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GLOBAL COUNCIL ON ENERGY EFFICIENCY

# REPORT ON ENERGY EFFICIENCY

## The Pathway to a Global Vision for Digitization & Decarbonation

# FOREWORD

**By HE Abdulla Nasser Lootah, Deputy Minister of Cabinet Affairs for Competitiveness and Knowledge Exchange, Chairman of the Emirates Competitiveness Council, and Vice-Chair of the National Committee on Sustainable Development Goals (SDGs), and Vice-Chair of the Global Council on SDGs.**

As Vice Chairman of the Global Councils on Sustainable Development Goals (SDGs), it is my distinct privilege to extend my heartfelt appreciation for the remarkable work carried out by the chairmanship and members of the Global Council on Energy Efficiency, and to EDF and Schneider Electric for leading the production of this insightful and visionary report on Energy Efficiency.

Members of the Global Council on Energy Efficiency, under the leadership of its **Chair, Mr. Luc Remont** and **Vice Chair, Dr Nawal Al Hosany**, and the thought leadership and expertise demonstrated by the joint team created by EDF and Schneider Electric, have not only provided a comprehensive overview of the current landscape but have also highlighted innovative solutions, best practices, and case studies that demonstrate the tangible impact of energy efficiency. It is heartening to see these great minds working together to take the lead in driving this conversation and inspiring action.

In an era where our collective commitment to sustainability and the pursuit of the SDGs has never been more critical, this report serves as an invaluable compass, guiding us toward a more sustainable future. It encapsulates a wealth of knowledge, innovation, and strategies that are essential for addressing one of the most pressing global challenges – ensuring that energy efficiency remains at the forefront of our efforts to build a greener, more resilient world.

It is impossible to overestimate the significance of energy efficiency. Optimizing our energy use is not only a goal, but a need given the fast-changing climate, rising urbanization, and rising energy demands. This paper provides a path for a future with more sustainable and efficient energy sources while also recognizing its importance.

I encourage leaders, policymakers, industries, and communities around the world to draw inspiration from the insights presented in this report. Together, we must embrace these findings and translate them into concrete actions that propel us closer achieving the SDGs. Our collective commitment to energy efficiency will not only reduce our environmental footprint, but also drive economic growth and improve the quality of life for all.

Abdulla Lootah

# OPENING REMARKS

Luc Rémont
Chairman and CEO EDF Group

HE. Dr. Nawal Al Hosany
The Permanent Representative of the UAE to IRENA

It is with great pleasure and a shared sense of responsibility that we, as the Chair and Vice Chair of the Global Council on Energy Efficiency, unite in extending our sincere congratulations on this ground-breaking report on Energy Efficiency produced by Schneider Electric and EDF.

In our roles both within the council and externally, we are aware of the urgent need for concerted efforts to address the challenges posed by climate change and unsustainable energy consumption. This report stands as a beacon, illuminating the path towards a more sustainable future. It reflects not only the expertise of many governments, businesses, organisations, and individuals around the world but also the collaborative spirit required to navigate the complex landscape of global energy efficiency.

As stewards of the SDGs, we are heartened to witness the alignment of this report with our shared vision for a world that is environmentally resilient, socially equitable, and economically prosperous. The insights within these pages underscore the integral role that energy efficiency plays in achieving multiple SDGs, from clean energy access to climate action and beyond.

This comprehensive collaboration provides a thorough analysis of the current state of energy efficiency best practices from around the world and emphasizes the pivotal role of technology in driving progress. The integration of cutting-edge technologies, smart systems, and innovative solutions is paramount to enhancing energy efficiency practices globally. The report serves as a testament to the transformative power of technological advancements in creating a more sustainable energy landscape.

Moreover, we recognize the indispensable role of young people in shaping the future outlined in this report. The enthusiasm, creativity, and commitment of young minds are instrumental in driving change and fostering a culture of sustainability. We call upon the younger generation to engage actively in advocating for and implementing energy-efficient practices. Empowering young leaders, supporting educational initiatives, and providing platforms for innovation will be key in realizing the ambitious goals set out in this report.

We urge leaders across all sectors and borders to heed the lessons and recommendations that have been made. The collaborative spirit demonstrated by the members of the Global Council on Energy Efficiency, combined with the transformative potential of technology and the unwavering dedication of policy makers, businesses, academia, and society, should serve as a model for global cooperation in addressing the multifaceted challenges of our time.

Luc Rémont

Dr. Nawal Al Hosany

# EXECUTIVE SUMMARY

**Energy efficiency is an essential lever for decarbonization** trajectories. The International Energy Agency expects energy efficiency to contribute up to 20% to total decarbonization of the energy system by 2050 in its Net Zero Emissions scenario. Without energy efficiency, the efforts made on other levers (in particular, the behavioral lever) will be too ambitious or even unattainable.

**Our current energy system is widely inefficient**: two thirds of the energy it extracts is lost at different steps of the energy cycle.

Technology solutions have been available for many years to improve energy efficiency in the building sector, in industry and for mobility. Solutions involving, in particular, a **mix of electrification and digitalization** provide great potential for priority action and can be deployed quickly.

Yet, energy retrofit is not deployed at scale even though available financing is not lacking. But the **economic barriers** are many: the need for upfront investments; stability and simplification of incentive schemes ; insufficient return on energy efficiency investments; and "harmful" subsidies supporting inefficient solutions. In addition, energy savings from available solutions and offers may appear insufficient or too uncertain. But current high energy prices, threats of energy or power shortages as well as enhanced offers for energy performance contracts have created the **context for a much more attractive investment decision.**

Integrating existing **financing** solutions has the potential to reduce upfront costs and improve visibility on energy and financial returns. Two powerful catalysts can help with this integration: digitalization, in order to streamline processes and aggregate assets; and partnerships, in order to mobilize the best skill sets at all steps of these complex multi-asset investment programs.

**Investing in energy efficiency carries a positive impact on net employment,** through direct job creation (e.g., installers, service providers), indirect job creation (e.g., manufacturing activities) and induced job creation. Delivering part of those investments will r**equire new skills and resources** in energy management, integration of energy efficiency solutions, building design and construction.

For a rapid deployment of energy efficiency solutions, priority should be given to the following areas: strong support of investment in efficient solutions (example: efficient lighting, heat pumps, EVs, electrification of industrial processes, etc.); the end of harmful subsidies for inefficient and fossil-based solutions; the gradual ban on the sale of inefficient solutions (in lighting, heating or mobility); and an increase in energy prices (proportional to their carbon content) accompanied by support for the most vulnerable populations which are most exposed to the impact of any rebound effect.

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# INTRODUCTION

Decarbonization of the economy must drastically accelerate

During COP27 in Sharm El-Sheikh, global leaders reunited to discuss and commit to further efforts to accelerate the decarbonization of the economy. Despite progress on multiple fronts (notably on loss and damage), the COP fell short of expectations. In his closing remarks in Sharm El-Sheik, the COP26 president Alok Sharma declared:

> *"Emissions peaking before 2025, as the science tells us is necessary. Not in this text. Clear follow-through on the phase down of coal. Not in this text. A clear commitment to phase out all fossil fuels. Not in this text. And the energy text, weakened, in the final minutes. Friends, I said in Glasgow that the pulse of 1.5 degrees was weak. Unfortunately, it remains on life support."* [1]

Thanks to the work of the Intergovernmental Panel on Climate Change (IPCC[2]), a 1.5-degree global warming by mid-century is now widely regarded as the key target to reach. The work of the IPCC also expands to consolidating a variety of scenarios to achieve this and, despite their differences, pathways remain equally ambitious, with a rapid transition away from fossil fuels, a decline in emissions of 30-50% by 2030, and zero (net) emissions by mid-century.

Yet, the stark reality is that these emissions have increased by an average 1% per year in the last decade[3]. We thus stand at an inflection point, a "make-or-break" moment. It is in this context that COP28 is taking place in Dubai, with a clear objective from the Presidency to deliver an ambitious energy package which includes tripling renewable energy capacity and doubling the rate of energy efficiency improvements across sectors by 2030, including ramping up electrification and enhanced cooling approaches, to enable the phase down of fossil fuels:

Greenhouse gas emissions today total around 50-55GtCO2e/year, out of which energy accounts for around 39GtCO2/year, or 75% of total (Figure 1). A 1.5-degree climate compatible pathway is thus also one that transforms the energy system.

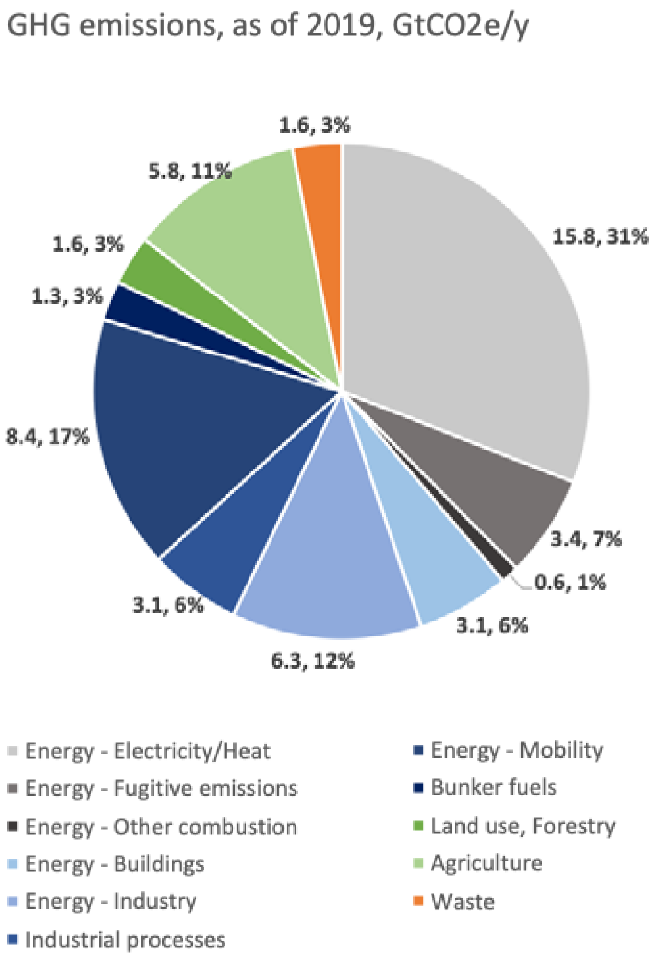



Figure 1 – Greenhouse gas emissions, per sector, as of 2019[4]

[1] UK COP26, 2022
[2] IPCC, 2014, 2021, 2022
[3] Based on data from ©OECD/IEA, 2017, 2021.
[4] Climate Watch data, 2023. Emissions reported here account for 51GtCO2e/y. The IPCC (2022) reports total greenhouse gas emissions of 59GtCO2e/y for the same year.

## How can the world break the carbon lock-in?

This report aims to provide answers to this key question. And its focus will be on energy efficiency, comprising energy efficiency improvements (of equipment, appliances, vehicles and building envelopes, etc..) as well as electrification. The reason for this focus is that energy efficiency is now widely acknowledged as a key driver of decarbonization.

Scenarios from the IPCC[5] consistent with a 1.5-degree trajectory all assume a final energy demand by 2050 that is lower or on par with current energy demand, despite economic growth. BloombergNEF[6] maps a net-zero scenario until mid-century with a final energy demand on par with current consumption. The International Renewable Energy Agency (IRENA[7]) also follows a similar path. The 2021 International Energy Agency[8] Net Zero Emission scenario (NZE) models an energy system with a final energy demand by 2050 that is 20% lower than current demand (Figure 2), a finding consistent with other scenarios, such as those from the Energy Transitions Commission or Schneider Electric[9].

The growing consensus is thus that final energy demand must be significantly optimized to make a climate-compatible trajectory possible.

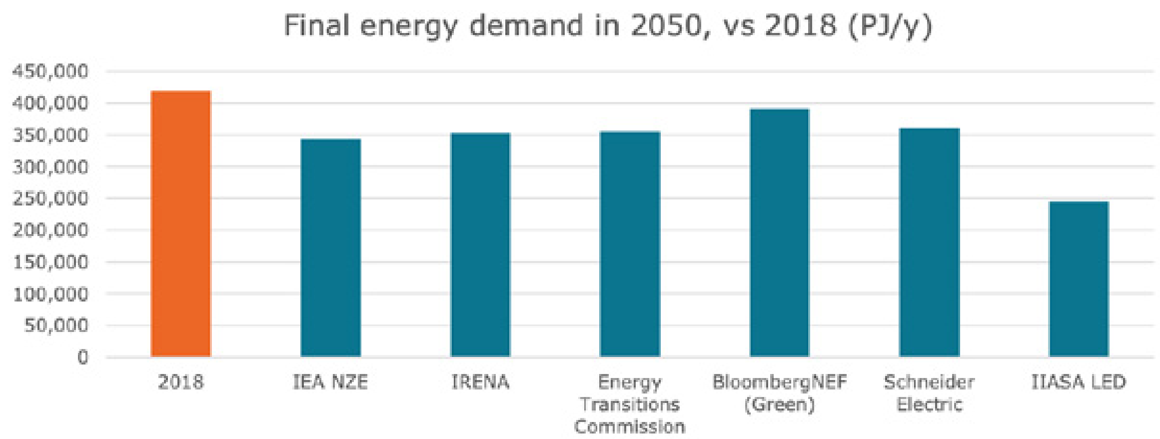
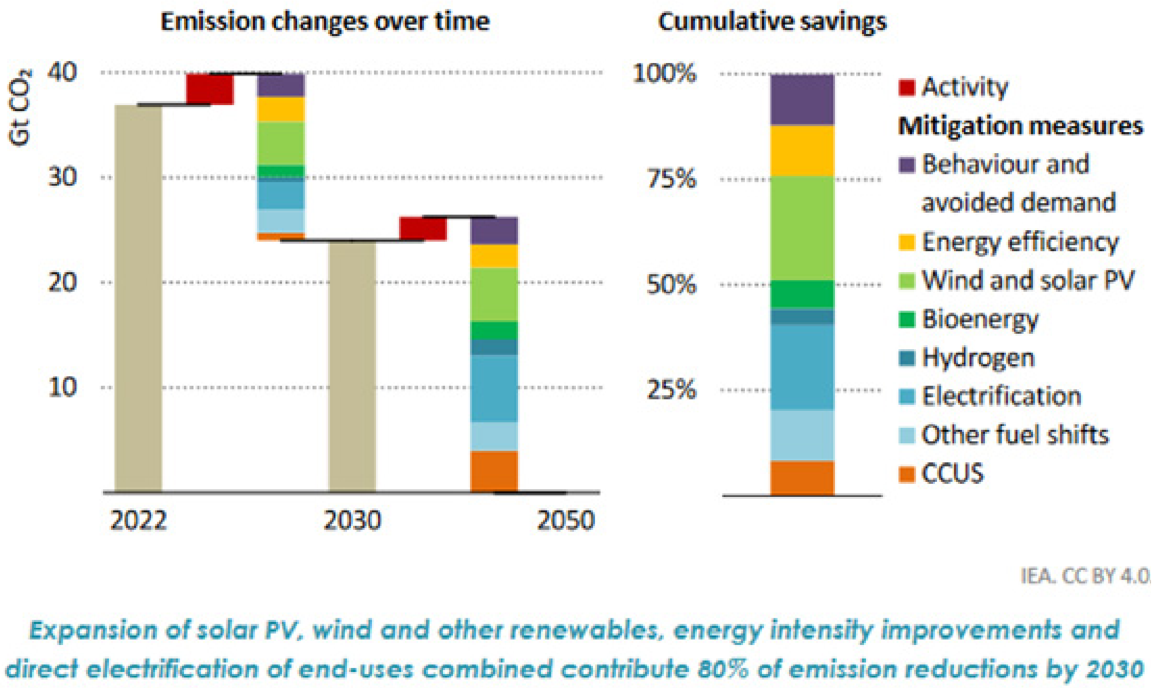



Figure 2 – Final energy demand across scenarios[10]

[5] IPCC 2022
[6] BloombergNEF, 2022
[7] IRENA, 2023
[8] ©OECD/IEA, 2021b
[9] Schneider Electric, 2021
[10] Schneider Electric, 2021 ; IRENA, 2023. Note that there is a slightly different baseline level for IRENA.

