implemented iteratively and repeatedly in a process of continuous improvement.

• **ENERGY POLICY (1)** - Established by senior management, defines the overall guidelines for the efforts to achieve greater energy efficiency and other energy policy objectives.

• **PLANNING (2)** - Identify the significant sources of energy consumption and savings potentials. Determine the order of priority of the energy saving efforts, set targets and elaborate action plans in line with policy.

• **IMPLEMENTATION AND OPERATION (3)** - Involve employees and the whole organization commitment in the implementation of the objectives and ensure better use of energy becomes a part of daily routines including within purchasing, operation and maintenance, energy efficient design activities, etc.

• **CHECKING AND CORRECTIVE ACTIONS (4)** - Monitoring all significant energy use and consumption flows and activities. Take preventive and corrective actions.

• **MANAGEMENT REVIEW (5)** - Management periodically evaluates the implementation of the plan, objectives and operational control to ensure its continuing suitability in the light of the commitment to continual improvement.

The implementation of energy management is facilitated by specific techniques and tools. The key techniques are energy audits, monitoring and benchmarking while the key tools are energy management and related standards. The energy manager is primarily a change manager, not a technical manager.

Most companies who implement energy management standards not only immediately reduce their energy bill, but also lower their water consumption and improve waste prevention. They improve overall performance and productivity of their plant and increase their competitiveness. Moreover, they get easier access to third party financing and benefit from increased investor confidence. On a long term, energy management standards guarantee that improvements are sustained over time and that organizations continuously improve energy performance at an ever-faster pace, cutting costs year on year.

ENERGY MANAGEMENT

1. Energy management projects most commonly produce savings between **10-30%** of total energy consumption, some peak at **85%**.

2. Only **1.5%** of Europe's medium-to-large companies have adopted the ISO 50001 standards on energy management.

6. Energy bill savings that come with improved energy management total **€58 billion** on annual average in the 20-year period between 2016-2035.

7. In a resounding majority of SMEs across Europe, there is no systematic energy management planning at all.

Adoption of energy management contributes to average net cost savings of €53 billion per year to 2035 and average CO_2 emissions savings of 165 Mt CO_2 per year.

3. The industry and service sectors could save over **25%** of their energy by 2035 by adopting energy management systems.

4. Better and more widely adopted energy management has the potential to save **~26%** of EU combined energy use in the industrial and service sectors of which **19%** could be delivered through more robust policies.

5. Energy management can decrease financial risk by maximizing power availability performance, contributing significantly to reduced electrical maintenance costs.

8. About **11%** of all EU energy consumption could be avoided by adopting more cost-efficient energy management systems.

9. Investment decisions should be based on Life Cycle Costing (LLC), including energy consumption and maintenance. For electric motors for instance, CAPEX is only about **3%** of the LCC, energy consumption **95%!**

10. Energy management can decrease the number of unplanned power outages, improve the effectiveness of maintenance activities, and reduce energy consumption.

Sources: Waide Strategic Efficiency, Schneider Electric

1. Include as a strategic organizational objective, beyond regular energy audits.

Consistent with the Energy Efficiency Directive's objectives (Art.8), energy management systems can enable organizations to achieve sustainable competitiveness, decouple growth from energy consumption, improve resilience versus energy prices volatility, foster innovation (circular economy, IoT, smart energy use, decentralized prosumers), and reduce CO_2 emissions.

2. Encourage continuous improvement of operational energy management in buildings.

Energy management has the great advantage to initiate behaviour change and a culture of permanent improvement, and is therefore well adapted to buildings and their entire lifetime. Energy in buildings account for 40% of overall energy consumption and 36% of CO_2 emissions. About 75% of today's building stock will be still standing in 2050: energy renovation is a key priority.

3. Unlock and promote the vast potential of energy savings in SMEs.

Optimizing energy consumption in SMEs will reduce their vulnerability against energy prices and markets, thereby contributing to an increase of their competitiveness and more sustainable value chains. SMEs are most often referred to as the backbone of the European economy with about 20 million SMEs in EU27 accounting for at least 1/3 of total industrial energy demand.

4. Bridge the gap between energy audits and energy management.

Energy audits set the baseline and identify sets of actions for more comprehensive energy management systems. This implies a new strategy to advance best practices, transparent result, staff training, and acknowledging that energy efficiency is a means to sustainable growth. Opens source databases with trustworthy energy benchmarks and financial benefits of energy savings will bridge this gap for Member States to achieve national targets by 2020 and beyond.

5. Establish a European certification scheme across Member States.

The Italians ESCOs certification scheme embeds energy management in performance contracting and thus guarantees substantial savings by optimizing energy consumption. The approach has a significant impact on job creation and local businesses by creating and developing new markets. Organizations in other countries could also choose from different benefits and risk options from building and operating energy efficiency measures or buying energy services from ESCOs.

Dr. Bernard Gindroz

Chairman of the CEN/CENELEC Sector Forum on Energy Management

What is the role of energy management in the energy transition?

Energy efficiency has the biggest and most cost-effective potential to decarbonize Europe, but is also the hardest since it has to take place on the demand side – inside Europe's millions of businesses and hundreds of millions of households. To face this challenge, EU policy has targeted energy efficiency to a large extent through product policy over the last decades. This is the low-hanging fruit where significant progress has been made to the extent that product policy is now subject to the law of diminishing returns.

There is an order of magnitude to tackling energy efficiency at the system level rather at the product level. The energy saving potential at the system level is huge but also elusive. How can we regulate the EU's many millions of actors to design, install, commission, operate, maintain and decommission energy systems with energy efficiency in mind throughout the lifetime of a system? This is where energy management comes in. We need to make energy management an inherent part of the licence to use energy. Only through the systematic approach of "plan-do-check-adjust" can we really tackle system efficiency. Energy Efficiency First means first and foremost Energy Management everywhere.

How is energy management a cost-effective solution?

Energy management is cost-effective by definition. The principles of energy management as embedded in the ISO 50001 standard (adopted at EU level as EN ISO 50001) could be employed, though the approach will need to be differentiated. Households need standardized approaches supported through their utility or other actors. On the other extreme, energy-intensive industry tends to use ISO 50001 adoption and certification. In-between, tailored approaches can be considered for buildings, SMEs, transport, education and health campuses or even cities.

Through the systematic approach of mapping energy saving opportunities and acting on them in a cyclic manner, energy management embeds a culture of gradual and permanent improvement. In the early stages of an energy management project, the focus is on organizational change by integrating the energy management cycle into an organization. Initial measures require little or no investment since they focus on behavioral or logistic aspects. For instance, procedures

> We need to make energy management an inherent part of the licence to use energy.

can be put in place for switching off idling equipment. Or in a metals processing plant, the process can be set-up so that metal from one step does not cool down before it is processed in the next step. Such simple measures easily save 3-5% of energy use over the first few years by which time energy management starts to stick and lifecycle costing becomes embedded into processes. Efficiency becomes a criterion in procurement. Efficiency improves and starts to produce non-energy benefits such as improved productivity, better product quality and reduced maintenance costs. In the case of ISO certification, companies that adopt ISO 50001 often also certify against ISO 9001 and 14001. Through the ISO management tools, operations are improved and become less vulnerable when facing energy and economic crises, which means they are ultimately more competitive.

What are the main challenges for energy management?

Above all, we need energy managers to act as 'change-makers' in their organizations. We need a managerial approach to energy management rather than a technical approach. This means an upgrade of the skill sets for energy managers with recognized and harmonized competences. The new managers will understand the baseline and energy savings potential, forecast energy needs, strategically source energy, calculate return on investment and understand the regulatory environment. This is a new job function with skills that very few people currently have. Standardization will play a key role in improving skills and competences through harmonized approaches followed by certification.

We need sufficient energy auditors with appropriate skills and certified competences, who can oversee energy processes in buildings, industry and cities and make cost-effective improvement proposals on which energy managers can act. This requires specialized professionals for the various sectors in industry, for buildings and for homes.