Figure 3 - Emissions reductions by mitigation measure in the NZE, 2022-2050 (courtesy of the International Energy Agency)




The International Energy Agency also considers energy efficiency and electrification to contribute to up to 40% of total decarbonization of the energy system by 2050 in its Net Zero Emissions scenario (NZE, Figure 3)

## There are reasons for energy efficiency to be considered as a critical solution to decarbonization

"Energy efficiency is the "first fuel"[11], a fuel for which "demand (…) needs to grow", and a fuel which does not require to be produced nor procured. The International Energy Agency[12] estimates that, thanks to energy efficiency[13] measures, costs for households in "advanced economies" could be reduced from today's by nearly 20%. Other studies have found paybacks of 2-8 years for digital solutions for efficiency, across both buildings and a variety of industries[14]. Passive efficiency solutions can bring higher savings, in the range of 15-50%, with longer paybacks, however, in the range of 10-30 years[15].

Another reason for the attractiveness of energy efficiency is, quite simply, that it works! Energy efficiency has already demonstrated its contribution to decarbonization. In the period 2016-2021, the International Energy Agency estimates that energy efficiency has more than halved global growth in energy demand, thereby mitigating associated emissions by a similar factor.

[11] Motherway B, 2019
[12] ©OECD/IEA, 2021b
[13] and efficient electrification
[14] Schneider Electric, 2021b ; © OECD/IEA, 2017b
[15] ©OECD/IEA, 2012, Energy Star, n.d., BPIE, 2022

In addition, energy efficiency also acts on the baseline of energy demand. If less energy needs to be decarbonized, the corresponding investments to decarbonize the remaining energy supply will therefore be lower, and more attractive. It avoids growth in fossil fuels infrastructure (hence associated costs, both capital andoperational expenses), and reduces growth in electricity demand, hence associated costs of infrastructure development.

A final reason for its attractiveness is that energy efficiency often comes with positive second order effects, such as comfort for households (more modern and efficient heating or cooling systems), or quality for manufacturing (more precise heating or motion systems, also reducing wear and tear), and these play a critical and often underestimated role in the process of adoption and change.

Additionally, the potential for energy efficiency is huge. Let's take a few examples. In the steel industry, the global average energy intensity ranges around 22GJ/ton of steel, with best available technologies around 20GJ/ton, and a thermodynamical limit of around 10GJ/ton (BF-BOF route). In the cement industry, the global average is around 3.5GJ/ton, with best available systems at around 3GJ/ton and a thermodynamical optimum of 1.8GJ/ton[16]. The average energy intensity of buildings[17] ranges around 150kWh/m2, with best-in-class construction projects now around 50kWh/m2, or 3 times less. Motor systems could be quickly upgraded to better systems, with average savings of around 20%[18]. And the list goes on. A US study notably suggested a potential of 50% overall, 2.5 times higher than the IEA projection within the Net Zero Emissions scenario, for instance[19].

## Progress on making the economy more efficient is still too slow, however

However, despite its potential, the deployment of ambitious energy efficiency programs has lagged, with an acceleration in 2022 primarily due to the energy crisis, which followed the Russian invasion of Ukraine in that year, and which led energy prices to skyrocket.

Primary energy intensity improvements reached 2% 2022 (compared to well below 1% in the previous years). This is however far behind the 3-4% per year targets of the International Energy Agency Net Zero Emissions scenario and the IRENA 1.5-degrees pathway for the decade to 2030[20].

Investments reached a record high of $US560 billion in 2022, a figure to compare, however, to the $US1,500 billion required for the period 2026-2030 in the Net Zero Emissions scenario[21].

## There is a larger story at play, however: boosting the efficiency of the energy system as a whole

Energy efficiency is thus widely recognized as a critical solution to rapid decarbonization of the energy system. It also shows strong potential, across all economic activities. Yet, progress to date has typically been slow, and much more needs now to be achieved, in a short period of time. This is the purpose of this paper: to cover both what is feasible, but also some of the roadblocks that have so far hampered its development.

Our current energy system is widely inefficient and wastes around 2/3rd of the energy it extracts in the first place. As can be seen in Figure 4, the actual useful energy required to provide for daily use services is only a fraction of the total, mainly due to the process of burning fossil fuels to produce heat, which is then used to fulfill direct needs such as building and industrial heat, mobility, industrial motion, etc. The efficiency of such conversion from fossil fuels to heat to other services is traditionally very low, resulting in significant losses.

Reducing losses in the energy system would significantly contribute to reducing emissions, as the latter are the corollary of the former. There is more to it as well. While the neo-classical economic approach has generally overlooked its role, given its limited direct contribution to GDP[23], it has become clear over many energy crises that energy is more than just a means

[16] ©OECD/IEA, 2007, ©OECD/IEA, 2022

[17] Enerdata, 2021, Tengfei et al., 2019, University of Michigan (n.d.). Commercial buildings have typically much higher energy intensities than residential buildings. The figure above is thus an order of magnitude, mainly applicable to urban settings.

[18] ©OECD/IEA, 2011, ©OECD/IEA, 2022, ©OECD/IEA, 2020

[19] Nadel et al., 2019

[20] ©OECD/IEA, 2022b ; IRENA, 2023

[21] ©OECD/IEA, 2022b

[23] Jefferson, 2014

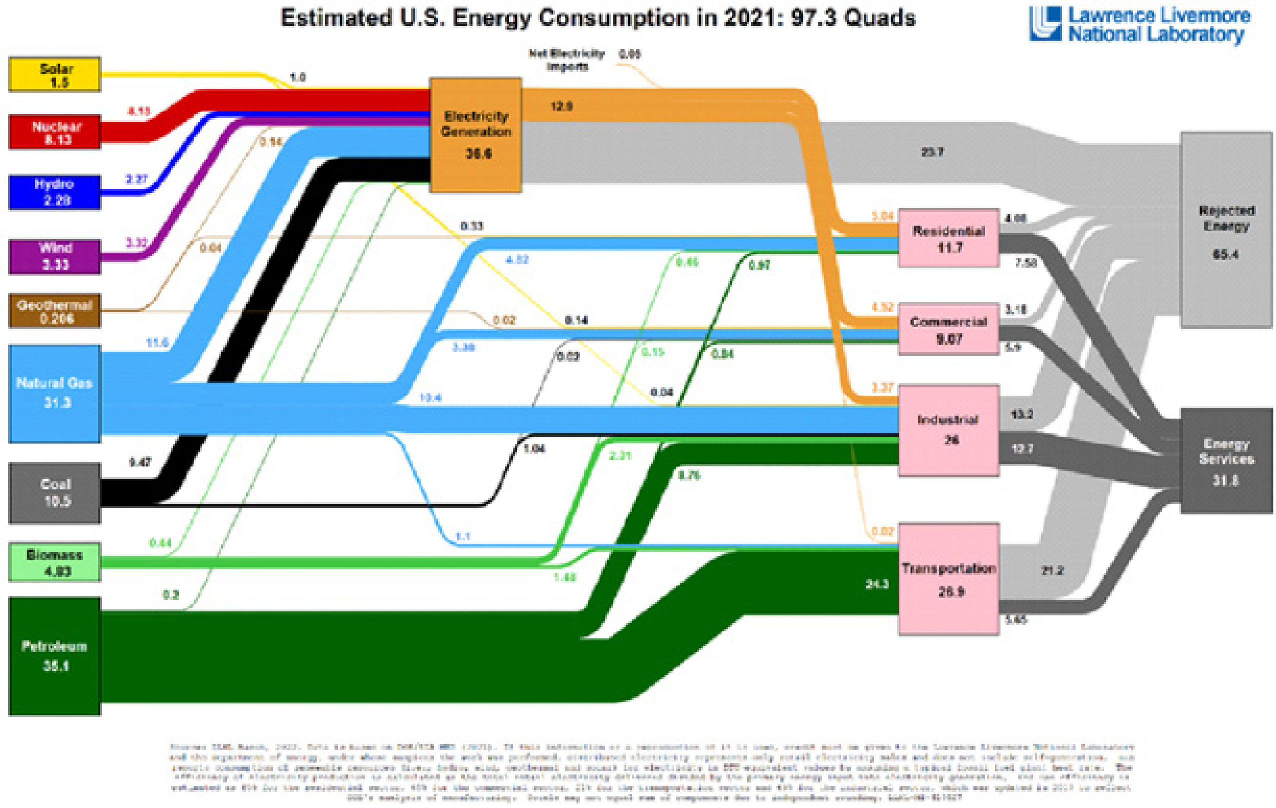



Figure 4 – The US energy system[22]

to an end, and that sustainable economic growth and development largely rely on a resilient, affordable and efficient inflow of energy, with many economists now studying this in greater depth[24].

In fact, economists have suggested that efficiency in the conversion and use of energy resources is a key factor of economic growth, alongside (and maybe ahead of) capital and labor productivity[25].

In other words, an efficient energy system not only contributes to decarbonizatione, it also plays a fundamental role in economic growth.

## A more systemic perspective of energy efficiency could thus be the key to reconciling sustainable development with economic development

The definition of what energy efficiency is must therefore be expanded to account for all these contributions that can have an impact on the overall efficiency of the energy system. Exploring the system as depicted in Figure 4, we suggest a framework made of 3 key categories, and largely inspired by existing academic work and the ASI framework[26]

[22] LLNL, 2021. We must note that primary energy estimates for nuclear and renewable are based on conventions, and thus such a reading of efficiency is more valuable for fossil fuels than it actually is for high-density energy resources such as nuclear, or free renewable energies.

[24] Foxon, 2011 ; Jefferson, 2014

[25] These economists use exergy instead of energy for their measurements. Their analyses, across a variety of countries around the world, show an average of around 80% losses across the energy system, in exergy terms. Ayres, 2011 ; Ayres & Warr, 2005 ; Serrenho et al., 2014 ; Serrenho et al., 2016 ; De Stercke, 2014.

[26] LCreutzig, Callaghan, et al., 2021; Creutzig, Niamir, et al., 2021; Creutzig et al., 2018; Nadel et al., 2019.

1. Opportunities to **improve** current applications and equipment: the traditional scope of energy efficiency (e.g., more efficient motors, LED lights, digital controls in buildings).
2. Opportunities to **shift** current applications and equipment to more efficientenergy resources, i.e., electrification (e.g., electrified power trains are 3 times more efficient than traditional combustion engines).
3. Opportunities to **avoid** energy use for different service provisions: new ways of arranging service provisions to limit resulting energy needs (e.g., sharing models or remote work, but also behavioral shifts).

In this report, we will explore these opportunities and differentiate between those that could be rapidly adopted (chapter 2) and enablers that require more profound changes to the way services are provided (chapter 3).

## Building an efficient energy system while mitigating rebound effects

Energy efficiency measures have also been criticized in the past for the rebound effects that they incurred[27].

Typically, these rebound effects are classed within three categories: direct rebound effects (related to savings on a specific service that prompt additional consumption of the same service ; indirect rebound effects (savings on a specific service that lead to additional purchases of other services); and macroeconomic rebound effects (economic growth, labor supply, etc.).

While such rebound effects are also synonyms of increased wealth, how they impact decarbonization pathways is of major importance. We will review the evidence as we progress through the solutions identified. We will see that, for direct rebound effects at least, there are many solutions that exist to mitigate them.

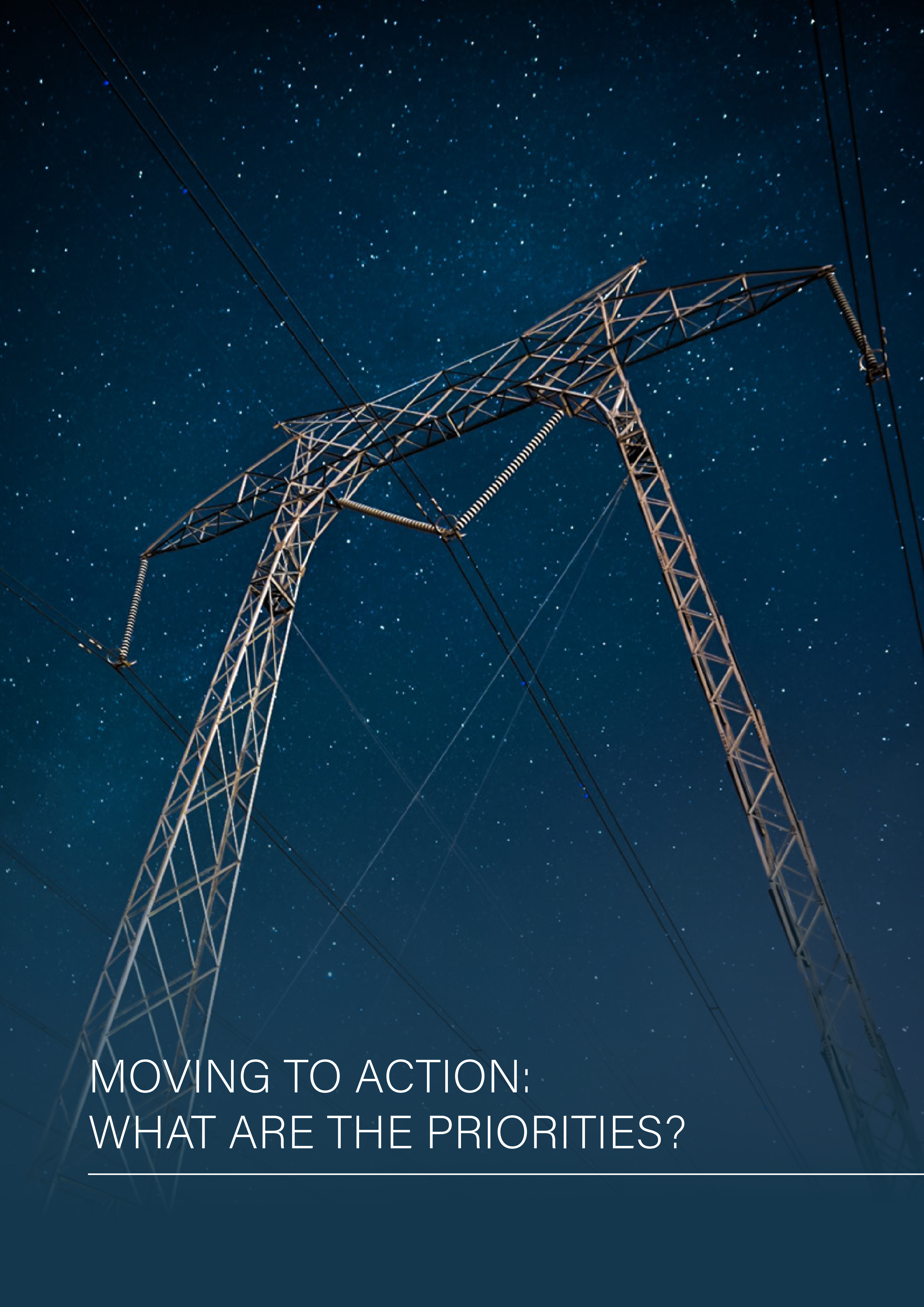
## A framework to navigate energy efficiency

As we navigate the contents of this report, we will list a number of key solutions to improve energy efficiency globally, including changes in behavior.