ENERGY MANAGEMENT STANDARDS
Germany

Aurubis is Europe's largest copper producer and as an energy-intensive company, its annual energy cost amounts to more than €150 million for electricity, natural gas, oil, coal, oxygen etc. In 2008, Aurubis established an Energy Management department at the Hamburg plant in charge of developing an energy monitoring and management system and implementing energy saving projects. Meanwhile, several Aurubis plants have achieved ISO 50001 certification. Aurubis has been fully committed to increasing the energy efficiency of its sites for decades, and from 1990 to 2015 saw the energy consumption per ton of copper produced fall from 4.6 MWh to 2.7 MWh. The Aurubis' energy monitoring system contains over 3,000 measurement points in the Hamburg facility. One of the major challenges was the organization of all measurement data into a centralized monitoring system that provides actionable information to the team. This challenge was successfully overcome – in a recent audit, TÜV (The German Association for Technical Inspection) praised Aurubis' recording and evaluation of energy use, as well as its energy reporting and regular assessment of possibilities for energy optimization. Digitalization of Aurubis' energy use has led to the control of energy consumption via energy flows in a transparent manner and helps identify and assess potential savings systematically. To ensure an experience and information exchange on energy efficiency and energy managements workshops coordinated by Corporate Energy and Climate Affairs are carried out regularly for the entire Group.

POWER GENERATION
Italy

Since 2009, EniPower (a power generation company, established in November 1999 and controlled by the Italian Oil&Gas major Eni), completed an ambitious and innovative program to replace conventional and relative inefficient units with modern "F class" combined cycles mainly fueled by natural gas. Through investment and management actions, EniPower is improving energy efficiency in its power plants to produce electricity for the market and to supply heat and electricity to the nearby petrochemical sites of Brindisi, Ferrara, Mantua, Ravenna and to the Eni refinery of Sannazzaro de' Burgundi and heat to the district heating systems of Mantua and San Donato Milanese (MI).

Continuous improvement is being fostered, particularly targeting auxiliary consumption and distribution network losses, as electric efficiency is mainly due to externalities, such as demand, load factor, weather conditions and technological plant features. In July 2013, the "EnMS project" was launched to further integrate management systems (ISO 14001, OHSAS 18001) that achieved the ISO 50001 certification in July 2015. EniPower has reported a cumulative annual saving, compared to the initial energy baseline, of about 10.500 Toe, roughly 8% of overall auxiliary consumption, or in other words about 24,5 Kton of avoided CO_2.

(Left) Aurubis plant in Hamburg. Source: Michael Lange
(Right) Energy management has improved the efficiency of EniPower combined cycle power plants in Italy. Source: SEF Power Plant

Building Automation

The Edge is the most sustainable office building on earth with a BREEAM-NL rating of 98.36%

Source: Jeroen Meijer

Advanced Building Energy Saving Technologies

Building Automation and Controls (BAC) enhance comfort and productivity while using less energy, thus reducing costs and bills. Acting as stand-alone and related to individual technical building systems, such controls can save vast amounts of energy in the average building. These savings further rise when control systems interact with each other, such as via a building energy management system (BEMS). Moreover, such a system would early detect faults in operation and diagnose defects in technical building systems..

All too often, energy improvement in buildings is only focused on the building fabric (such as insulation) and the installed equipment (like LEDs or high-efficiency boilers), but overlooks the opportunities in more efficient and dynamic operability. This is where advanced controls and automation enter the picture.

Examples of energy reduction measures that can be realized with improved building automation and controls:

- **Smart HVAC (1)** controls use sensors to limit energy consumption in unoccupied zones

- **Automatic hydronic balancing (2)** continuously adjusts the flow and pressure in the piping system and radiators to optimize generation, distribution and emission of heat throughout the building

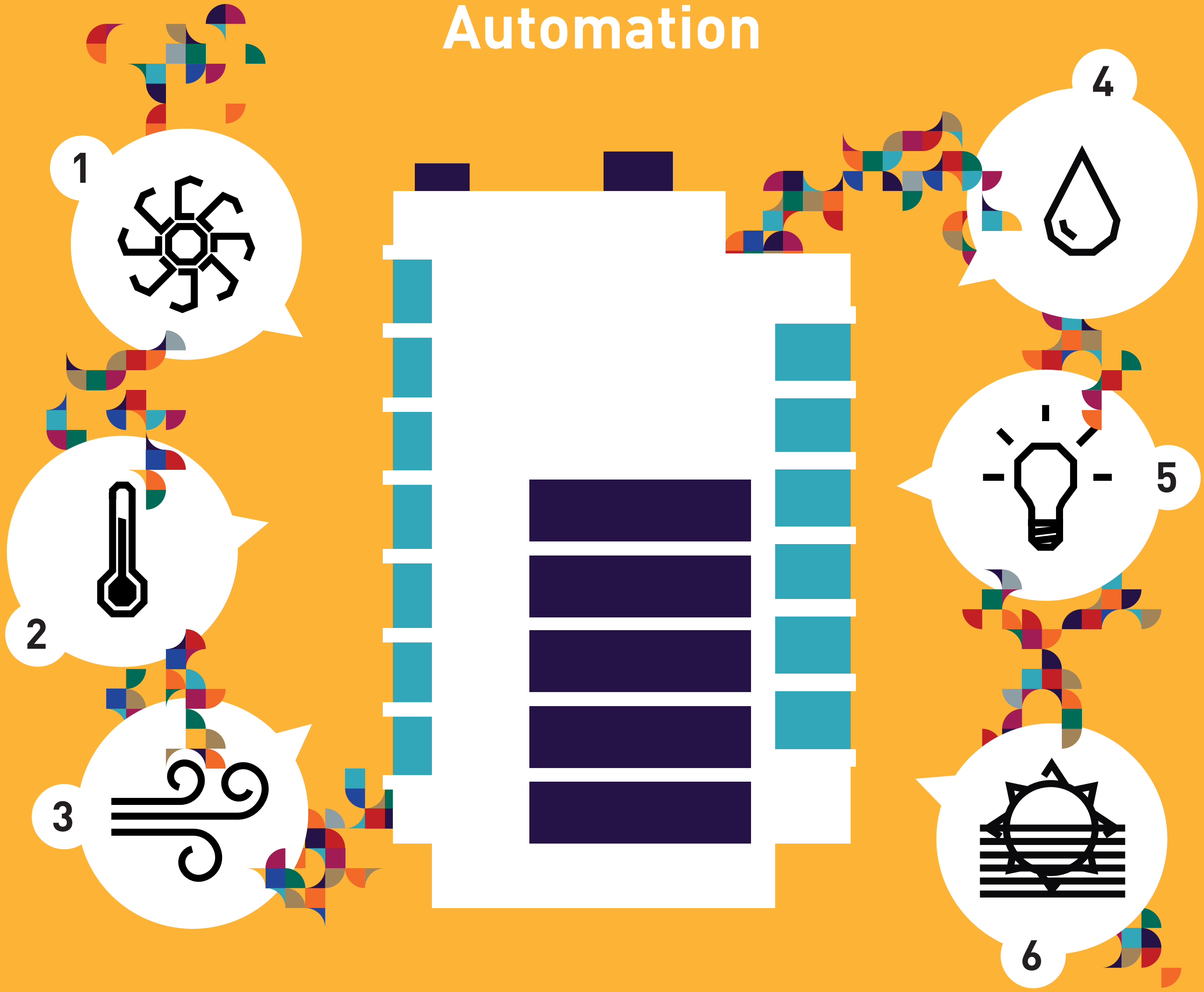
- **Sensors and drives (3)** enable variable demand control of ventilation optimizing the level of indoor air quality at minimal energy cost
- In sanitary hot water, **advanced controls (4)** can reduce the temperature without causing health risks because of legionella

- **Advanced lighting controls (5)** avoid overuse by dimming functions that adapt to daylight and occupancy

- **Solar shading (6)** manages the amount of solar heat and daylight that enters the building

Acting as stand-alone and related to individual technologies, such controls can save vast amounts of energy in the average building. Moreover, such a system would detect early faults in operation and diagnose defects in technical building systems. Building technologies also interact with the energy system – outside the building. A smart building can automatically adapt (within preset individual preferences) according to changing energy needs and price fluctuations. The (automated) building stock facilitates the use of renewable energy sources and increases the overall grid stability by providing the grid with massive load shifting and storage capabilities.

Building Automation



1. Buildings account for **40%** of Europe's energy consumption, more than any other sector.

2. About **26%** of total public and commercial buildings (floor area) in the EU is thought to have building energy management systems (BEMS) (operational capacity) installed.

3. **2/3** of Europe's buildings standing today are expected to remain in use in 2050

7. Only about half of the installed building management systems (BMS) have more than an elementary energy-management capacity.

8. Proper application of building automation would save between **22-30%** of the total energy consumption in European buildings. The import of natural gas could also be reduced up to **13%** [without taking into account additional energy savings potential that could be achieved by changing inefficient heat generators, or chillers].

Proper application of building automation could reduce between 156 to 419 million tons of CO_2 emissions per year.

4. Leading European countries producing Building Automation products products include Germany, Switzerland, France, and Italy.

5. An estimated **250,000** direct jobs could be created by 2030 across Europe... indirect jobs could reach over 3 million.

6. Building automation deployment across Europe reduces greenhouse gas emissions as much as removing **82 to 220 million cars**.

9. Improving the energy performance of buildings would increase housing affordability and could address social imbalances by helping between **0.5 to 3.2 million** European households to emerge from energy poverty.

10. Building automation and controls are low capital investments (typically 30€/m² in non-residential buildings and 12€/m² in residential buildings), with a fast payback period (2-5 years).

Sources: EC , Waide Strategy Efficiency, ECI, Ecofys, eu.bac

1. **Enforce existing requirements like Article 8 of Energy Performance of Buildings Directive (EPBD).**
A regulatory framework exists but nothing is happening on the market. Member States are simply not implementing the existing regulatory framework. Guidance principles for Member States to implement the EPBD need to be published and supported by best practice examples for different building types; nonetheless, there will be no overcome of the market and regulatory failures without a legislation setting basic binding requirements on key functionalities, such as continuous monitoring, benchmarking efficiency, optimizing generation, distribution and use of energy.

2. **Increase energy performance transparency to drive demand and facilitate enforcement.**
Assessing and documenting the energy performance of technical building systems can increase awareness of possible efficiency gains and help drive demand, while the introduction of a Smartness Indicator would stimulate market uptake. Track progress via the collection of data at national levels on the state of technical building systems in existing buildings and modernize building systems in national renovation strategies with KPIs.

3. **Harmonize building system standards across Europe.**
Revise existing standards to focus on system performance and clarify energy performance requirements for technical building systems and the key functionalities. A simple glossary with clear terminology can help with standardization.

4. **Clarify the contribution of technical building systems for full decarbonization.**
Optimize technical building systems in staged deep renovation strategies with a comprehensive ranking of all available measures based on a) how fast they can deliver cost and carbon savings and b) how effectively they will facilitate the implementation of subsequent measures. Highlight the role of control systems in balancing the minimized energy losses, the internal gains and the remaining energy needs for nearly zero-energy buildings (nZEBs).

5. **Unlock 10 billion euros of public and private funds until 2020.**
Pursue, implement, and communicate the Smart Finance for Smart Buildings initiative to a) encourage the more effective use of public funds, including through the development of flexible energy efficiency and renewable financing platforms, b) to help project developers bring good project ideas to maturity, and c) to make energy efficient building projects more attractive to investors, builders, and owners.

Dr. Peter Hug

Managing Director of the European Building Automation and Controls Association

How are Building Automation and Control Systems (BACS) cost-effective for decarbonizing Europe's energy system?

BACS are low capital investments (typically 30€/m^2 in non-residential buildings and 12€/m^2 in residential buildings) – for procurement, installation and commissioning. The payback period is short: on average 3 years. In a scenario from now to 2030, the monetary benefits are 9 times higher than the costs.

When we talk about reducing CO_2 emissions, we have figures from several studies telling us that optimization of Europe's building stock (residential and non-residential) through BACS would lead to yearly savings of around 111 million tons of CO_2 emissions (equivalent to Belgium's gross domestic energy consumption in 2014).

Optimal application of building automation and controls throughout Europe's building stock would cost roughly €6 billion per year, which is very little compared to the amount the EU pays on energy imports (more than €200 billion per year). Furthermore, BACS facilitate the integration of on-site renewable energy sources, particularly in near zero-energy buildings (nZEBs), maximizing self-consumption.

Is Europe leading or following BACS? What should be done to ensure EU leadership?

The Energy Performance of Buildings Directive (EPBD) review proposal from the European Commission clearly highlights Building Automation and Control Systems as one of the key technologies for achieving energy savings in a cost-efficient way. However, this proposal is not enough to overcome the market failures and barriers that currently hamper building optimization, such as split incentives between building owners and tenants, lack of awareness and insufficient regulatory framework. The only way to do this would be to introduce market-oriented measures fostering minimum requirements to ensure that larger buildings are well equipped with certain functionalities such as continuous monitoring, benchmarking efficiency, optimizing generation, distribution and use of energy.

How do BACS impact the end user of the energy system?

In residential buildings, automatic room temperature controls complement metering and billing information. In their absence, citizens would know how much they are spending, but remain largely unable to take effective action. This can have a huge impact on fighting energy poverty which, according to the EU Survey on Income and Living Conditions (EU SILC), affects more than 54 million European citizens (11% of the EU population).

In commercial buildings, BACS monitoring and automation functions help staff to maintain availability, lower consumption and run a building against budgets / measures taken. Moreover, let's not forget that BACS improve the indoor environment quality, with positive impacts on health, well-being, comfort and productivity.

> the European institutions should be more ambitious in the frameworks regarding energy efficiency.

What is the key to engage end users more in the energy transition?

We have plenty of impressive figures on the benefits that BACS bring to everyone. It's a win-win situation. Therefore, we are quite often asked why these benefits are not already being achieved by the market. One of the biggest obstacles are the split incentives between landlords and tenants. It is a clear issue that has already had negative consequences on the market and must be addressed and resolved at European level. Furthermore, as the Ecodesign framework successfully demonstrated it can make sense to define mandatory minimum requirements at European level. This approach is working for the Ecodesign framework and I think that the European institutions should also be more ambitious in the frameworks regarding energy efficiency.

What other conditions need to be in place for BACS to thrive?

Besides the minimum requirements for BACS implementation, in terms of a definition of the functionalities that technical building systems and building automation systems have to perform in larger buildings, both residential and non-residential, I think that the Smartness Indicator proposed by the European Commission in the EPBD review can be a very useful tool. It should cover flexibility and demand response and intelligently connect features with enhanced energy saving capabilities. These features are increasingly important, in particular for nZEBs, as they facilitate the matching of the expected and actual energy performances by adapting energy use to actual part load conditions and individual needs. It should complement and not be merged with the information that is currently displayed on the Energy Performance Certificates.

eu.bac european building automation controls association

HOTEL MANAGEMENT EFFICIENCY
United Arab Emirates

The Crowne Plaza Abu Dhabi on Yas Island achieved a 240% return on investment in operational savings within the first 12-month period. This impressive result was reached due to the 24/7 web-based monitoring of the facility, collecting data from the building management system and highlighting when the building was running outside the desired conditions. A monthly report translated the data captured into recommendations and actions to improve the operational efficiency of the facility. Other recommendations included the replacement of defective sensors and the need to change logical programming of air handling units to enable a more consistent temperature throughout the hotel.

HYDRONIC BALANCING & CONTROL
Sweden

After analysis by Danfoss, the housing association in Mjölby, Sweden, decided to implement an automatic balancing solution for the heating system and to install new thermostatic valves on all radiators. With the new solution implemented, the housing association now saves more than 20% on the energy bill every year with a 3-year payback time after implementing automatic balancing and thermostatic radiator valves. Apart from the energy savings, the housing association was pleased to be able to provide an improved indoor comfort to the residents.

MODERN ENGINEERING AND SUSTAINABILITY
Netherlands

The Edge office building in Amsterdam is designed according to 'The New World of Work' principles and consists of a glass exterior and large, open floor plans situated in a U-shape around a 15-story, north-facing atrium. The atrium is surrounded by balconies and residents can easily move between levels to gather in naturally-lighted areas. The Edge is a net-zero energy building. The south façade is fitted with solar panels on all non-window surfaces. Additionally, aquifer thermal energy storage (approximately 130 meters below ground) generates all energy required for building heating and cooling. Rainwater harvesting, electric vehicle charging stations, and motion-sensored ventilation are some of the other eco-friendly features at The Edge.

The Edge not only sets a new global benchmark for the built environment, but also prioritizes the comfort, health and productivity of its occupants. Real-time energy consumption and efficiency data gathered from Schneider Electric's EcoStruxure Building solution is shared with building occupants and visitors via a dashboard on a video screen located in The Edge lobby.

(Left) Crowne Plaza Abu Dhabi. Source: Honeywell
(Middle) Residential building in Mjölby, Sweden. Source: Danfoss
(Right) The Edge – the "world's most sustainable office building". Source: Schneider Electric

In Italy, around 8% of power consumption is supplied by solar energy - the highest share in Europe.