The following figure summarizes our key findings.

| Energy Efficiency Opportunities | | | |
|---|---|---|---|
| | **Solution** | **Potential** | **Adoption / Issues** |
| Buildings | | | |
| Avoid | Eco-friendly actions | Up to 20-30% savings observed | Behaviors and possible rebounds over time |
| Shift | Heat Pumps | 2/3rd energy saved compared to traditional boilers/furnaces | Initial capital<br>Electricity prices and taxation, relative to e.g., natural gas |
| Improve | Digital technologies<br>LED lights | 10-40% savings | Paybacks below 8 years in average<br>No rebound<br>Lack of awareness of benefits |
| Industry | | | |
| Avoid | Circular Economy | 5-20%[28] | Emerging<br>Lack of effective value chains<br>Lack of business models |
| Shift | Electrification and Heat Pumps | Savings up to 30-50% in some cases[29] | Lack of awareness and competencies<br>Process redesigns<br>Electricity prices and taxation |
| Improve | Motor systems<br>Digital technologies | Up to 20% | |
| Mobility | | | |
| Avoid | New patterns (e.g., remote work) | 1-15% savings | Subject to rebound effects, lack of clarity |
| Shift | Electrification | 2/3rd energy saved compared to traditional engines | Availability of charging infrastructure<br>Cost parity by 2030 across most segments / regions |
| Improve | Vehicle efficiency<br>Lightweighting<br>Modal shifts and mobility as a service | Limited for efficiency<br>Up to 40% for modal shifts | Rebound effects on efficiency observed<br>Availability of public transportation infrastructure |

[27] Brockway et al., 2021; Creutzig et al., 2019; Wadud et al., 2016
[28] Creutzig et al., 2021
[29] Beyond Zero Emissions, 2018



# MOVING TO ACTION: WHAT ARE THE PRIORITIES?

Manish Pant

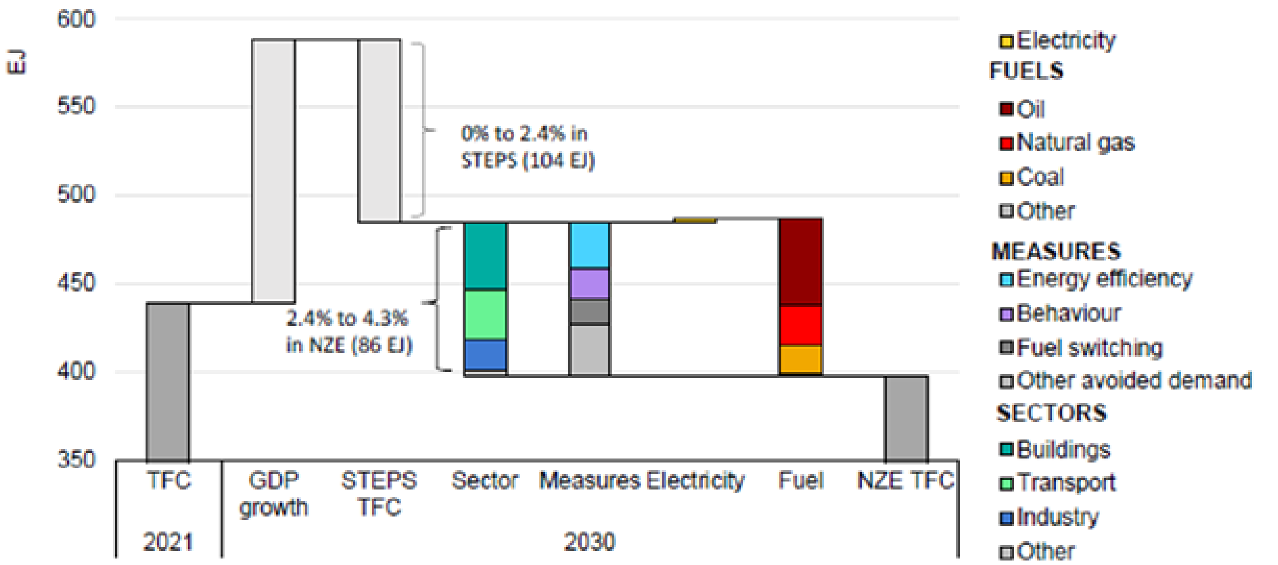
Executive Vice-President of International Operations, Schneider Electric

“We need to be working on both sides of the equation – supply and demand.
Most of the time, we look at the supply side of the equation, which is obviously fossil fuel generation and ask, how can we change the supply to something which is green? Carbon capture operates the same way, in that you produce it and then capture it.
The demand side is something which is, to a large extent, hidden. At home, the only visibility is your electricity bill. So we need to ensure homeowners, and commercial and industrial users can see what is happening – what are the elements they can control and therefore make a difference.
Today with digital technologies, everything is visible in real time on our mobile phones. With home automation, you can see what you’re using. You can control it. You can switch it off, you can programme it. The same is true for industrial applications and infrastructure. You can really monitor your energy in real time and therefore you’re able to intervene and act on it. It pays for itself.

Energy Efficiency: The Decade for Action": this is how the IEA titled its 8th Annual Global Conference on Energy Efficiency that took place in June 2023 in Versailles. This is also a clear call to accelerate action as current efforts and ambitions (Stated Energy Policies Scenario by 2030) fall short of the IEA's trajectory in its Net Zero Emissions by 2050 scenario. EU commissioner Kadri Simson also proposed, at the press conference closing the informal meeting of environment and energy Ministers on 12th July, doubling the global rate of energy efficiency improvements this decade compared to the previous decade. As shown in the figure below[30], efforts need to be doubled with contributions from all sectors (Building, Transport and Industry) and with energy efficiency being a key lever, as well as behavior and fuel switching.

In this section, we will cover all 3 sectors (Building, Transport & Industry), focusing on actions and solutions that have a significant impact and are mature enough to be implemented on a global scale by 2030.

Global final energy demand by measure, 2021 to 2030, STEPS and NZE





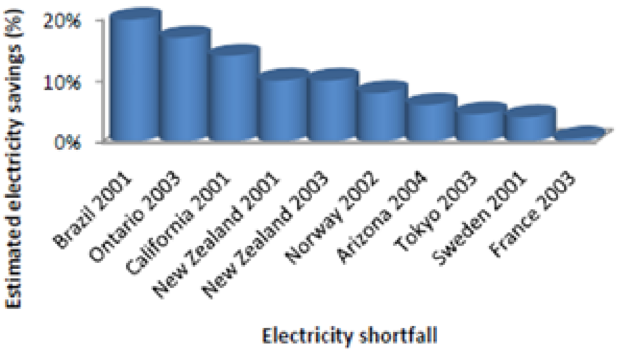

Note: Data based on WEO 2022. TFC= Total Final Consumption; STEPS= Stated Energy Policies Scenario, policies currently in place; NZE = Net Zero Emissions by 2050 scenario; Fuel switching includes mainly electrification. Other avoided demand includes resource and material efficiency gains, circular economy effects and structural and economic effects, such as the response of consumers to higher prices.

[30] Energy Efficiency - The Decade for Action (Ministerial Briefing), IEA (June 2023)

## Taking action in the building sector

## Applying eco-friendly actions can reduce household energy consumption by 10 to 20%.

Case studies show that electricity saving plans in shortage situations can be very effective. Savings can be as high as 20% - Japan 2001, Brazil 2001 - or even 30% in extreme, short-term cases - Alaska. In most cases, the savings programs have made it possible to avoid blackouts.




Estimated savings achieved through emergency energy-saving programs[31]

| | | YOKYO | TOHOKU | KANSAI |
|---|---|---|---|---|
| Target | | -15% | -15% | -10% or more |
| Results | | -19% | -18% | -8% |
| | Large customers | -27% | -18% | -9% |
| | Small customers | -19% | -17% | -10% |
| | Households | -11% | -18% | -4% |

Estimation of Electricity Demand Reduction by Sector in Summer 2011 Compared to 2010 Summer Levels (Weather-Adjusted)[32]

Savings measures in these emergency situations are very effective if implemented over a short period, but most are difficult to maintain. However, some practices can be adopted for the long term, particularly in the residential sector. Industries usually stop measures that are considered very restrictive, if there are no obligations.

The effectiveness of the measures depends on good targeting of actions, which requires detailed sectoral data on final energy and power consumption. The right targeting of measures makes it possible to identify the sectors in which savings can be made at limited social, economic and political cost.

Most of the reduction in demand comes from a limited number of measures in:

1. Industry: on-site self-production, shifting production times or even transferring production in the event of localized shortages, measures on motors and pumps, etc.
2. Tertiary and Residential: room temperature adjustment, limitation of air-conditioning operating hours, substitution by other heating sources in the case of dual-energy housing, unnecessary lighting off, number of light points reduction, alternating street lighting, lighting of public facilities reduction, disconnection of unused or unnecessary equipment (second refrigerators and freezers), use of equipment modification (e.g. using the dishwasher, not using the tumble dryer, shifting the period of use, increasing the fill rate), shorter shower duration, lowering the temperature of DHW cylinders), etc.
3. Businesses: improved management of heating, ventilation and air conditioning (buildings are over-ventilated, lighting and temperature management), even though it is difficult to implement in the short term.

In most studies, prices have risen sharply and are likely to have played an important role in achieving energy savings. Price signals are effective, particularly for peak-load savings.

In countries where the volume of savings has been very high, rationing coupled with penalties (or even the threat of blackouts) has been introduced, often targeting large consumers, and sometimes all sectors including households.

Financial incentives are sometimes used and prove effective (e.g. reduced bills in California in 2001).

Even in crisis situations it is possible to encourage investment in efficient equipment, but it must be affordable.

[31] Update 2011 Saving electricity in a hurry update 2022 - Sara Bryan Pasquier – International Energy Agency

[32] Saving Electricity in a Hurry: A Japanese Experience after the Great East Japan Earthquake in 2011 - Osamu Kimura and Ken-ichiro Nishio, Central Research Institute of Electric Power Industry

Information campaigns wereimplemented in all the cases studied. They are essential and reinforce the effectiveness of other measures. They are widely disseminated and adjusted by sector and by use. When it comes to reducing peak demand, messages are disseminated on a daily basis with simple recommendations on a limited set of actions.

The measures implemented are very conventional (thermostat, lighting, etc.), and it is important to target those with a significant potential for savings (either in terms of consumption or peak effect).

## Digital solutions in the home make these gains sustainable over time.

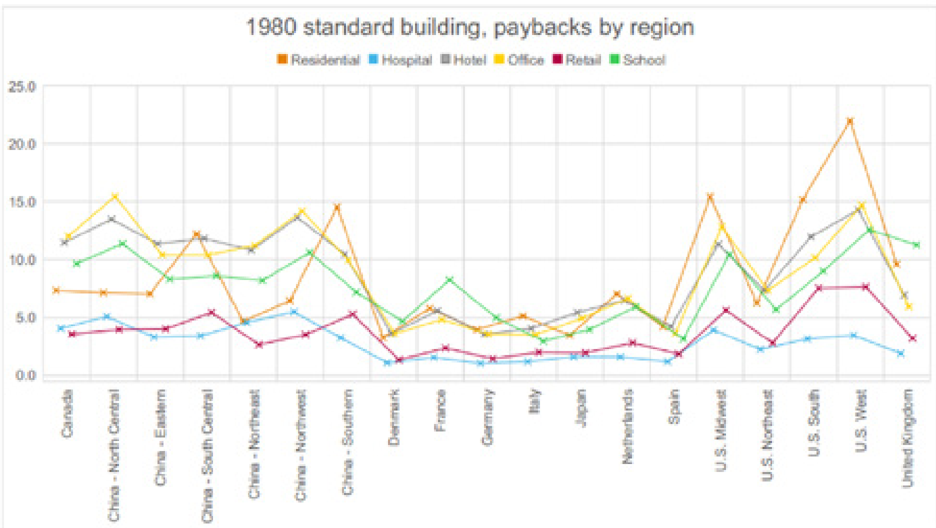
Controlling energy use in the home is a source of energy savings and CO2 emissions. The development of the use of electric storage water heaters in the housing stock in the 1970s, combined with off-peak hours, made it possible to shift a large volume of consumption from peak hours to off-peak hours. In doing so, the production of hot water at night had a second impact: by bringing it closer to morning consumption, the off-peak system reduced the heat losses associated with storing large quantities of hot water. Recent studies carried out by EDF R&D have estimated that 12% of savings can be made by controlling hot water tanks.

Further studies have demonstrated the benefits of even more detailed control of usage. A hot water tank that is controlled during off-peak hours can see its energy consumption fall by a further 3% to 7% if it is controlled according to how hot water is used by households. Self-learning algorithms now have the capacity to anticipate draw-off habits and manage the heating of hot water as closely as possible to consumers' needs.

When it comes to heating, ADEME[33] considers that the use of a thermostat capable of finely managing the set heating temperature by controlling reductions during night-time or unoccupied periods can reduce energy consumption by 15% in France. EDF R&D studies show savings of 20 to 35%, depending on usage.

Controlling flexible use is also a way of increasing the use of photovoltaic self-production. Studies carried out by EDF R&D, on the basis of field monitoring, have shown that the proportion of energy produced by a home's rooftop photovoltaic systems and consumed by the home's uses could increase by 20 to 35% by controlling the equipment, particularly the production of domestic hot water. In this context, control takes into account both sunshine and user behavior forecasts.

**Overall, studies show that we can get 10-20% energy efficiency in households, and 10-40% in commercial buildings, with paybacks below 8 years in many cases and as low as 2 years in specific cases** (see figure below). It is also worth mentioning that digital solutions are key when it comes to maintaining savings over time and limiting rebound effects.