Source: Enel Green Power

Solar Power

The sun has been powering the Earth for millennia, but only relatively recently have we started using the sun for solar power.

This is surprising, given that the sun supplies enough power in one hour to provide the total energy needs of the world for a whole year. In fact, some estimates show we would only need to cover a land area the size of Spain to power the entire planet with solar. No other energy technology can compete with this potential. **Solar's low-cost, versatility and reliability, means that it is poised to become the dominant energy source by 2050.**

In Europe, over 70% of the market is roof-top solar. Our estimates show that around 5 million houses in Europe have solar on their roofs. Solar is easy to install, easy to maintain and an easy way to save money. It works through photovoltaic cells converting sunlight into direct electricity. The inverter then converts the direct electricity into alternating current (AC) electricity which is used to power your lights and appliances.

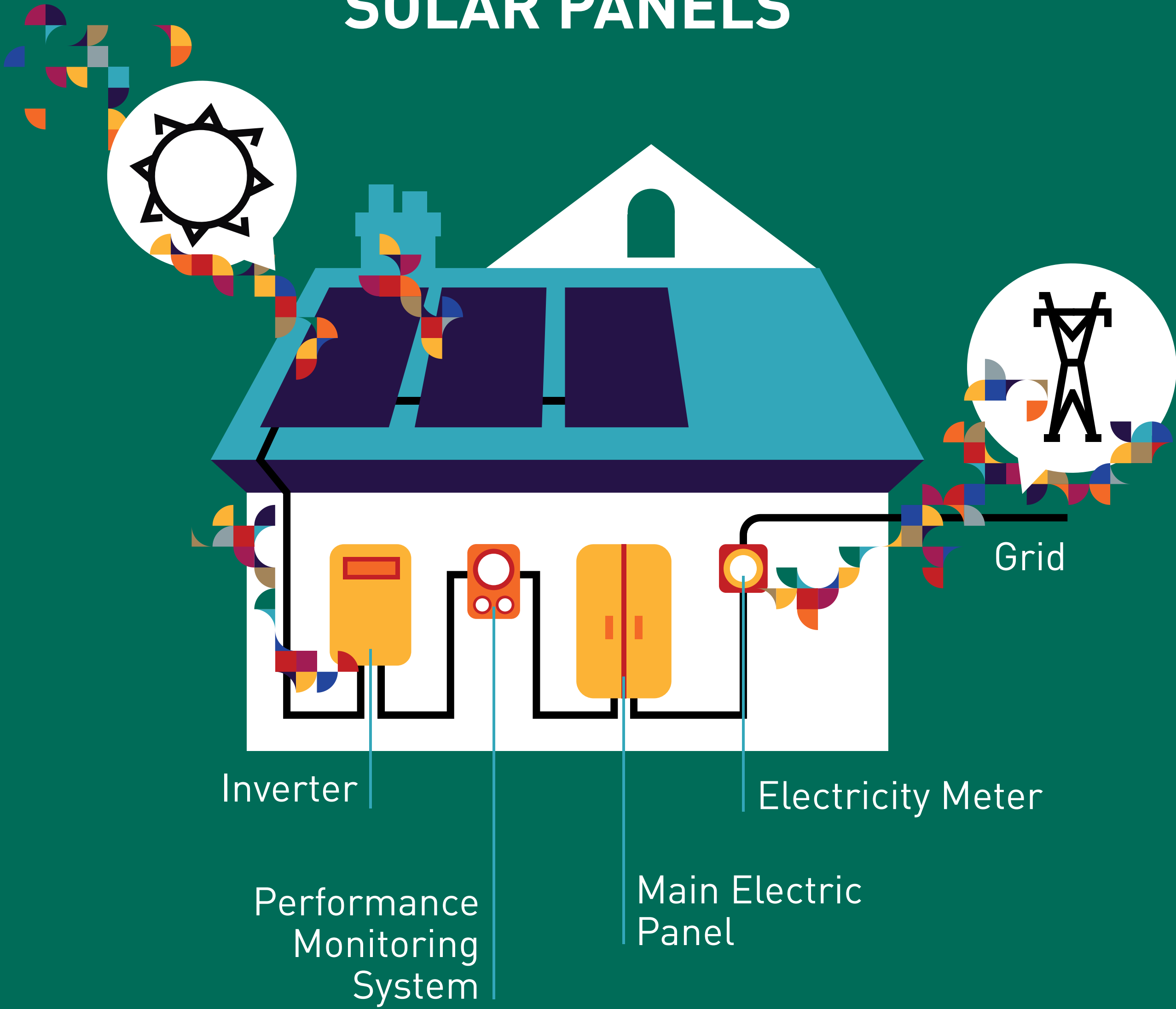
Perhaps the most common objection from solar sceptics is "the sun doesn't shine at night". We have solved this: we now have storage systems that temporarily store generated solar power and deliver clean electricity around the clock. Tesla's Powerwall and SonnenBatterie are great examples of pioneering storage systems that empower consumers to take control over their energy supply.

The European Commission recognizes this unstoppable revolution and have recently brought forward a right to self-consume and self-generate energy. This is a significant new right for all European citizens that will have a huge impact on the energy sector. The forthcoming digitalization of the energy system will also bring forward a whole host of new solar opportunities for consumers and businesses alike – and make the process of going solar even more convenient.

DID YOU KNOW?

Solar power and renewable energies helped Europe cut its greenhouse gas emissions and fossil fuel consumption by 10% in 2015. This demonstrates that clean energy technologies, like solar, are vital to reducing CO_2 emissions. Scaling up and accelerating the deployment is imperative to be able to limit global warming to 2°C.

SOLAR PANELS



1. The global on-grid solar power market grew by **49%** to 76.1GW in 2016, from 51.2GW in 2015.

2. The cost of solar PV systems has dropped by **75%** since 2009 and by 2020, prices are expected to drop by **25-40%**.

Solar PV generation reduces global CO_2 emissions by 200-300 million tons annually, equivalent to the total greenhouse gas emissions in France.

3. Solar is the world's largest renewable energy employer, accounting for an estimated **2.8 million jobs** worldwide in 2015, up about **11%** since 2014.

4. In 2018, storage systems serving solar PV installations in Germany are expected to double to **100,000.**

5. Since 2000, when the modern solar success story began with the implementation of Germany's feed-in-tariff program, installed global solar power capacity has multiplied by a factor of more than **150**.

6. Solar and wind are now at the same cost as new thermal power generation in more than **30 countries.**

7. The EU's top 3 solar electricity producers are Italy, Greece and Germany where solar covers more than **7%** of their needs.

8. In 2016, Europe passed the incredible milestone of **100GW**, making Europe the most solarized region in the world.

9. An estimated **89 million** people in developing countries have at least one solar lighting product in their home.

10. Solar power is the energy choice of Europeans: with **94%** in favor of the use of solar power in their country.

Sources: IEA, Eurobarometer, IRENA, WEF, BNEF/Lighting Global, SolarPower Europe, IHS, BSW

Top 5 priorities to make solar flourish in Europe:

1. Market rules which allow for a market-based energy transition and which enable a flexible power system to harness renewable energies when they are abundantly available at lowest cost.

2. A reliable governance system to steer investments in renewable energy and in flexible assets and to organize the retreat of inflexible polluting plants.

3. Remove the current trade measures on solar panels and cells; the duties make solar more expensive than necessary in Europe.

4. Build an industrial competitiveness strategy for solar in Europe, which should have at its heart the objective of the EU taking the global leadership on the existing and next generation of solar technologies and services.

5. Raise the European Union's 2030 Renewable Energy target to at least 35% (now at 27%).

West Molesey, outside Greater London, UK.
Source: Lightsource

Dr. Christian Westermeier

President of SolarPower Europe

Why is solar power a sustainable energy solution for Europe?

Europe must rapidly reduce its CO_2 emissions and transition to a low-carbon economy. With the cost of solar falling 75% since 2009 and further price reductions projected, solar is a cost-efficient solution to decarbonize our power sector and fight climate change. Already today, solar is providing millions of Europeans across the continent with clean and affordable energy.

Solar is also the energy choice of Europeans with 94% in favor of the use of solar power in their country. With such popular support, solar is a solution for policy-makers who are looking for the right technology at the right price. To put it simply, this is Solution Solar!

How can solar mitigate climate change?

At the 2015 Paris Climate Conference (CoP21), solar and renewable energies were widely recognized as a key solution to help mitigate climate change and keep global temperatures from rising more than 2° Celsius. This is why we saw a wave of new solar initiatives launched at CoP21 such as the International Solar Alliance and the Global Solar Council which SolarPower Europe chairs.

According to the International Renewable Energy Agency (IRENA), solar power generation reduces global CO_2 emissions by 200-300 million tons annually, equivalent to the total greenhouse gas emissions in France. What we have ready at our disposal is a technology that can address the twin needs of expanding global energy consumption and decarbonization. We now need to take advantage of this opportunity and substantially increase the deployment of solar and renewable energies. This will set us on a cleaner path and help us combat dangerous climate change.

What are the most exciting developments happening in solar?

Storage, mobility and digitalization play an ever-larger role in solar energy's evolution. Storage combined with solar means that consumers can produce their own energy, which will fundamentally reshape the relationship between retailers and their customers. Solar and storage of course also means more efficiency and better use of our technology, as the storage system will temporarily store generated solar power.

The solar industry is a key facilitator of a socially-just energy transition and could support 300,000 direct and indirect jobs by 2030.

Solar will also play an integral role in low carbon transport. Soon, we will see electrical vehicles (EVs) with integrated solar panels on their roofs sourcing electricity from solar charging systems. What all this amounts to is the digitalization of the solar and energy sector. We are just beginning to see what will be a new fully fledged digitalised energy system. In the next years, we will see a flood of new digital services for consumers based on solar electricity, including new ways of selling, controlling and gaining revenue from 'smart solar'.

What are the barriers to solar growth in Europe?

We need a stable and predictable economic and political framework that sends the right signals to investors. We live in an age where feed-in-tariffs (FITs) are disappearing and being replaced with tendering schemes in Europe. Given this development, the price of solar systems becomes even more important and that is why we believe the current trade measures on solar panels need to be removed, as they add to the cost unnecessarily. This would allow solar to be even more competitive than it already is with other energy technologies in Europe.

How many jobs can solar really bring to Europe?

SolarPower Europe is working with the European Commission to build an industrial competitiveness strategy for solar, which aims to deliver the growth of our sector in terms of installations, jobs and wealth creation. One of our aims in the industrial strategy is to reach 350 GW of installed solar in Europe by 2030, up from around 100 GW today. Therefore, the solar industry is a key facilitator of a socially-just energy transition and could support 300,000 direct and indirect jobs by 2030, more than doubling the 120,000 jobs provided by solar in Europe today. We will work with the European Commission to promote this industrial strategy, which will place solar on the path to becoming the leading contributor to Europe's energy system for decades to come.

SOLAR IN EUROPE CELEBRATES 100 GW LANDMARK

In 2016, Europe reached an incredible solar power milestone, installing 100 gigawatts (GW) of grid-connected photovoltaic (PV) power. Just a few years ago, solar was considered a niche alternative technology, but it is now a major element of our energy system. In fact, solar power is one of the most competitive forms of energy generation in Europe today. This achievement is primarily due to two factors: 1) an incredible 80% reduction in costs and 2) regulatory frameworks that are supportive of solar as countries have acted to meet the European Union's Renewable Energy Directive.

THE LARGEST SOLAR FAÇADE IN THE WORLD

Denmark

Copenhagen is home to the world's largest solar façade. The new Copenhagen International School features 12,000 solar panels that can generate 300 megawatt hours of electricity per year, covering more than half of the school's annual energy needs. Building integrated solar is poised to play a key role in the development of smart buildings in Europe – watch this space!

RUNNING ON 100% RENEWABLES
Portugal

In May 2016, Portugal made headlines when the southern European country had run for four days only on renewable energy. Indeed, for 107-hours straight, Portugal's electricity consumption was fuelled entirely by solar and other renewables – proving that the clean energy future is fully viable.

WHAT'S IN STORE
Germany

In 2016, it was revealed that 41% of all new solar installations in Germany were equipped with storage batteries, more than anywhere else in the world. This level compares with less than 14% in 2014. Storage in combination with solar is set to take off, in fact, the German battery storage market is expected to grow with up to 30,000 new storage systems in 2017.

(Left) Rising from less than 3 GW of solar PV capacity in 2005, Europe surpassed 100 GW in the second quarter of 2016 making Europe the first region to pass this milestone.
Source: Hanau Energies

(Middle) As of early February 2017, the Copenhagen International School's new building in the Nordhavn district features the largest solar facade in the world. The 12,000 solar glass panels can generate 300 megawatt hours of electricity per year, more than half of the school's annual energy needs.
Source: Adam Mørk

(Right) The Sun Ship (Das Sonnenschiff) is a small community that is run entirely by solar energy. It was built in 2004 in Freiburg im Breisgau's renowned Vauban quarter. Sonnenschiff was designed by architect Rolf Disch, who also built the Heliotrope, and generates four times more energy than it uses.
Source: Stadt Freiburg

Tesla Model S participating in the EV Rally
in Trollstigen, Norway
Source: Norsk Elbilforening

Electric Vehicles

Transport is now the EU's largest source of CO_2 emission. The primary issue is road transport that causes almost ¾ of total transport emissions. Tackling this issue will require a transformation from the internal combustion engine to electric powertrain along with the progressive decarbonisation of electricity production.

Electric vehicles (EVs) are at the heart of developing synergies between the transport and energy sectors. EV integration into the electricity grid offers a particularly compelling solution for energy storage and grid services, enabled by so-called vehicle-to-grid mechanisms and smart charging. EVs therefore have a role to play both in the energy and transport transitions, and provide a market-ready solution to put the EU on track to meet the targets of the Paris 2015 agreement. While the automotive industry is starting to invest more seriously in electric powertrains, consumer uptake in the EU is also progressing quickly now.

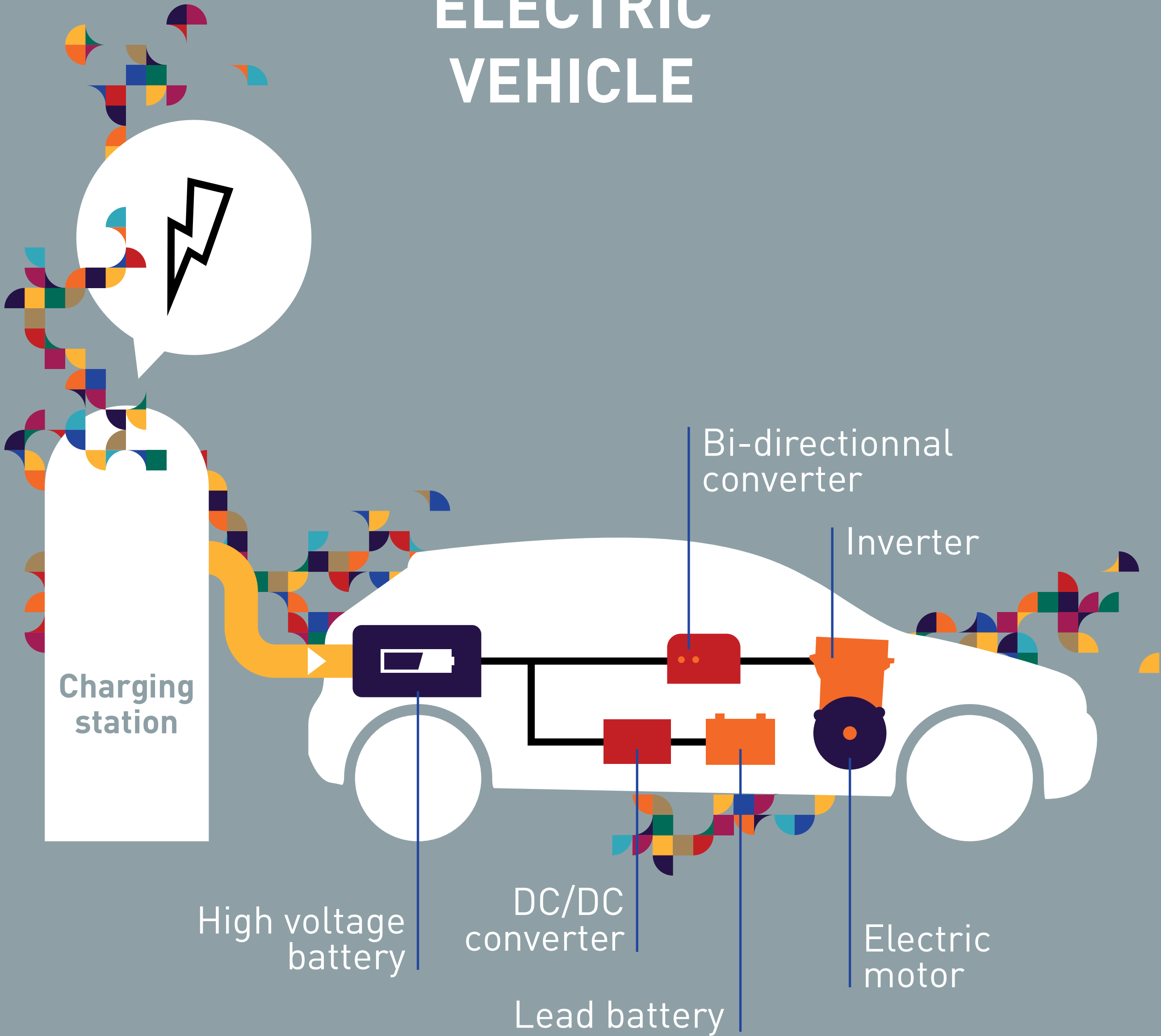
As a nascent market, electric vehicles need the right policy framework to thrive. Looking at EV policy developments in California and in China, the introduction of a scheme equivalent to a zero emission vehicle mandate for car manufacturers is an efficient mechanism to steer the market. This will also provide the required certainties to develop a comprehensive electric vehicle ecosystem, particularly in term of infrastructure requirements.