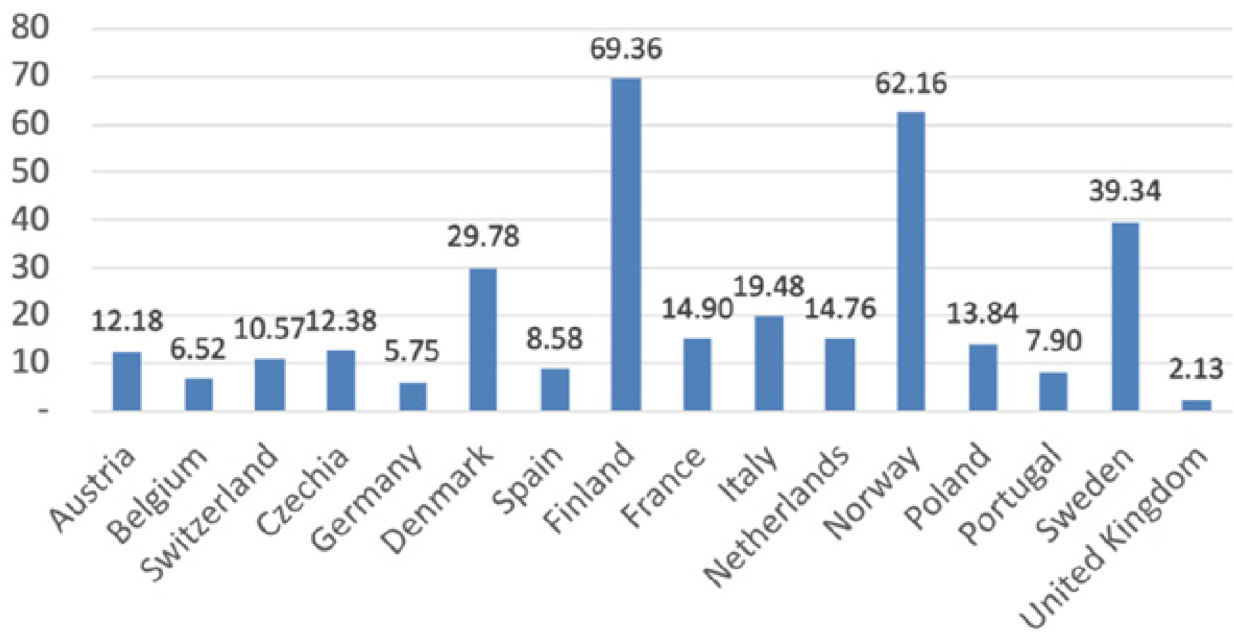

1980 standard building, paybacks by region (category A)[34]

[33] Agence de l'environnement et de la maîtrise de l'énergie, the French public agency for the environment and energy management
[34] Cracking the Energy Efficiency Case in Buildings, Schneider Electric Sustainability Research Institute (October 2021)

## Heat pumps: the reference solution in buildings for greater efficiency and a transition to low-carbon energy sources.

Heat pumps are booming in many countries. As the graph[35] below shows, the penetration rate is very high in Scandinavian countries such as Denmark, Finland and Norway, demonstrating that heat pumps are not a technology reserved exclusively for temperate climates.

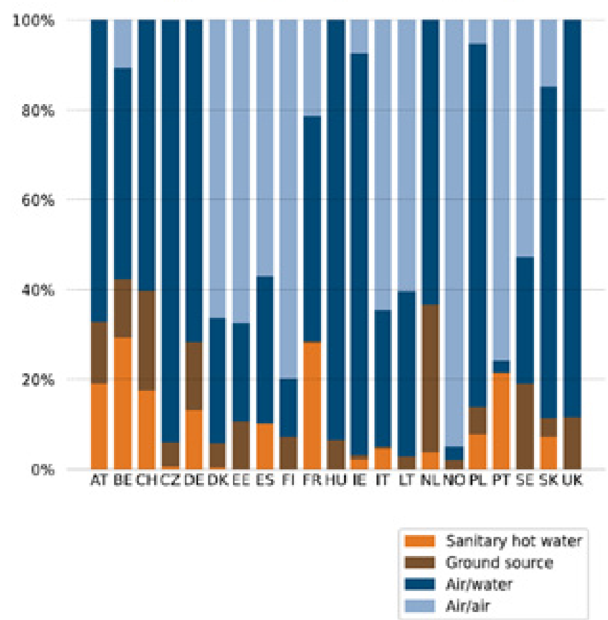
**Heat pumps sold per 1,000 households in 2022 per country (household numbers based on 2021 data)**




Emblematic of the concept of renewable energy, heat pumps recover calories from an external medium (ground, water, air) to supply heat and/or cold to the target environment.

The simplest version to install, the aerothermal heat pump (Air/Air or Air/Water), consists of an outdoor unit that can be installed on a roof terrace, on the ground or on a balcony, and an indoor unit. It recovers heat from the outside air and distributes it to the air in the building. This is a very widely developed solution, not only in countries with warm climates, but also, as shown in this figure[36], in countries with moderate or even cold climates.[37]

*Chart 3.1-7: Share of energy source used per country. Blue: air-source, brown: ground-source*




[35] EHPA, feb. 2023 (https://www.ehpa.org/press_releases/heat-pump-record-3-million-units-sold-in-2022-contributing-to-repowereu-targets/)

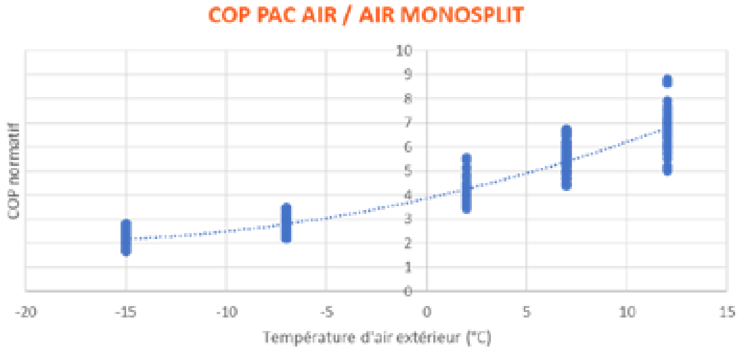
[36] EHPA Market Report 2022

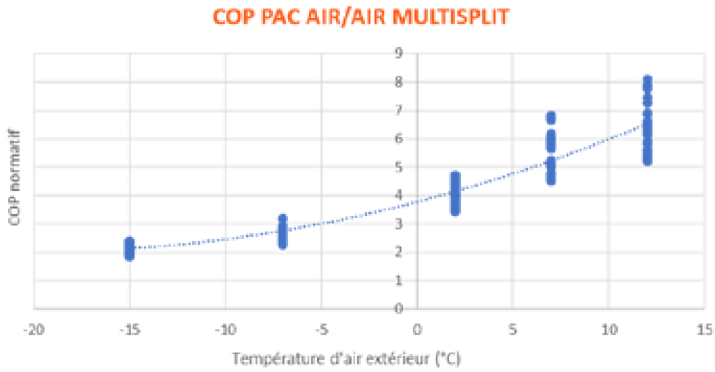
[37] https://ars.els-cdn.com/content/image/1-s2.0-S2542435123003513-mmc1.pdf

The performance of heat pumps is expressed by their COP (for Coefficient Of Performance). This is the ratio between the energy supplied (heating a home, for example) and the energy consumed (electricity to run the heat pump).

The figures on the right were drawn up on the basis of an analysis by EDF R&D of the normative performance[38] of several dozen of the best-selling products in France.

At an outdoor temperature of 0°C, an air-to-air heat pump achieves an average COP of 4, which means that for a consumption of 1 kWh of electricity, the machine is capable of providing 4 kWh of heating for a home. The "free" 3 kWh are then taken from the environment.



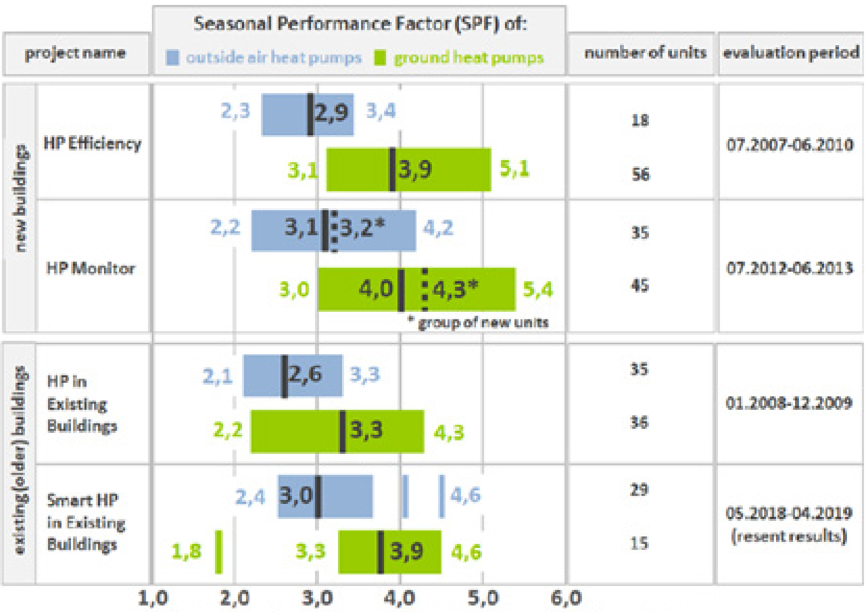



Fig. 2. Averages values and ranges of the SPF in existing residential houses in Germany

This "theoretical" performance can also be seen in the field, and continues to improve. The figure[39] below summarizes the performance of 250 heat pumps installed in Germany. In 10 years, the average COP of air/water heat pumps installed in existing buildings for renovation purposes has risen from 2.6 to 3.0 on average over the whole year.

[38] Certified values of test results in accordance with NF EN 14511 under the partial load conditions of NF EN 14825 for calculating seasonal performance.

[39] Heat pumps in existing residential buildings, Fraunhofer ISE, 2021

## Digital solutions encourage sensible and sustainable energy renovation, considering the "unique" architectural features of buildings and the life plans of their occupants.

The digital revolution has not affected the construction industry to the same extent as other sectors, but change is underway. BIM (Building Information Modelling) is no longer reserved for large new tertiary complexes. Attaching a database to a physical asset is developing in all sectors, as attested by the housing information booklet. These digital solutions will undoubtedly increase households' motivation to act.

The energy renovation business is characterized by a high degree of fragmentation. Apart from the specific case of social housing, demand is usually from private individuals. Even in the case of condominiums, the decision-making process is so long that individualized solutions are preferable.

Upstream of these sectors, the construction industry offers a range of products. However, when it comes to renovation, the prescription business is often reduced to its simplest form. Product specification is usually the result of the installer's habits, the customer's practical constraints and the availability of distribution networks. The service provided by the product, its impact on energy efficiency or comfort is usually left out of the equation. In some cases, an approximate assessment of requirements can lead to over-consumption or worse, when products are in short supply, to improvisation in the field with product sourcing being guided by local availability and a project's constraints, in particular its deadlines.

Fluctuating costs are another notorious problem in the renovation industry - a source of perplexity and even skepticism among customers. It's not uncommon that prices vary by a factor of three with the same request for work and the same expression of need. It all depends on the company's workload, the hope of winning the customer's loyalty, the company's level of qualification for the work requested, the solution chosen... Of course, there will always be outliers, but it is fair to say that most of the renovation work meets standard needs for which a little professionalization, based on modern practices, would make it possible to rationalize the preparation of quotations.

The approximate nature of quotations shows that the renovation industry is satisfied with a certain degree of imprecision. This proves that companies are highly adaptable. But it is not likely to reassure customers. How can they have confidence in quality and deadlines if the craftsman himself cannot see the site unfolding before his very eyes when he draws up his quotation?

In this context, renovation must be accompanied by a layer of services upstream of the work. These services must bring professionalism to the industry and confidence to customers. They must also provide technical and practical justification for the solutions proposed. The development of 3D scanning, BIM, image analysis and the ever-increasing amount of data available on the Internet, from connected objects or smart meters, are all sources that can be exploited to make renovation work more objective, to industrialize the processes involved, and to produce diagnostics, quantity surveys and estimates almost automatically.

Artificial intelligence methods can carry out an energy diagnosis of an existing building without any input other than the external data that may be collected for that building. It is therefore possible to build a diagnostic tool based on the interpretation of images available on the Internet, using deep learning neural network technologies. This exercise requires the availability of many images and the involvement of experts to 'label' these images in order to train the neural network. Street-View images can be widely used for this purpose. The aim is to automatically identify the key elements of a given building in order to produce a digital model capable of dynamically calculating its energy behavior.

With an estimate of the building's energy behavior and its main dimensional characteristics, it is possible to draw up technical designs (insulation surfaces, number and size of windows, power of an energy system, number of extractions and air inlets for a mechanical ventilation system, etc.) for renovation solutions, with a good level of detail in terms of the services offered.

The reliability of these tools will be greatly enhanced in the future by 'self-care' solutions that allow users to carry out their own 3D scans of their homes using their smartphones. Applications using LIDAR - light impulse radar - or virtual reality are offered on most recent smartphones.


Moving on to the automatic quotation stage can then be done in different ways, either by using standard services available in the technical literature (e.g. BATIPRIX) or by using standard services provided by an installation company that subscribes to the automated quotation system. Reference can also be made to any public data on renovation support schemes.

## Digital solutions are also a key lever in new constructions where inefficiencies are significant.

Although new constructions offer more opportunities of doing things right first time in terms of energy efficiency, inefficiencies are still a big challenge. And the stakes are significant, especially in new economies where urbanization is still ongoing. What studies[40] show us is that:

1. Construction accounts for more than 13% of global GDP (including capital equipment; 6-7% without) and employs over 7% of the global workforce, around 250 million people for a net contribution of around US$10 trillion annually.
2. As a whole, this sector has made virtually no productivity gains in several decades.
3. Civil and industrial construction is generally more efficient, handled by large and well-organized enterprises with strong engineering, process, and procurement activities, yet the bulk of construction lies in smaller projects and all the specialized contracting that goes with them (painting, roofing, plumbing, electrical works, etc.), which drives down productivity significantly. In fact, many of these activities may have experienced negative productivity over the last decades.

[40] See for example : "Reinventing construction through a productivity revolution", McKinsey Global Institute (Feb. 2017)

4. This is notably due to the inherent fragmentation of the sector. In the European Union, construction companies with more than 250 employees barely contribute 20 percent to the total sector output. Figures are similar, if not worse, in the United States.
5. This also has to do with the significant volume of regulations that apply to the sector, on average (in the United States) seven times more than in other sectors (such as agriculture or mining).

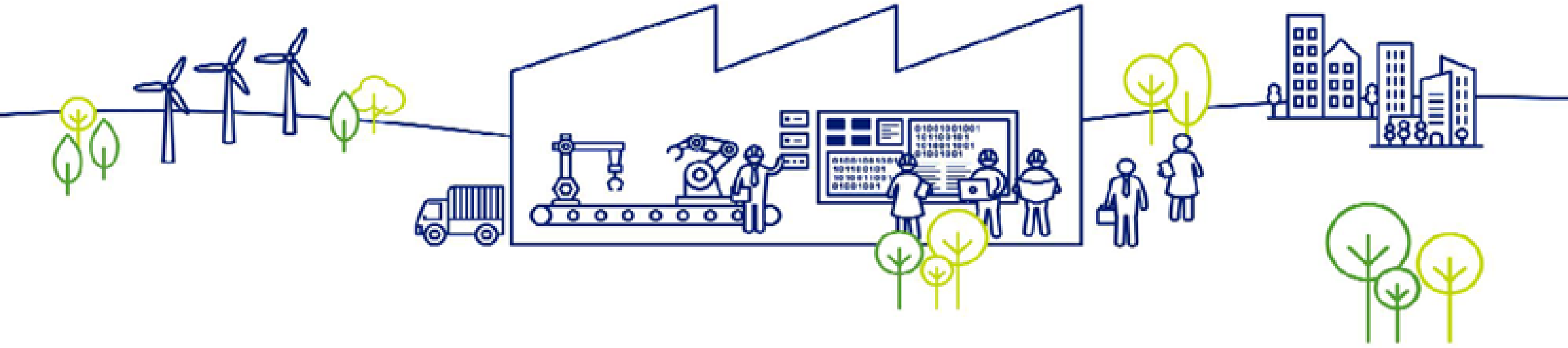
This fragmentation and huge complexity lead to coordination and project management issues, misaligned incentives, global underskilling, and underinvestment. Digital solutions are a key lever to close these gaps.