The shift to electric vehicles will also bring about additional employment and environmental benefits for the EU. As far as competitiveness and jobs are concerned, the early start of an EV production in Europe will be key to maintain its worldwide leading status in car manufacturing. In parallel, European cities will become cleaner with incremental EV uptake mainly due to the reduction in noise and less pollutant emissions.

DID YOU KNOW?

Since 2014, global electric vehicle (EV) sales have more than doubled, while worldwide EV sales jumped by 42% in 2016 compared to 2015. Today, more than 2 million electric vehicles are driving on the world's roads.

ELECTRIC VEHICLE



1. Electric vehicle market growth in Europe is projected to go from 630,000 vehicles in circulation to **900,000** in 2017.

2. European countries leading in sales of EVs include Norway, Austria, France and the Netherlands.

3. Electric vehicles produce no tailpipe emissions, meaning no CO_2, nor fine particles or NOx, thus improving air quality and health in cities.

6. The transition to electric vehicles could generate between 501,000 and **1.1 million** net additional jobs by 2030.

7. In 2017, there are around **110,000** publicly accessible charging points in the EU, including Norway and the UK.

8. New EV models like the 2017 Chevrolet Bolt, the Opel E-Ampera and upgraded Renault ZOE and Nissan Leaf have a real world driving range of **300-350 km**.

With its 100,000 electric vehicles, that account for only 3% of the total passenger car fleet, Norway saves approximately 200,000 tons of CO_2 emissions annually.

4. Carbon-free gross electricity generation in Europe went up from **46%** (2000) to 52% (2012) and should reach 58% (2020), 66% (2030) and **73%** (2050).

5. EV carbon emissions from 'well-to-wheels' are estimated at only **78g CO_2** equivalent compared to 185g for conventional gasoline and 145g for diesel engines.

9. Leading EV sales in Europe in 2016 included Renault Zoe **(21,619 cars)**, Nissan Leaf **(18,876)** and BMW i3 **(15,091)**.

10. Major EV investments: Daimler announced €10 billion by 2025 and Volkswagen aims to electrify **25%** of its fleet by 2025.

Sources: EAFO, EVvolumes, ACEA, Aria, European Commission, DG MOVE, ECF, T&E, Electrive.net

1. **Stimulate EV market uptake with a European Zero Emission Vehicle (ZEV) mandate and ambitious CO_2 targets.**
A ZEV mandate of 15-20% by 2025 and 30-35% in 2030 would ensure a progressive transition to an alternative powertrain. Parallel to that, European regulation should set a CO_2 fleet average at 80g WLTP (Worldwide harmonized Light vehicles Test Procedures) in 2025 and 60g WLTP in 2030, which equals a reduction of 6-8% per year between 2020 and 2030.

2. **Tackle kilometer range anxiety of drivers by adapting infrastructure roll-out.**
Adapted charging infrastructure is a prerequisite for consumer uptake of electric vehicles. This means that in urban areas the emphasis should be put on normal charging (<22 kW), which is more appropriate to city use of EVs. By contrast, fast charging infrastructure (>50 kW) should be deployed primarily along motorways, where EV users need to charge more rapidly than in cities.

3. **Integrate EVs in the electricity grid with smart charging and demand response services.**
Allowing demand response mechanisms and storage activities, in which electric vehicles have a key role to play, will enable the smooth integration of EVs in the electricity grid. This is of particular importance given the current trend of increasing electricity demand and growing share of renewables in the electricity mix.

4. **All new buildings should be equipped with electric charging points.**
To stimulate EV use, the installation of charging points in residential and commercial buildings should be promoted. Such requirements would contribute to put in place the necessary infrastructure in buildings, making them ready for the deployment of electric vehicles.

5. **Electric vehicle users should be granted in-kind benefits**
Cities should put in place incentives for EV use in urban centers by allocating dedicated parking places with free charging points. In addition, EVs should be allowed to use bus lanes, as is already the case in Oslo. Furthermore, cities should introduce exponential zones of low or zero carbon emissions to encourage the use of electric vehicles.

Greg Archer

Director of Clean Vehicles at Transport & Environment

What innovations can we expect from electric vehicles between now and 2050?

In the coming years, we can expect electric vehicles to become much cheaper, to improve significantly their range, and to charge more quickly in 15 minutes. For at least the next 10 years, progress will be made through mass production and incremental improvements in current lithium-ion battery chemistry. We expect to see battery pack prices at €150/KWh by the early 2020's by which time it will be cheaper to lease an EV with a range of over 500km than a conventional car; and the utility of the EV will be almost as good. Within a decade, advanced solid state batteries or lithium-sulfur/air technologies could be market-ready and lead to a further step change in battery performance and cost leading to the final replacement of the internal combustion engine for almost all applications.

How do electric vehicles contribute to the energy transition?

Electric vehicles can provide flexible demand and storage mechanisms to the electricity grid, through demand response services. They will be progressively used for grid balancing and integrated into homes as these also become partially off-grid. In this context, electric vehicles will act as a key enabler in the transition from electricity consumers to prosumers.

Is Europe leading or following on electro-mobility? What should be done to ensure EU leadership?

The EU remains a global leader for electromobility. The EU is the second biggest market for EVs globally, and is likely to retain this position. Nissan-Renault is the biggest manufacturer of electric vehicles in the world. This leader status could be maintained by the introduction of a Zero Emission Vehicle Sales Target of 15-20% by 2025 and above 35% by 2030. If supported by reform of car taxation these changes would make electric vehicles more attractive for company fleets, compared to conventionally fueled equivalents. In the case of Germany for instance, electric vehicles are taxed more heavily than diesel cars. This needs to change.

What do you think is the key to engage end users in the energy transition?

There are four key needs that would lead to more profound user engagement in the energy transition: 1) the price of electric vehicles has to drop to make electric cars more affordable. 2) the performance of EVs has to increase so that their utility becomes comparable to conventionally fueled cars. 3) the use of charging infrastructure should make recharging an electric car as easy as refueling a petrol car. And 4) the car industry needs to provide the market with much more choice and apply its outstanding sales and marketing skills to showcase electric vehicles as an attractive and modern alternative to the internal combustion engine. If that happens, alongside in-use incentives in cities, then the transition to electric vehicles will happen very rapidly.

What other major technological developments will accompany electric vehicles deployment?

The transition to electric vehicles will occur simultaneously with the raise of connected and driverless technologies. This will create many beneficial synergies, but will also entail some risks. That is why cities will need to make sure that we do not only address air pollution and climate problems. We should also avoid that our cities remain car dominated. To ensure this transition, a shift is needed from privately owned to shared mobility models, in parallel to the growth of the electric vehicle fleet. This way, cities will be able to allocate more road space to bikes and buses, in order to create a system of connected electric co-modality in urban areas.

We can expect electric vehicles to become much cheaper, to improve significantly their range and to charge faster.