## Taking action in industry

The role of the industrial sector is both fundamental and transformative. It forms the backbone of our world's economic development - from the production lines of factories to high-tech research labs. There is a strong link between productivity and value creation. Industries transform raw materials into finished goods, a process that creates significant value. The industrial sector, encompassing a vast range of activities, also plays a pivotal role in job creation. And these jobs come with higher-than-average incomes, leading to increased living standards and thereby contributing to social progress in a more inclusive world.

Despite these benefits, industrial activities also come with a sustainability challenge. Industry is indeed accountable for around 30% of global greenhouse gas emissions. Heavy industries are responsible for a little over half of these (55%), with light industries forming the rest. Both need to be considered separately. The former often take the form of large and concentrated sites, which therefore require focused efforts at upgrading facilities to Best Available Technologies (for which the potential remains high) and deploying new technologies, such as heat recovery, electrification, hydrogen and others. The latter is more fragmented, and often composed of Small and Medium Enterprises (SMEs). The challenges these companies face is thus different: lower capacity to investment, higher ability to turn around rapidly. In both, the potential for decarbonization and energy and operational efficiency remains high. And modern technologies such as digital can play a significant role in accelerating the spread of energy efficiency within industry – this is often referred to as smart manufacturing.

Yet, today, fewer than 30% of companies have successfully deployed smart factory programs at scale[41]. Because of the extremely positive impact on energy and resource efficiency, on top of operational efficiency, it is critical that public and private organizations step up their efforts to scale up smart manufacturing for a more sustainable et energy efficient world.



## The data-generating "smart factory" opens up new potential for energy efficiency gains.

The Industry of the Future refers to all the transformations taking place within existing or new plants.

The term "industry" is used to encompass all manufacturing and production activities, which are not necessarily located on the same industrial site. Some manufacturers produce their products in a so-called "extended" factory. For example, when BMW produces a car, several factories around the world work

[41] McKinsey https://www.mckinsey.com/capabilities/operations/our-insights/covid-19-an-inflection-point-for-industry-40

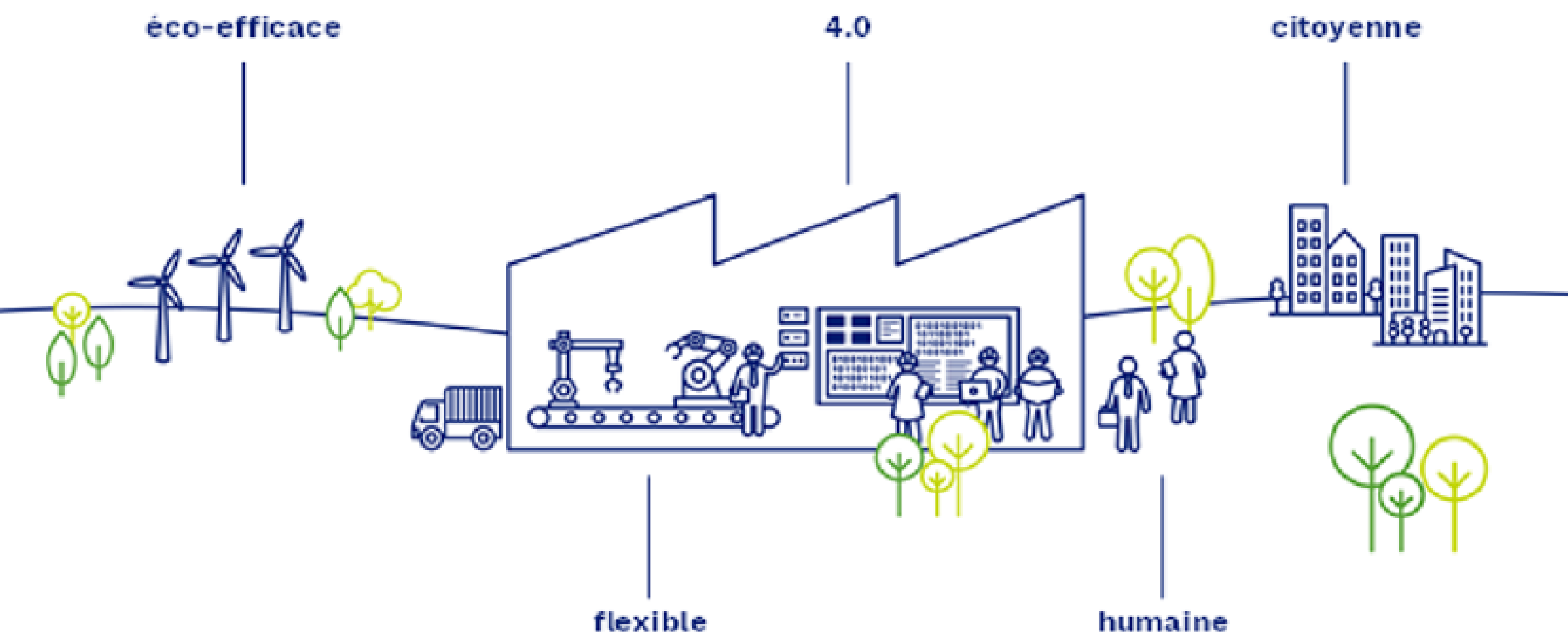
in parallel and in coordination to manufacture the various components that will then be assembled. For example, the assembly plants in Leipzig and Munich coordinate the production of more than 20,000 parts per vehicle produced worldwide, with the plants being interconnected.

The Industry of the Future primarily concerns existing plants, which are being transformed in order to become more competitive and adapt to changes, particularly those linked to changes in customer demand. This means being more agile and being able to adapt production almost in real time.

The notion of the Industry of the Future therefore encompasses all these transformations and is broken down into five main areas: flexible plant, digital plant, plant in harmony with people, plant that reduces its environmental footprint and a corporate citizen. Digital technology and Green Tech technologies are increasingly present in all these areas.
At the core of the change management process toward smart factories lies operational excellence. Operational excellence serves as a foundation for productivity and efficiency in industrial operations. By continually improving processes, fostering leadership and teamwork, and eliminating waste, companies can achieve operational excellence. When combined with sustainability goals, operational excellence becomes a powerful driver of economic growth, wealth creation and environmental success. By optimizing resource usage and reducing energy consumption, organizations can achieve both enhanced productivity and contribute to long-term sustainability through efficiency.

Operational excellence, a philosophy that encourages continuous improvement, leadership, and teamwork, is the toolbox for productivity and it intersects remarkably with sustainability goals. It can be best defined by 3 pillars: Process, People and Technology.

1. Process Efficiency: Process efficiency lies at the core of operational excellence, with an essential principle being the elimination of waste. When viewed through the lens of sustainability, waste takes on a broader meaning. It involves not just inefficient business practices, but also the waste of resources and energy. Lean methodologies and other similar process improvement tools can be used to identify these inefficiencies. By eliminating waste and reducing resource usage, businesses can enhance productivity while also contributing to environmental sustainability.
2. Technology: Data analytics provide insights into process performance and environmental impact, while automation technologies reduce repetitive tasks and decrease raw materials and energy resource consumption. However, it's vital to remember that technology should augment, not replace, the human aspect of operational excellence.
3. Empowering People: Operational excellence is fundamentally about people. Employee involvement in the quest for operational excellence and sustainability can spark creativity and problem-solving, driving further improvements in productivity. Encouraging a culture where employees feel empowered to suggest sustainable improvements and are rewarded for their initiatives forms the bedrock of this approach.



Such development can prove beneficial at every level of the enterprise:

**At operator level:** Thanks to the large number of measurement sensors, production machines are increasingly incorporating assistance and automation functions. Operators focus their attention on the control screens, which provide an overview of the data produced by the sensors in real time, without having the time or expertise to analyze it.

**At the level of the company's main functions:** The digitization of the factory has paradoxically siloed functions. Sales, Production, Finance, HR - each has specialized in its own field, manipulating its own data and KPIs. This compartmentalization affects overall performance and defines the limits of the company's computerized system. The cross-use of this compartmentalized data within the company would offer new performance levers.

**At the middle management level:** These managers complain that on average they spend 25% of their time on reporting instead of managing their teams.

Also, manufacturers are under increasing pressure to reduce their environmental footprint. Improving the performance of plants is also an opportunity to take environmental performance into account.

Here are some of the typical Operational KPIs when driving continuous improvement toward operational excellence practice in sustainability:

1. Waste Reduction.
2. Water Consumption Reduction.
3. Wastewater Reduction.
4. GHG Emission Reduction.
5. Energy Efficiency.

New technologies such as 5G, AI, cloud and edge computing, robotics, and industrial metaverse(s) further strengthen the case for Smart manufacturing. And Smart manufacturing companies are already natively equipped to implement such technologies.

Overall, the potential source of energy savings is estimated at 40% of current consumption.

We can classify the various actions to be taken into four main areas:

1. Rethink the "recipe" for your product by using less material, less energy and more natural materials.
2. Optimize Assets efficiency: Recover energy losses with energy recovery machineries. Upgrade to higher performance machineries, robotic, automation and apply variable speed drives on motors.
3. Optimize Plant Efficiency: Integrate Sustainability KPIs into Operational Excellence practice. Upgrade to Smart factory through Digital transformation. Implement new processes to enable circularity in-manufacturing plants.
4. Optimize Value Chain: Optimize your operation from design to operation with digital twins. Share data with ecosystem. Exchange energy, materials, co-products or waste with other local players.

At workshop and plant level, this means implementing all the energy efficiency solutions, using the best available techniques and processes that substitute decarbonized electricity for fossil fuels, and recovering waste heat.

To achieve this, a systemic approach is needed to identify the optimum solutions and organize progressive investment. Product lifecycle analyses (LCA) can identify the most polluting operations, and eco-design can consider the projected environmental impact of the product's use.

Energy and "exergy" analyses (economic value and usability of the energy source) include all the components of the transformation processes. The approach must be carried out at the level of detail required to put the process studied into perspective in relation to competing processes, and to incorporate the limitation of pollutant emissions of all kinds.

To obtain the most energy-efficient solution, the methodology involves estimating the minimum energy required (MRE) to manufacture the product. This estimate will be used to implement improvements that are possible, sustainable and economically optimal. For example, recovering waste heat with a heat pump could lead to the replacement of a boiler.

Other solutions need to be considered, including:

1. Better management of the plant's increasingly electrical equipment.
2. Electrifying transport (internal and external), i.e. the supply chain.
3. Reviewing the general organization of the production system, based on digitization and increasingly available data, taking into account the need for production flexibility.
4. Including the environment parameter in plant improvements.
5. Making better use of data.

As part of their digital transformation to improve performance and develop new products, manufacturers need to take environmental parameters into account from the outset, so that they can make virtuous investment choices.

As in other areas, the collection, management and analysis of data will enable new optimization levers to be activated, and the entire energy and pollution cycle of product manufacture to be better controlled.
The success of these transformations depends on increased synergies between a company's business lines and the exchange of data.

## Motors and lighting: an example of mature energy efficiency solutions that are developing favorably.

According to the International Energy Agency[42], 21% of electricity consumption could be saved if a traditional energy system was replaced with an energy efficient system.

Electric motors account for 70% of electricity consumption in industry. Replacing an IE1 motor with an IE3 or IE4 motor improves efficiency by an average of 2 to 5%. Installing an electronic variable speed drive on an electric motor can deliver energy savings of 15 to 20% on average for processes with variable loads. The audit carried out on a chemical site in Normandy identified potential electricity savings of 800 MWh/year by replacing 25 electric motors, representing an investment of €135k and a payback period of 2 years.

[42] Energy Efficiency Policy Opportunities for Electric Motor-Driven Systems, IEA (2011)

## The electrification of industry, combined with a low-carbon energy mix, is an essential lever..

Studies show that the potential of electrification is >60% across most industries as shown in the graph below[43]. Some countries have set ambitious targets: for example, French authorities aim to reacha 70% overall electrification rate (in final energy terms) by 2050 vs. ~40% currently. Globally, IEA Net Zero Scenario sets the target at 50% in 2050 vs. current ~19%.
Although the potential is huge, and the rationale for electrification is already well established, in order to take action, priority needs to be given to the most cost-effective solutions that are technically mature and sufficiently robust for industrial players to adopt them.

With this in mind, low-temperature thermal applications, and in particular the electrification of heat for drying and steam, are probably the best candidates in the short term. Industrial heat pump technologies are relatively mature and offer significant energy efficiency gains. Other mature electrical solutions (boilers, furnaces, mechanical steam compressors) will also develop, either by becoming more competitive, or through the introduction of more attractive public subsidies.

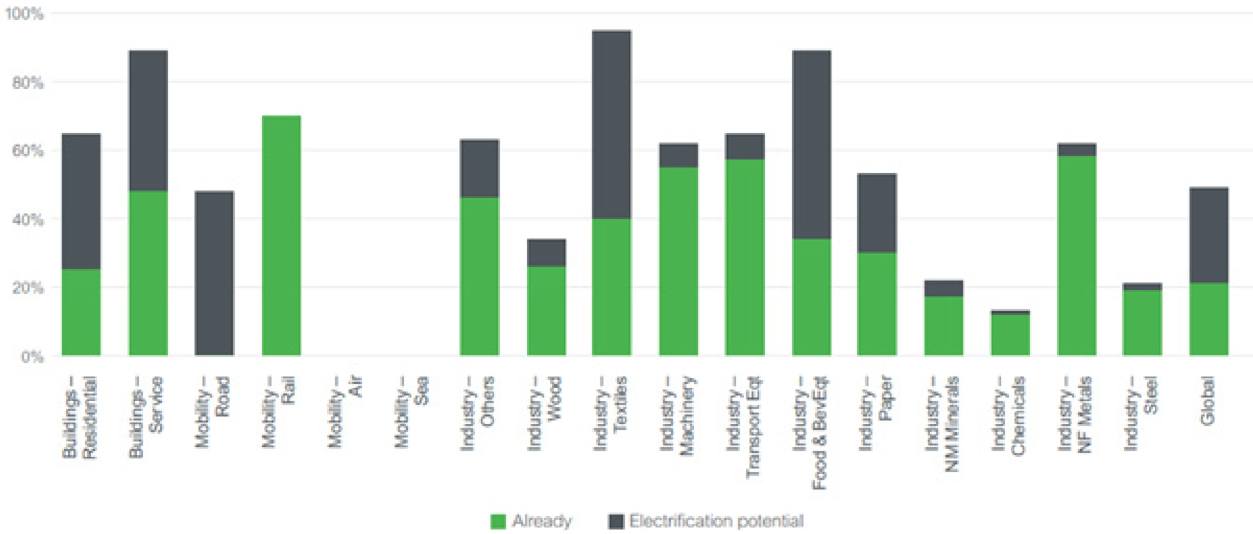
## Heat pumps: promising "firsts" and the "wall" of steam to break down.

The "Net Zero by 2050" scenario proposed by the IEA anticipates the installation of 500 MW of very high temperature heat pumps in industry every month for the next 30 years. To achieve this, a number of hurdles need to be overcome, in particular steam production, which is too widely used in industry to be ignored.

Heat pumps are competing with heat recovery by heat exchanger, when there is available waste heat that is higher than the temperature of the thermal use that is to be supplied. However, there is still a quantity of unused energy that could be recovered by heat pumps, estimated at 12% of the thermal needs of industry. This estimate takes into account the coexistence, both temporal and geographical, of thermal waste to be recovered and thermal needs to be met.

The main challenges are improving competitiveness and integrating very-high-temperature heat pumps (between 100 and 150°C) into industrial processes, while guaranteeing reliability and optimization.

In addition to developing this technological solution, the other challenge is to identify the specific or




Electrification penetration, by sector (% of final energy demand)

[43] Road to a rapid transition to sustainable energy security in Europe, Schneider Electric Sustainability Research Institute (October 2022)

even unique industrial situation - the geographical and temporal location of needs and resources - that will enable the greatest value to be derived from it. Researchers are therefore developing on-site energy diagnostic tools to identify energy optimization actions and circular economy tools that will make it possible to identify sources of energy savings and carbon emissions on a regional scale (see point 2.4).

## Industry in its local environment: circular economy and energy efficiency

The energy and, above all, environmental performance of industry must be considered beyond the confines of the plant. While the various scopes for analyzing the environmental footprint encourage this, the experiments conducted on the theme of industrial ecology show that there are real benefits to be gained from sharing energy and material flows in order to make better use of them.

## Taking action on mobility

## Energy efficiency in transport requires a transformation of everyday mobility.

The fight against climate change in the field of transport is structured around three systemic logics: improve, shift and avoid. Improve refers to technological innovation in modes of transport and flow management. Examples include innovation in engine efficiency and the development and democratization of electric vehicles. Shift corresponds to the modal shift towards soft, less energy-consuming modes of transport. Avoid seeks to have a direct impact on the need to travel by considering the spatial form and organization of business and residential centers, with the ultimate aim of reducing the need for (constrained) mobility.

This system of action on mobility was developed in the 1990s and gained momentum on the international stage throughout the 2000s. The articulation of these logics in public policies aims to meet the European Union's commitment to reduce transport-related $CO_2$ emissions by 90% by 2050.

### Decarbonizing mobility: electrifying vehicle fleets (improve)

As observed by Frédéric HERAN and Arnaud SIVERT[44], the energy efficiency of vehicles has improved significantly over the last 60 years. Between 1960 and 2017, energy consumption per kilometer for passenger transport decreased by 39% in France. But there is still huge potential for further reductions if all the characteristics of personal vehicles are considered: not only engine efficiency, but also vehicle mass and aerodynamics.

For car manufacturers, however, there is no question of touching sensitive features of their products at the risk of confusing the consumer. On the contrary, they must continue to move their vehicles upmarket by offering ever more features, to encourage customers to buy more sophisticated and more expensive cars and thus increase their margins. So, it's hardly surprising that their efforts have produced meagre results.

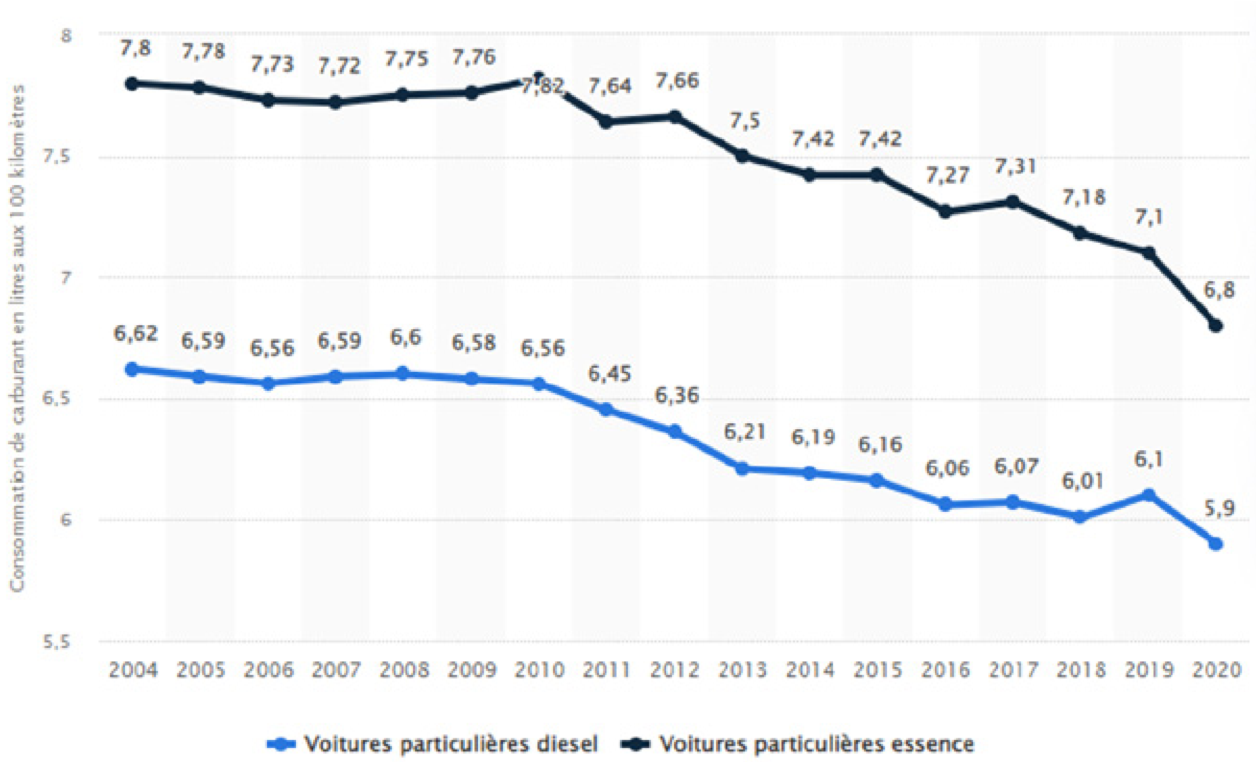
[44] « L'amélioration de l'efficacité énergétique des véhicules individuels » - Transports Urbains 2022/1 (n°121)

In the 1960s, cars weighed an average of 800 kg. The weight then increased, reaching 1,293 kg in 2007. Since then, it has fluctuated around 1250 kg, because all the efforts made over the last 15 years to make vehicles lighter have been cancelled out by several developments: increased demands in terms of safety, greater habitability, new comfort equipment, added design features and more powerful engines. Nevertheless, limiting vehicle weight remains the main objective set by the automotive industry to reduce greenhouse gas emissions.

Many carmakers have also demonstrated that it is possible to significantly reduce the aerodynamic drag of their vehicles. But such feats limit innovation in terms of design, leading to very similar-looking vehicles (low height, plunging bonnet, low roof, rear tracks narrower than the front, streamlined tires, solid rims, etc.). The considerable development of 'cross-over' vehicles (a cross between a family car and an off-road vehicle) and SUVs (sport utility vehicles with a high, bulky body) completely undermines these efforts, because, compared with a city car, their imposing silhouette increases the frontal area by around 50%, which means that aerodynamic drag is increased by the same amount.

In 2020, the unit fuel consumption observed for the French fleet[45] was 6.8 l/100 km for petrol cars (i.e. 599 Wh/km) and 5.9 l/100 km for diesel cars (i.e. 572 Wh/km).

Electric cars are more energy efficient. A 100% electric city car will consume around 150 Wh/km, i.e. 3 to 4 times less than a combustion engine car. While user costs are already lower than conventional vehicles, purchase costs will drop below those of conventional vehicles by around 2030 across most segments of mobility and regions. For instance, SUVs in Europe could reach parity by as early as 2025. The same sector in India would however reach parity in the early 2030s[46] . Sales of combustion engines peaked in 2017 and are now in decline. Globally, 14% of passenger vehicles sold are EVs and that share is expected to rise above 30% by 2026. In some countries, such as China or Germany, it is already well above 50%. Beyond passenger vehicles, bus fleets and two- and three-wheelers are also electrifying rapidly.




45 https://fr.statista.com/statistiques/486554/consommation-de-carburant-moyenne-voiture-france/

46 BloombergNEF, 2023

## Maria Fernanda Suarez

President, Banco Popular

“I’m a believer that with climate change and energy efficiency, what is really going to get us to a good place and reach net zero is technology and R&D. People say all the time, “We are advancing.” But the advances have not been commercially efficient, so the technology is there but it is not affordable for people.

If you want to change your air conditioner to the most efficient one, you need to invest a lot of money. People have consciences, but it also needs to make economic sense for them as well.

## Modal shift: underlying trends continuing (Shift)

The energy savings achieved by the switch to electric cars should not hide the reality of mobility performance. Cars are still very inefficient in terms of energy consumption, because they essentially transport their own mass rather than people and loads. This "dead weight ratio" (= empty weight / laden weight) was as high as 87% in the 1960s. As vehicle occupancy rates fall and vehicles become heavier, this figure rose to 92% in 2020. This poor performance means a huge waste of energy and materials. What's more, when it comes to manufacturing a car, "the mass of raw materials mobilized represents 7 to 10 times that of the vehicle manufactured, not to mention the unused materials (soil excavated during the construction of infrastructure, etc.)".

The governance of mobility is part and parcel of a modal choice paradigm. Since the 1990s, the European Union has favored a modal shift policy. At the local level of municipalities and conurbations, there is a collective effort to reduce the use of the car and to offer residents a range of modes of transport, drawing on the modelling and information capabilities of mobility platforms. Nevertheless, the modal shift towards less energy-consuming and less polluting modes of transport is still very low.

The only shift in the modal mix is generally taking place in urban centers, while the rest of the country is still largely dominated by the carbon-intensive private car. In France, as an example, between 2008

| Caractéristique | Masse du véhicule (kg) | Puissance maximale du moteur (W) | Vitesse moyenne (km/h) | Puissance utilisée à la vitesse moyenne (W) | Efficacité énergétique (Wh/km) | Par rapport à la voiture électrique |
|---|---|---|---|---|---|---|
| Calcul | | | b | a | a / b | |
| Vélomobile | 30 | - | 35 | 100 | 3 | / 50 |
| Vélo | 14 | - | 18 | 100 | 5,5 | / 27 |
| Vélomobile à assistance élec. | 50 | 250 | 45 | 350 | 8 | / 19 |
| Marche | - | - | 4 | 40 | 10 | / 15 |
| Vélo à assistance électrique | 20 | 250 | 25 | 350 | 14 | / 11 |
| Scooter électrique | 90 | 4 500 | 45 | 1 300 | 29 | / 5 |
| Voiturette électrique | 450 | 6 000 | 45 | 3 400 | 77 | / 2 |
| Petite voiture électrique | 920 | 33 000 | 45 | 5 800 | 130 | / 1,15 |
| Voiture électrique | 1 500 | 80 000 | 45 | 6 700 | 150 | 1 |

Current efforts to improve the energy efficiency of motor vehicles and reduce their weight are still far from sufficient to meet the challenges of the future. To achieve significant results, we will need to design vehicles that are much lighter and slower. Thanks to its excellent aerodynamics and controlled weight of 50 kg, an electric velomobile travelling at 45 km/h has record energy efficiency, 19 times better than that of a 1.5 t electric car such as the small EV Renault Zoé (see table above)[47].

and 2019, the modal mix has changed little: the car's share represented 65% of journeys in 2008, and 63% in 2019.

Public transport has seen the smallest fluctuation, rising from 8% of the modal share in 2008 to 9% in 2019. Walking has increased slightly, rising from 22% to almost 24% - and finally cycling has stagnated at just under 3%.

The modal shift from the private car to low-carbon modes of transport requires the development of intermodality. The development of intermodal infrastructures is a fundamental trend that has been emerging for several decades. Many towns and cities limit their actions to their own perimeter. Setting up mobility organizing authorities on a regional scale will make it possible to improve the coherence of mobility policies.

[47] "Improving the energy efficiency of individual vehicles" - Transports Urbains 2022/1 (n°121)

Another important value of shared mobility services is economic. Passenger vehicles typically sit idle over 90% of the time, representing a major immobilization of capital. With less recourse to private mobility capital could be freed up and utilized in other activities with greater economic productivity, i.e., another source of efficiency.

The rise of autonomous transportation also promises significant benefits. Research suggests that its advent could see as much as tenfold cut in mobility costs[48]. It could also lead to rebound effects, however, which are still hard to fully quantify. Sources differ on the timing of its development, but most agree that some segments of mobility are likely to be powered by some form of autonomous transport by 2030. True level-5 autonomy would not be fully available before 2040-2050, however, yet uncertainties remain about the speed at which this may materialize. In addition, the key issue with level-5 autonomy is the actual integration of autonomous cars with human drivers. Changes in regulation to avoid this integration and ensure parallel services could accelerate its development.

In new economies where urbanization is still growing, availability of performant public transport and affordable new mobility services are critical to limit the impact of growing congestion due to private cars.

## Emerging thoughts on demobility (avoid)

Sociologists emphasize the need to reconcile the social and environmental justice aspects of mobility. This paradigm shift involves reflecting on the fundamental reasons why people need to travel and why they do so. Reducing mobility is one way of meeting this dual challenge. Policies based on modal shift and technological innovation are currently exclusive and, as many experts have pointed out, create new mobility needs, as reflected in the steady increase in distances travelled since the 1970s. This logic of reducing travel and mobility is already present in household mobility practices: remote working and e-commerce are tools for spatio-temporal adjustments in the organization of daily life, making it possible to eliminate travel. Overall, households in peri-urban areas are implementing strategies to rationalize travel, particularly by car, by valuing and investing in local activities.

The development of electric mobility must be accompanied by the development of V1G and V2G to guarantee the overall performance of the electrical system.

Electric vehicles offer considerable storage capacity when connected to the grid. It is essential for the system that electric mobility goes hand in hand with the development of smart charging - first through the simple off-peak tariff signal, then in a more integrated way with the electrical system thanks to V2G technology.

[48] Arbib and Seba, 2017

# ENABLERS

When it comes to enablers, it is important to think in terms of emission reduction first: measures, whether regulatory or incentive-based, must be targeted and calibrated with a view to decarbonizing the economy, including energy efficiency.

## Public Policies

Energy efficiency public policies require a combination of economic signals and standards/regulations to be effective. Here's a breakdown of when each is typically needed.

**Economic Signals (Taxes, Subsidies, Investment Support)**

- Incentivizing Adoption: economic signals can encourage individuals and businesses to adopt energy-efficient technologies and practices. For example, tax incentives or subsidies for purchasing energy-efficient appliances (heat pumps, EVs) or tools (digital platforms) can stimulate adoption.
- Market Transformation: economic signals can help transform markets by making energy-efficient products and services more financially attractive, which, in turn, drives innovation and competition in the energy efficiency sector.
- Addressing Market Failures: economic signals can address market failures where the upfront cost of energy-efficient technologies is higher, but the long-term savings are significant. Subsidies or low-interest loans can bridge this gap.
- Behavioral Change: economic signals can motivate changes in behavior, such as reducing energy consumption or investing in efficiency upgrades, by making it financially beneficial.