TRANSPORT & ENVIRONMENT

ELECTRIC AND SHARED MOBILITY

France

Electric and shared mobility is an integrated part to the Lyon smart city project in France. Bluely, the car sharing scheme launched in 2013, now comprises over 300 vehicles, and totals more than 7,000 subscribers. The Bluely charging network is composed of 500 charging points in more than 100 charging stations across the city of Lyon and its suburbs. With a rate of €4 per 30 minutes and a subscription fee of €1 per month for users under 25, the offer provided by the Bolloré Group is particularly attractive to young people. In 2017, the company aims at reaching 175,000 hires compared to 100,000 in 2016.

SECOND-LIFE FOR EV BATTERIES

Germany

BMW has developed an initiative together with Vattenfall and Bosch to give used car battery packs a second-life. The use of second-life EV batteries is currently tested in a 2 megawatt (MW) energy storage system in Hamburg to keep the electricity grid stable. The electricity storage facility comprises 2,600 battery modules from more than 100 electric vehicles. Work on battery second-life development led BMW and Vattenfall to sign a partnership for the use of batteries in the Princess Alexia wind farm (Netherlands), providing a storage capacity of up to 3.2 MW.

ELECTRIC CITY LOGISTICS

Germany

Deutsche Post DHL (DPDHL) developed its own electric van dedicated to the last mile delivery, after buying in 2014 a startup called StreetScooter.

Production started end of 2016, with the first 2,000 units. StreetScooters have an in-service range of 50 to 80 km between recharges, and can carry up to 650 kg of load at a time. The initial plan was to produce around 5,000 units a year.

In the future, the company will not limit the production of the Streetscooter to its own usage. It is already looking for a second production site in order to double its annual production, and intends to sell half of it to third-party customers, mainly local governments and large fleet customers. The StreetScooters' market price is expected to be around €32,000.

DPDHL's decision is both beneficial for the environment and for the company's budget. Indeed, electric vehicles' total cost of ownership (TCO) is more advantageous than TCO of conventionally fueled vehicles.

(Left) Station Bluely, Lyon, France. Source: Benoît Prieur
(Middle) Energy storage facility, Hambourg, Germany.
Source: Electrek
(Right) DHL steetscooter at work, Utrecht, Netherlands.
Source: harry_nl

Designed by the renowned Italian architect, Renzo Piano, Il Vulcano Buono (The Good Volcano) was inspired by Mount Vesuvius and includes over 250 heat pumps for heating, cooling and hot water provision.
Source: Clivet

Heat
Pumps

Heat pumps provide heating, cooling and sanitary hot water for residential, commercial and industrial applications. They convert ambient energy from air (aerothermal), ground (geothermal) and water (hydrothermal) but also excess heat from buildings and processes to useful heat. This conversion is done via the refrigerant cycle, which is also used in refrigerators and air conditioning systems. Heat pump technology is efficient and mature. Typical capacities range from 2-20kW for single family buildings, up to 100kW for multi-dwelling residential applications and even higher capacities for commercial applications. Industrial and district heating heat pumps reach capacities of several MW. Operating the unit when surplus electricity is available and storing that surplus energy in the form of heat provides significant demand response capacity to the electric system and enables the integration of a larger share of renewable electricity.

> Highest efficiency is reached when heating and cooling is needed at the same time.

Low-Carbon Technology

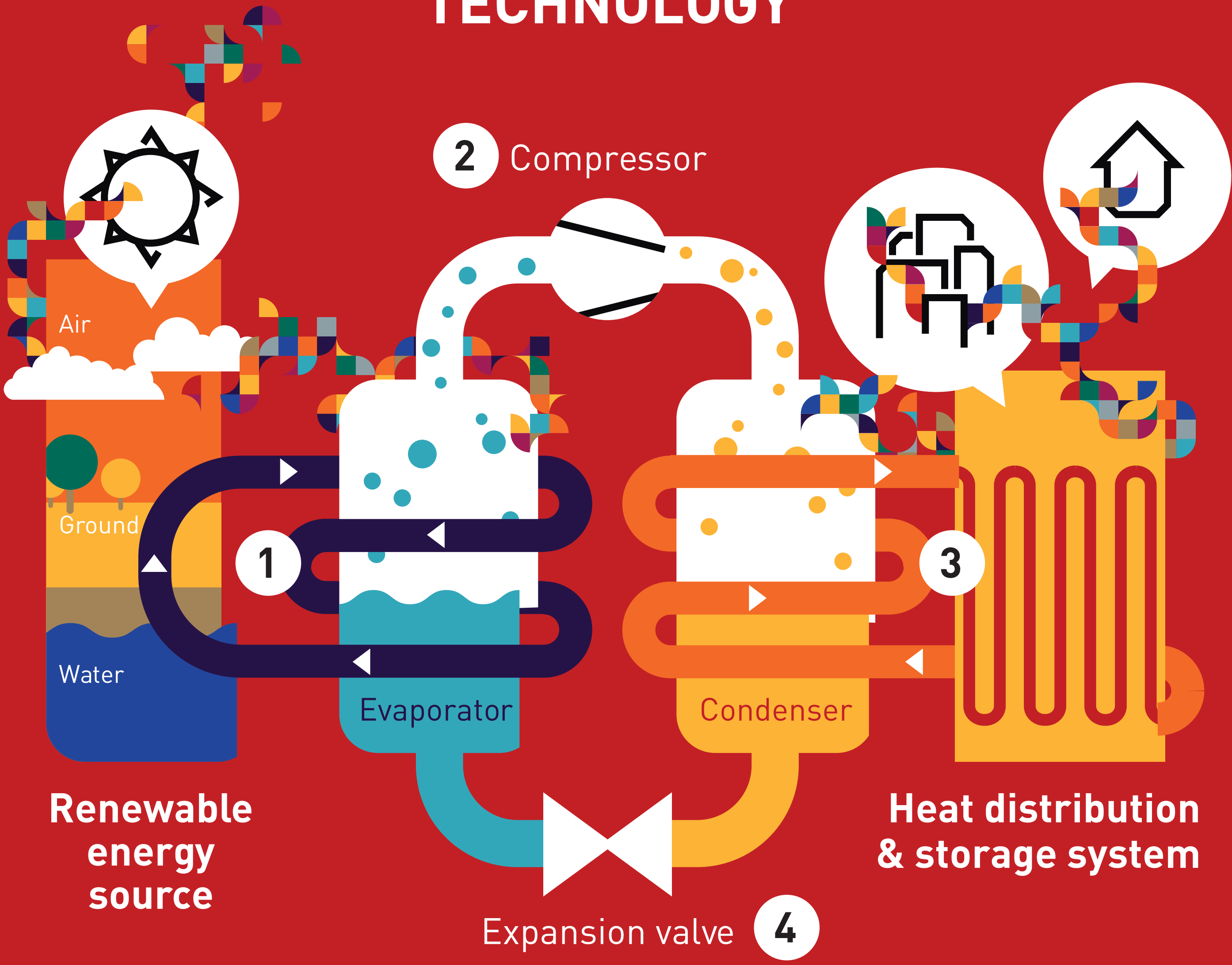
A heat pump system consists of a heat source, the heat pump unit and a system to distribute heating and cooling. Among several possible concepts, the electric compression cycle is most common. The heat pump works as follows: **(1) a transfer fluid (refrigerant)** is exposed to the energy source, where it evaporates and thus cools the source. Using a **compressor (2)**, the refrigerant vapour is compressed and its temperature increased. In the next step **(3)**, the high temperature – high pressure vapour – is fed into a heat exchanger where the energy is transferred to a distribution system. The vapour cools down and condenses. After the pressure is released in an **expansion valve (4)**, the liquid is exposed to the heat source again and the cycle is closed.

Heat pumps always provide heating and cooling at the same time. In the heating mode, outdoor ambient energy is the heat source and the building/process is the heat sink. In the cooling mode, the building/process is cooled down using the outside as heat sink. Highest efficiency is reached when heating and cooling is needed at the same time.

DID YOU KNOW?

Heat pumps help reduce air pollution: in China, the administration of Beijing has started a replacement program to eliminate oil and coal boilers in order to tackle the air pollution; 160,000 units have been replaced in 2016 and the program will continue in 2017 with expansion plans to neighbouring provinces.

HEAT PUMP TECHNOLOGY



1. In 2016, every day, about **2,700** new heat pumps were installed in Europe (annual sales of close to 1,000,000)

2. **18.6%** of all Europe's heating and cooling is derived from renewable energy, **10%** of which comes from heat pumps.