**Standards and Regulations**

- Mandatory Compliance: regulations set minimum efficiency standards for appliances, vehicles, and buildings, ensuring that products entering the market meet certain efficiency criteria.
- Consumer Protection: standards protect consumers by ensuring that products and services meet a certain level of quality and efficiency, preventing the sale of subpar or inefficient products.
- Long-Term Planning: regulations provide a long-term framework that ensures energy efficiency goals are met consistently over time, even if economic conditions change. Regulations can be essential for achieving environmental and climate goals, as they set targets that industries must meet to reduce their environmental impact.

In practice, both economic signals and standards/regulations are often needed to drive significant energy efficiency improvements. Economic incentives motivate individual choices, while regulations create a baseline that ensures energy efficiency gains are made across entire industries and sectors. They work in tandem to create a supportive environment for energy efficiency efforts, fostering innovation and reducing energy consumption.

Energy efficiency policies are crucial for reducing energy consumption and environmental impact. They can be implemented at different levels and by various actors:

**International Level:**

- Paris Agreement: An international treaty aimed at limiting global warming by reducing greenhouse gas emissions. Countries commit to reducing their carbon emissions, which often involves improving energy efficiency.
- Montreal Protocol: Focuses on phasing out ozone-depleting substances, which indirectly promotes energy-efficient alternatives.

**Regional or National Level:**

- Energy Efficiency Targets: governments set energy savings targets over a given period of time, covering the whole economy and that may be distributed by sector
- Energy Efficiency Standards: governments set mandatory efficiency standards for appliances, vehicles, and buildings.
- Tax Incentives: offering tax breaks for businesses and individuals who invest in energy-efficient technologies and practices.
- Low carbon Energy Targets: mandating a percentage of energy generation from low carbon sources inherently encourages efficiency.
- Energy Efficiency Programs: governments may run programs to retrofit public buildings and support industrial energy efficiency.
- Public Awareness Campaigns: Governments and NGOs can run campaigns to educate the public about energy-efficient practices.

**Local Level:**

- Building Codes: local governments can enforce energy-efficient building codes, ensuring new construction and renovations meet efficiency standards.
- Public Transportation: expanding and improving public transportation systems reduces individual car use, promoting energy efficiency.
- Green Building Certifications: local certification programs encourage energy-efficient building practices.
- Municipal Energy Reduction Targets: local governments set targets for reducing their own energy consumption and emissions.

Implemented at different levels and by various actors, these policies and actions collectively contribute to improving energy efficiency and reducing the environmental impact of energy consumption.

# Financing

## Current positive trends supporting energy efficiency investments and financing

Technology solutions have been available for many years to improve energy efficiency in homes and businesses and yet, the backlog of energy retrofit is staggering[49] and this is not for lack of financing. Indeed, until the recent energy crisis in Europe that pushed gas and other energy prices significantly higher, the low cost of energy did not make a compelling case for individuals or companies to invest in retrofitting their buildings or production tools. With low power prices, the payout looked unattractive. Also the offer on the market was not promising substantial energy savings, nor guaranteeing these savings would indeed be achieved. **Current high energy prices, threats of energy or power shortages as well as an increased offer for energy performance contracts have created the context for a much more attractive investment decision.**

Similarly, it is only recently that new regulations, in the EU and other regions, and ambitions towards decarbonization have emerged and translated into **public commitments from countries and companies to achieve "Net Zero" targets** in the next decades. These commitments cannot be delivered soley by switching from fossil fuels to clean energy or power sources. **Sufficiency and energy efficiency are key components of the equation to Net Zero.**

Besides voluntary commitments, an increased number of **mandatory obligations** have also been imposed especially in Europe: disclosure by companies (CSRD) and investors (SFDR) of the data related to their investments' carbon footprint and impact on other aspects of sustainable development, obligation for landlords to achieve a minimum energy efficiency level if they want to rent their properties to third parties, etc. These new regulations have emerged beyond OECD countries: for example, in Kenya, as early as 2006, an Energy Act was introduced that requires high energy users ($24k/per year) to undergo an energy audit and obtain recommendations around energy efficiency for their businesses. This law has triggered renovation investments and created a market in which energy efficiency providers compete, hopefully leading to t a reduction in the total cost of renovation.

The **synchronicity of the two trends** is fortunate as it allows companies' management to **justify investments in energy efficiency** in order to deliver on their commitment to reduce GHG emissions, without having to incur additional costs. In some cases, such intrinsically profitable investments can even be made without the company making any upfront CAPEX investments, thanks to the emergence of ESCOs (Energy Service Companies) and their offer to provide "Energy as a Service", i.e. carry the assets on their own balance sheet so that they do not impact the end users'.

The last component of the equation, **the capital and funding to deploy energy efficiency equipment is increasingly available** as asset owners and banks look for green assets to satisfy their investors and/or shareholders (and increasingly all their stakeholders) to (i) demonstrate their contribution to the energy transition but also (ii) gradually shift away from exposure to fossil fuel(ed) assets that could become stranded in a short to medium term horizon, should carbon pricing become the norm.

[49] For example in Europe, buildings are the single largest energy consumer, using 40% of our energy and creating 36% of our greenhouse gas emissions since most of them are not energy efficient and are still mostly powered by fossil fuels.

**With all these positive trends** supporting energy efficiency investments and their financing, **one could expect to see massive programs under implementation** and material results observed in terms of reduction of costs and GHG emissions. **Yet, this is not happening** - or at least not at the required pace to deliver the Paris Agreement.

In the following sections we will focus on two key markets where energy efficiency needs to be scaled up quickly: residential buildings and industrial ones. We'll try to identify the key hurdles preventing or slowing down the pace of investments, as well as the successful innovations that overcame these hurdles and suggestions as to the ways these could be replicated and scaled up.

## Financing residential building renovation

Residential building renovation is a daunting task that comes in the form of hundreds of millions of small dispersed and heterogeneous buildings. I**n Europe alone, achieving a decarbonized building stock by 2050 will require around EUR 325 billion annually**, with approximately EUR 250 billion for residential and EUR 75 billion for public buildings[50].

Simplifying and harmonizing all schemes to meet the climate and energy challenges is critical. There are many different regulatory and incentive schemes for renovation, with different definitions, eligibility criteria, calculation methods and regular revisions, making them particularly difficult to understand and implement.

Yet the multi-impact nature is often overlooked: beyond the reduction in energy bills derived from the energy efficiency retrofit, **there are multiple benefits for private owners of buildings or apartments that should make such investment decisions easy:** improved value of the property (a building with lower energy bills sells better than one that shows massive heating and cooling costs all year long), improved health (air quality is significantly cleaner in renovated buildings with a direct impact on inhabitants' health), improved comfort and aesthetics, reduced operational and maintenance costs, reduced GHG emissions resulting in some countries in energy savings certificates that can be monetized to reduce the upfront costs needed for the retrofit.

**But the pace and extent of renovation of residential buildings remains well under the level needed** to stay within a 1.5 or even 2 degrees category. The main hurdles are the following:

1. **Energy savings are not sufficient to repay the deep renovation costs.** A more holistic approach is necessary to identify all the benefits of energy renovation to balance out the upfront costs needed.
2. Despite the significant number of **subsidies** available to support individuals in their renovation projects, they are disbursed **via lengthy and tedious processes** by multiple public entities often using non-digital methods. In addition, many people do not feel competent, or patient enough to launch such complex and expensive projects, especially those on low incomes who would benefit the most, but are often also the ones with the lowest confidence levels.
3. **Housing quality is often assessed narrowly,** focusing on the technical and environmental performance aspects, whereas broader policy objectives and impact categories may be more appropriate to fully capture multiple benefits, including in the long run (e.g. health improvement).
4. Many terms and thematic investment areas (e.g. energy efficiency and affordable housing) have not been universally defined, making it difficult to identify benchmarks, KPIs and set industry best practices[51]

Availability of financing is not a key hurdle, however **banks and other financial institutions interacting with building owners are in a key position to raise awareness amongst their customers and offer to be a trusted advisor** to accompany them throughout their renovation journey, not only in the financing part but also in the selection of solutions (deep renovation vs superficial one) and the solution providers to execute it, as well as collection of subsidies and other relevant energy savings certificates, if any.

Such "one stop shop" offers are not yet mainstream, but they have been tried out in Spain by GNE Finance and in France with the Sociétés de Tiers Financement. In parallel, the Energiesprong initiative aims to create the conditions to scale up the E=0 buildings thanks to simplification, standardization and replication, as well as pre-fabrication and pre-assembling of all components this leads to a reduction in costs and a much faster completion of the works, limiting the disruption to the occupants.

[50] Roadmap to Renovation Wave, European Union

[51] PRI (2018) Impact Investing Market Map, and UNEPFI (2018) Positive Impact Investment in Real Estate Discussion Paper

Investors are increasingly attracted by green or SDG-linked financing, whether it is for residential or industrial, or other investments, targeting both market returns and measurable impacts. The EU taxonomy as well as other similar frameworks in other regions have significantly raised the bar as to what may be considered "green", without the risk of being accused of greenwashing.

Financial institutions already finance renovation at multiple levels (social landlords, homeowners, solutions providers…) and have started to aggregate these loans in vehicles designed for placement to long term investors. For example, in the US, thanks to an innovative set of administrative rules (R-PACE), energy efficiency solutions providers were offered the possibility to extend financing to homeowners for their energy efficiency renovation, such financing being repaid via the same process as property taxes (thereby decreasing the likelihood of payment default) and with a priority order on the underlying security.

The energy efficiency renovation loan is also "attached" to the property: if the homeowner becomes insolvent and the house is sold, the new owner (who benefits from a fully/partly renovated house) has to accept the liability to repay the energy efficiency repayment to the solution provider. Such a beneficial scheme has enabled a massive scaleup of energy efficiency retro fits (In the US, the R-PACE program has lent $7.7 Bn for energy efficient renovations, as at Dec 2021[52])

**Importantly, any scale up in financing solutions will need to address homeowners of lesser credit standing.** Hence the need to further engage with public administrations and find synergies, explore public-private partnership models where the public sector and/or philanthropic capital can be mobilized to de-risk lending to less credit worthy customers.

It's important to note that a complete cost-benefits analysis should demonstrate that this is a profitable investment for public authorities since, as demonstrated above, the multiple benefits and positive value and risk implications of energy efficiency create savings in the public budget that should compensate for any losses resulting from such de-risking commitments.

To demonstrate this, it is essential that social and environmental impacts resulting from home renovations are tracked and given a monetary value.

[52] Pacenation.org

## Financing Industry decarbonization:

Obstacles to energy efficient renovations at industrial companies:

- **Cost:** Implementing energy-efficient technologies and upgrading infrastructure may require substantial investments for an industrial company, especially heavy industry. Chief Financial Officers will typically compare the expected ROI from such investments to other core business development investments that typically show better returns, at least in the short term. Moreover, certain manufacturing processes may rely on high-energy consumption equipment or have inherent inefficiencies that are difficult to mitigate: the few solutions that exist will likely be very expensive with a long payout.

- **Lack of awareness:** Many industrial companies may not be fully aware of the potential benefits of energy efficiency renovations and/or the available technologies and solutions. Without proper knowledge and understanding, they may not prioritize energy efficiency or allocate resources towards implementing such measures.

- **Complex industrial processes:** Industrial operations often involve complex processes and specialized equipment. Retrofitting existing systems to improve energy efficiency can be challenging and will require careful planning to avoid disruption of production or quality: such disruption is a material hurdle to decision-making towards energy efficiency retrofits.

- **Regulatory and policy barriers:** Despite many subsidies dedicated to energy efficiency, the regulatory environment can sometimes also hinder energy efficiency renovations. Companies may face challenges related to compliance with energy efficiency standards, obtaining permits, or navigating complex regulatory frameworks.

- **Financing options:** Taking on additional debt to fund significant energy efficiency renovations might be a key hurdle for CapEx intensive companies already significantly leveraged. High interest rates, as in the current environment, can also affect the overall ROI, whether funding is provided by the corporate or by the solution provider.

- **Short-term focus:** Industrial companies often prioritize short-term financial goals and may overlook the long-term benefits of energy efficiency renovations. Without a clear understanding of the potential cost savings and environmental as well as social benefits (e.g. improved staff retention due to healthier workplace and/or pride to work for a "greener" employer), organizations may not prioritize these initiatives.

- **To overcome these hurdles**, it is crucial for industrial companies to develop a comprehensive energy management strategy, conduct energy audits to identify potential savings, educate staff about energy efficiency and other co-benefits, and seek partnerships with experts in the field. Additionally, supportive policies, financial incentives, and technical assistance from government agencies can be critical catalysts to incentivize and/or facilitate energy efficiency renovations.

As explained above, recent years have seen a significant increase in commitments from companies to reduce their carbon footprint, and a need to reduce their energy bills as a result of rising energy prices. Such a rise indemand has led to increased innovation in the technical and financial solutions offered to carbon intensive companies, as well as the emergence of new players in the market called energy service companies (ESCOs) which design, implement, and finance energy efficiency upgrades under Energy Service Performance Contracts (ESPCs). ESPCs are agreements between an industrial company and an ESCO, where the ESCO funds and installs the required CAPEX and software and is then repaid through the energy cost savings generated by the project over a specified period. ESPCs provide an attractive option for industrial companies as they can implement energy efficiency measures without having to pay high upfront capital investments.

If a company has the ability to issue more debt and purchase the equipment needed, such debt will in most cases qualify for a "green" label, hence it can issue green bonds or green loans to raise capital for energy efficiency renovations. While not necessarily cheaper than normal corporate bonds or loans, these green debt instruments attract investors interested in supporting sustainable initiatives, and provide companies with an enlarged investor base composed of "buy and hold" investors that will provide more stability than other types of investors in case of conjunctural market fluctuations.

Malu Paiva

Sustainability Executive Vice President,
Vale Foundation

“I would say a big part of our challenge regarding emissions could be solved if we looked at whether what already exists can be improved, rather than just looking at what needs to be invented. That needs a lot of investment and it takes time to develop new technologies.

With energy efficiency you can get quicker, impactful results. So don’t only go for what gets the most attention – also go for what you can improve.

Utility Energy Efficiency Programs are another funding option for industrial companies: many utility companies have created an in-house ESCO and offer energy efficiency programs and incentives to their industrial customers, as an additional service on top of providing power or other energy supply. These programs may include rebates, grants, or low-interest loans to encourage energy efficiency upgrades. Industrial companies can take advantage of these offerings to reduce the financial burden of their renovation projects. Amongst them, On-Bill Financing (OBF) is a financing mechanism where the cost of energy efficiency renovations is added to the utility bill of the industrial company. The company repays the investment over time through the savings generated by the energy efficiency measures. OBF allows industrial customers to spread the cost of renovations over an extended period, making it more manageable.

Energy Savings certificates can be another source of financing for energy efficiency investments. For example in France, utilities or other entities responsible for supplying energy (electricity, gas, heat, etc.) to end-users companies are required to meet specific energy savings targets, expressed in terms of energy consumption reductions, over a defined period.
To reachtheir targets, they can undertake energy efficiency projects directly by assisting their clients in making these investments or, more commonly, they can buy Energy Savings certificates (CEE in French) from other entities that have implemented energy-saving actions or projects. Such obligations and related instruments to monetize energy savings are an efficient catalyst to incentivize all actors to make energy efficiency investments. They also help the country to meet its nationally determined contribution (NDCs) obligations as part of the Paris Agreement, but need to be directed towards measures that offer the greatest potential for decarbonization.