5. A heat pump + photovoltaic + battery home energy system can provide heating, cooling and hot water, **day and night.**

6. Heat pump induced growth in the efficient electrification of heating and cooling, will not lead to a significant increase in total electricity demand.

Installed heat pumps in Europe save nearly x2 the CO_2 emissions of Statoil – any year.

3. In 2017, the total installed heat pump stock will exceed **10 million** installed units (compared to approx. 119 million buildings).

4. Heat pumps provide demand side flexibility: all heat pumps in operation by end of 2015 could provide **298 GWh** of storage capacity.

7. France, Italy and Sweden are the **top 3 markets** for heat pumps in Europe with huge growth potential in important markets like Spain, Germany, and Poland.

8. The heat pump stock is expected to double by 2030, making ambient heat the **most important renewable energy** after biomass.

9. Heat pumps can be used in industry. The technical potential in applications such as food processing, drying, chemicals or textiles is estimated at **174 TWh.**

10. A total of **61 million** heat pumps is needed to replace the energy coming from Russian gas.

Sources: EHPA , Eurostat Shares, Fraunhofer Institute, IRENA, Viessmann

1. Shift subsidies from fossil fuels to low/no emission technologies.
Subsidies for fossil fuels prevail across the EU, keeping operation costs artificially low. With the investment costs of greener solutions still higher, the additional costs are rarely recovered over the useful life of the installation.

2. Include heating based on fossil energy (as well as transport) under ETS to put a price on the negative environmental impact of using them.
There is no price signal influencing the negative environmental impact from burning fossil energy in the heating sector. Electricity is covered by the European Trading Scheme (ETS), but combustion-based heating is not covered. Correct a mismatch in taxation between electricity and fossil energy.

3. Provide standard investment packages for companies, cities and citizens to gain benefits.
While you can find financing solutions for buying a new car, the banking sector does not facilitate investing in new heating solutions, distribution infrastructure and building systems that would lower energy consumption.

4. Facilitate and simplify replacement of existing boilers with no-emission solutions.
Current heating solutions benefit from decades of optimization and standardization. For the installer, this is business as usual: the basic like-for-like replacement, fault-forgiving and recognized by the client as working. This ease of installation has yet to be achieved for "2050-ready" replacement solutions to come faster to market.

5. Standardize green renovation packages for buildings across Europe.
If a heating system fails, a fast replacement is required, but in such "distressed purchase" situations the suggested replacement is rarely the best long-term solution. Standardized green renovation packages including financing and (if needed) an upgrade of the building envelope must become the *modus operandi* in the renovation sector.

Martin Forsén

President of the European Heat Pump Association

Is Europe going fast enough in moving towards a more decarbonised society?

Clearly not! We are only starting to scratch the surface. We need to go much faster in making heating and cooling in Europe more sustainable. The electricity sector has made some progress and the need to electrify the energy sector is slowly but steadily gaining ground. We need brave decisions to favor cleaner "2050-ready" technologies for their deployment in the market.

What steps are needed to create the political framework and support scheme?

I believe in strict eco-design requirements in combination with measures that make polluting technologies economically less attractive. One solution is the introduction of a price signal for the use of carbon, such as a cap-and-trade system, or more likely now as a carbon base price.

We need a paradigm shift in the transport and heating sector. The lighting sector is a leading example on how a change of paradigm enforced by legislation may lead to tremendous energy savings. The road transport and heating sector need a similar shift. The small incremental improvements that are still seen in these sectors are not enough.

Technologies that contribute to making the necessary transition are proven and available. Policy-makers need to move away from traditional technologies by implementing stronger regulations. Support schemes may speed up the process in individual markets for making new technologies economically interesting, but it will be even more important to stop fossil fuel subsidies.

Where do we stand today in decarbonising heating and cooling in Europe?

The carbon footprint of the heating sector in most of Europe is immense and the transformation of the heating sector in Europe remains very slow. In the UK, there are around 1.6 million gas boilers installed annually and only a minor fraction of the boiler market consists of heat pumps and other carbon-lean systems. It is time to reassess the heating sector and introduce regulation to report the sector's carbon footprint. If it does not decline fast enough, additional and stricter measures are needed to improve the situation. National targets should also be fixed to comply with the Paris CoP21 agreement. This is not difficult, nor controversial.

We know what needs to be done to fulfill what we have already agreed upon, but this will mean inevitably that we need to abandon traditional technologies. Sweden is a good example of how this can be done. Since 1990, greenhouse gas emissions related to heating in buildings have been reduced by 90% by an almost complete phase out of fossil fuels. The transformation of the heating sector has been realised by the broad introduction of heat pumps and fuel shift in the district heating sector. Today, more than 50% of all single family houses are equipped with a heat pump and the market share for heat pumps in new construction exceeds 80%.

Heat pumps are central to the decarbonisation of the heating and cooling sector.

What role do you see for heat pump technologies in this context?

Heat pumps are central to the decarbonisation of the heating sector. Heat pumps are unique in the sense that they reduce greenhouse gas emissions, improve energy efficiency and increase the integration and use of renewable energy. And they can provide both heating and cooling at the same time, which makes the technology particularly interesting for commercial and industrial applications. Heat pumps can therefore play an important balancing role in electricity grids with ever increasing share of intermittent renewable electricity.

What is the biggest obstacle limiting the deployment of heat pumps?

We need to continue disseminating information and training installers. As sales continue to pick up, economies of scale will contribute to more competition and cost reductions. The biggest obstacle right now is the low prices of fossil fuels, the high price of electricity and the significant price difference between heat pumps and gas boilers for retrofitting applications. As long as gas is not greening at significantly higher speeds, every new gas boiler means a lost opportunity for substantial greenhouse gas reductions. We need to find more efficient ways to address the end consumers that are in need of replacements and we need the policy-makers to recognise fully what needs to be done. I am confident that heat pumps will be a key integrator technology for the energy transformation of the heating sector. The only question is how long until the major markets in Europe really take off.

ehpa european heat pump association

INDUSTRIAL
Norway

In 2009, the growing population of Drammen led to a reconstruction of the heating system in order to meet the growing heat demand. Realizing that the 8˚C averaging fjord temperature throughout the year is an ideal heat source for water source heat pumps, the heating company of Drammen switched from fossil fuels to renewable heat generation. With an installed capacity of 13.2 MW from heat pump and 30 MW from fossil fuel, the system meets the heat demand of a community of 63,000 people and its businesses. Operating for nearly 4 years, the heat pump has reached the mark of 200 GWh of successful heat generation.

RESIDENTIAL
Sweden

Sickla Strand is located in Nacka, a community south of Stockholm. In a renovation project, 330 apartments were connected to a new 900 kW ground coupled heat pump (600kW of capacity is provided by geothermal wells, 300kW from electricity). Using a mono energetic system design, most of the energy demand is covered by the large heat pump, with peak demand being covered by electric resistant heaters. The use of ventilation systems has greatly reduced energy losses. An investment of 25 million SEK leads to savings of 2.5 million SEK/year and a payback time of 10 years.

COMMERCIAL
Italy

Developed in 2009, the "Volcano Buono"mall in Naples consists of a central food court,shops, restaurants, hotels, residential spaces, a collegeand a cultural center with a total useful area of 16,000 m^2. All thermal energy supplied to the Vulcano is 100% renewable, and for the most part produced locally. A central heating and cooling plant with three heat pumps and 64 borehole heat exchangers (each 300 meters deep) provides sustainable heating and cooling, and allows wasteheat to be recovered locally. The heat pump solution substantially reduces the need for installed cooling capacity, and eliminates the need for dry air liquid coolers. This creates more attractive surroundings, and allows more efficient use of buildings.

This multipurpose complex is sourced by renewable energy from water and the air (WLHP System) and includes over 250 heat pumps: 9 rooftop air-to-air heat pumps + 54 rooftop water-to-air heat pumps + over 240 ventilation and air handling units + 4 water-to-water heat pumps + 2 super silent chillers + over 150 water-to-air heat pumps.

(Left) District heating heat pumps. Source: Star Refrigeration
(Middle) Residential buildings in Sickla Strand. Source: Arild Vågen
(Right) The Good Volcano shopping mall. Source: Clivet

The coordinators of this report - Stuart Reigeluth from Revolve Media and Diedert Debusscher from the European Copper Institute - are grateful to all contributors, in particular the EU Commissioner for Climate Action and Energy, Mr. Miguel Arias Cañete, and the other industry leaders that gave generously of their time and expertise to shed light on raising awareness about their respective technologies.

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