Green Investment Banks are another type of catalyst that governments or regions can  create to provide dedicated financing for energy efficiency projects. These institutions offer low-interest loans or grants to support industrial companies in implementing energy efficiency renovations.

Another funding source dedicated to these investments are Energy Efficiency Funds whose number have also increased recently. These funds are typically managed by private asset managers but are raising funds from both public and private investor sources. They typically provide longer term financial support for energy efficiency projects compared to commercial banks, thanks to their "buy and hold" Limited Partnership. Examples include Susi Partners, Amber, Blue Path, etc.

Last, but not least, banks have a full suite of financing solutions for industrial companies and/or their Energy Services providers. For small size investments, the equipment or technologies needed for energy efficiency renovations can be leased instead of purchased outright. Lease financing spreads the cost over a period, allowing companies to benefit from the energy savings generated by the upgrades without having to fund upfront capital. Leasing solutions can also be offered to portfolios of assets of different nature provided  they are installed and managed by the same entity (an ESCO for example). The debt related to the leased asset or energy performance contract can be deconsolidated from the industrial company's balance sheet. In some cases, subject to specific contractual clauses in ESPCs, the assets and related debt can also be deconsolidated from the balance sheet of the ESCO, thereby enabling such a company to continue developing more business without the need to raise more equity.

The availability and suitability of financing solutions can vary depending on the country, region, and specific circumstances. Industrial companies should explore local programs, incentives, and financial institutions to identify the most appropriate financing options for their energy efficiency renovation projects. Increasingly local or international consultants specialize in advising large companies in the design and implementation of their decarbonization strategy, including with the selection of the solutions providers and most efficient financing solutions.

The situation in emerging markets and developing economies is often less advanced than in developed countries. However, there is a vibrant ecosystem of start-ups and larger energy companies that offer decarbonization solutions "as a service" to local SMEs or industrial companies looking to reduce their energy bills and switch from fossil fuel to solar power on their premises or nearby. Beyond the incentive to make energy costs savings and reduce their GHG emissions, these companies' investment decisions are often also driven by the lack of reliability of the local power grid which creates unplanned disruption to their business processes.

## Conclusion

The momentum has never been stronger for homeowners and companies to invest in the energy efficiency renovation of their buildings and production tools: Net zero pledges, increased energy prices, the search for a sustainable development path that meets all stakeholders' expectations, etc. These common drivers face common hurdles: multiple small scale investments must be coordinated to achieve an efficient renovation, lack of knowledge of existing technical and financing solutions, complexity of multiple funding sources (subsidies, savings certificates, loans, performance contracts…), delays and disruptions generated by the retrofitting, underestimation of the co-benefits derived from these investments (on top of the reduced costs and pollution) leading to an underestimation of the actual ROI (including non-monetized impacts) of these investments, etc.

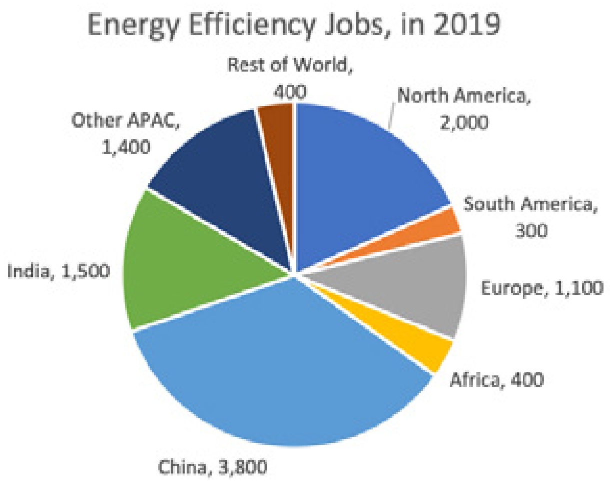
Technical and financial solutions exist, however they need to be improved in order to offer a seamless "one stop shop" offer to end-users where no - or insignificant - upfront cost is required and where there is a high level of certainty about the speed, quality and efficiency of the work done. To achieve such an integration of solutions and deliver a positive user experience, we can point to two powerful catalysts: digitalization and partnerships. Digitalization will encourage faster deployment and rigorous monitoring, as well as the opportunity to standardize and aggregate assets for improved financing costs thanks to diversification. Partnerships are essential to mobilize the best skill sets at all stages of these complex multi-asset investment programs, in order to provide the best outcomes and deliver impacts in multiple SDGs.

## Jobs

### Energy Efficiency as major job creation engine

The energy efficiency industry today employs around 11 million people across the world[53], with 2/3rd of them in mature economies. This compares to around 65 million jobs in the energy sector as a whole[54].

Close to half of these jobs are in the building market, with the rest in a variety of industrial sectors. Energy efficiency thus concerns all sectors of activity and, as was shown in the previous chapter, offers **significant opportunities across the entire economy.**




Energy Efficiency jobs, per region

Energy efficiency also creates **a variety of jobs in a multitude of functions.** According to the International Energy Agency, about 40% of these jobs are related to construction (including service) activities, another 20% in manufacturing (e.g., efficient appliances, smart controls, etc.) and the rest in a variety of other supporting activities (e.g., program management, architecture and engineering, financing, etc.). Brown et al.[55] offer a more detailed breakdown, using a slightly different approach yet showing a consistent split overall.

| Jobs breakdown for energy efficiency | Buildings | Industry |
|---|---|---|
| Construction | 20% | 10% |
| HVAC, Cooling, Refrigeration | 25% | 10% |
| Lighting | 10% | 5% |
| Machinery | NA | 30% |
| Digital | 15% | 20% |
| Others | 30% | 25% |

Energy Efficiency jobs, per type

The International Energy Agency estimates that 15 Full Time Equivalent (FTE) are created for every US$1 million invested in buildings, and around 10 FTE/$US1 million in industry[56]. This estimate, though prey to uncertainty, is generally widely acknowledged, notably by the scientific literature. Brown et al. estimate that 12.75 FTE are created for every US$1 million invested, a consistent average with the figures from the International Energy Agency.

They also explain that this ratio can be further broken down into direct job creations (e.g., installers, service providers), indirect job creations (e.g., manufacturing activities) and induced job creations (e.g., jobs that are created from rising consumption levels and increased wages). On average, every US$1 million invested in energy efficiency leads to the creation of 4 direct jobs and 3.5 indirect jobs - and around 5 jobs are induced as a result.

As can be seen above, the effects of energy investment are felt across a broad array of sectors and have material impacts on the economy, which are not limited to directly related occupations. It is truly **a system change.**

Finally, investing in energy efficiency also creates more jobs (in more sectors and across more functions) than investing in fossil fuels. Garrett-Peltier[57] reviewed the difference in job creation between both sectors for direct and indirect jobs (induced jobs were excluded).

| Jobs per activity | Direct | Indirect | Induced | Total |
|---|---|---|---|---|
| Energy Efficiency | 4.6 | 3.1 | Not assessed | 7.7 |
| Fossil Fuels | 1 | 1.7 | Not assessed | 2.7 |

Energy Efficiency jobs vs Fossil Fuel jobs

[53] OECD/IEA, 2022

[54] All data is from 2019. Since then, the figure is closer to 70 million, with a 5-7% annual growth.

[55] Brown et al., 2020

[56] OECD/IEA, 2020

[57] Garrett-Peltier, 2017

She concluded, as the table above suggests, that 5 more jobs (or 3 times as many) are created for every US$1 million that is switched from fossil fuels to energy efficiency, not accounting for other positive effects such as economic savings and associated induced job creations.

This is what Costantini et al.[58] also confirmed in a detailed review for the European Union, where they assessed that **energy efficiency investments had a positive impact on net employment, hence economic growth.**

To conclude, energy efficiency is thus not only a foundational pillar of decarbonization, but also a major job creation engine and a strong enabler of economic growth.

## Youth and Sustainability

Over the past decade, the term 'sustainability' has become more familiar within the youth demographic than any other time before. A 2022 survey by Deloitte found that 90% of Gen Z respondents said that sustainability is important to them, and 83% said that they are willing to make changes to their lifestyle to reduce their environmental impact[59]. Young people are interested in sustainability - from recycling and the circular economy, to technical innovations in the world of renewables.

At the same time, qualitative studies[60] (source)have shown how 16 to 25 year olds are worried specifically about climate change (59% very or extremely worried, 84% at least moderately worried). Over 50% felt sad, anxious, angry, powerless, helpless, and guilty.

Climate change has significant implications for the health and futures of children and young people, yet they have little power to limit its harm, making them vulnerable to increased climate anxiety. It is, therefore, not surprising to see them taking to the public stage to express their fears and their desire for structural reform.

In recent years, nations, businesses, and individuals have led many movements that involve younger people, inviting them to take action to address the environmental challenges the world is facing.

## Energy Efficient Youth

When we talk about having a sustainable future, energy efficiency is a very important component that is not stressed as much as sustainability is. Generally, energy efficiency consists of using different technologies, behaviors, or practices that reduce energy consumption and energy waste while providing the same amount of output, and productivity to reduce the strain on the planet. It is not only important because it protects the environment and helps in reducing greenhouse gases which contribute to climate change and air quality, but it also reduces costs and can save money on energy bills.

Some world organizations have directed their attention towards engaging young people in the energy efficiency narrative. According to the World Energy Outlook report, a 2022 survey by the International Energy Agency (IEA) found that 73% of young people aged 18-24 are willing to take action to reduce their energy consumption[61].The World Economic Forum found that 65% of young people are interested in learning more about energy efficiency, according to the Global Risk Report survey conducted in 2023[62].

A 2021 study by the European Commission found that young people are more likely to engage in energy-efficient behaviors, such as turning off lights when they leave a room and unplugging electronics when they are not in use[63].

[58] Costantini et al., 2018

[59] Deloitte 2023 Gen Z and Millenial survey - https://www.deloitte.com/global/en/issues/work/content/genzmillennialsurvey.html

[60] The Lancet – Climate anxiety in children and young people https://www.thelancet.com/journals/lanplh/article/PIIS2542-5196(21)00278-3/fulltext

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## Conclusion

Improving public knowledge of energy efficiency is essential to creating a sustainable future. Energy efficiency sometimes gets overlooked in conversations and regulations related to sustainability, despite its many advantages. We must recognize the importance of sustainability and give it more emphasis if we want to establish a comprehensive approach to the issue.

Energy efficiency plays a critical role in environmental protection, reducing greenhouse gas emissions, and battling climate change in addition to conserving resources. Additionally, it offers significant economic benefits, such as cost reductions, increased competitiveness, and sustained growth.

Energy efficiency must be treated with equal importance as renewable energy sources in order to maximize their combined advantages and realize its full potential. Furthermore, it is essential to engage young people in energy efficiency projects by giving them the necessary tools. Incorporating the younger generation's creativity, enthusiasm, and vision can forge lasting change. Supportive measures, including policies, incentives, and educational integration, are essential in creating a robust energy efficiency ecosystem.

Through collaboration and shared knowledge, we can pave the path to a truly sustainable future, conserving resources, reducing costs, and preserving the planet for generations to come.

# Appendices

## Appendix 1: Case studies

### Local community of residents in Nice, Côte d'Azur metropolitan area to reduce energy demand during peak consumption periods

Between 2014 and 2016, EDF conducted an experiment in partnership with the Nice Côte d'Azur metropolitan area and the CSTB to set up a community of residents whose mission was to reduce energy demand during peak consumption periods (6pm to 8pm). Using a dedicated application, 140 households equipped with smart meters were encouraged to reduce their electricity consumption between 6pm and 8pm for 25 days between November 2015 and June 2016. The participants (i) received a warning the day before each consumption peak, (ii) were free to choose the electrical equipment they wanted to reduce their consumption, (iii) accumulated points to reward the savings they made and (iv) contributed to the funding of a community project through these actions.

This experiment showed that it is possible to mobilize behavioral energy efficiency levers in a community of households brought together using digital tools. The participation rate in the 25 alerts launched via the application reached 80%. For these households, consumption between 6pm and 8pm fell by an average of 30% thanks to behavioral changes, particularly in terms of cooking habits (cooking earlier or eating cold meals). Support for the solidarity project was well received and motivated them (80%). The principle of a community of participants gave a collective impetus to the action and  more weight to the individual gesture. The project was seen as concrete, giving people a sense of ownership. Lastly, the local roots at regional and neighborhood level were important in getting households to sign up to the project.

### Samwoh's "Smart Hub," a pioneering achievement as Singapore's first energy-positive industrial building

Samwoh's ambitious goal of centralizing its operations in Singapore and unifying facilities scattered across five locations, led to a ground-breaking partnership with Schneider Electric. Their mission was clear: achieve efficient energy usage and future-proof operations for sustainable growth. The result of this collaboration is Samwoh's "Smart Hub," a pioneering achievement as Singapore's first energy-positive industrial building, generating more energy than it consumes.

Schneider Electric's solutions, including EcoStruxure Building Operation and various connected products like Smart Panels and PowerLogic™ meters, have delivered impressive outcomes. Samwoh has achieved up to 50% savings in utility costs through efficient energy usage, with at least 25% of the electricity generated by the facility's solar panels being returned to the national grid. The project's sustainability efforts were rewarded with Singapore's Building and Construction Authority's Green Mark Platinum (Positive Energy) certification, showcasing the success of Samwoh's commitment to efficient energy usage and future-proofing its operations.

### Integrated platform for building management and analytics at Resorts World Las Vegas

Resorts World Las Vegas, in its quest to become Las Vegas' latest mega-resort and a sustainability pioneer on the Strip, made sustainability its core mission from the outset. Recognizing the need for a partner capable of helping them establish a new benchmark for sustainable and opulent hospitality, Resorts World Las Vegas turned to Schneider Electric's EcoStruxure Building Operation, an integrated platform for building management and analytics. This solution has not only enabled Resorts World Las Vegas to realize impressive results, such as a 30% reduction in energy consumption compared to baseline figures, but has also streamlined the monitoring of numerous data sources across their vast facility. Additionally, it has ensured reliable power supply in a mixed-use complex spanning over 7 million square feet while seamlessly integrating various third-party systems, enhancing the overall efficiency of the resort's operations with a more holistic approach to sustainability, bringing together various aspects of energy management, water conservation, and more. This collaboration has positioned Resorts World Las Vegas as a leader in sustainable and luxurious hospitality.

## Building Management Systems (BMS) at Takeda's facility in Singapore

Takeda, a pharmaceutical giant with a commitment to achieving net-zero operations by 2035, faced the challenge of advancing their corporate sustainability goals while improving operational resilience, business efficiency, and the well-being of their employees. They opted to connect with Schneider Electric, leveraging their industry expertise and extensive EcoStruxure solutions. Takeda implemented Building Management Systems (BMS), power solutions, and automation technologies, along with cutting-edge industrial software from AVEVA.
The benefits have been substantial, with Takeda's facility in Singapore becoming the first positive energy building in their manufacturing network and Singapore's pharmaceutical industry. It boasts an energy surplus of at least 15% generated from renewable sources. This achievement aligns with Takeda's sustainability goals and has resulted in a safer and more comfortable work environment for their staff. The facility has also received the prestigious Green Mark Platinum Positive Energy certification from Singapore's Building and Construction Authority, setting a standard for future sites and demonstrating tangible results in terms of energy surplus and improved staff well-being.

Since 2019, Salvador has been replacing its street incandescent lights with LED lights as one of the initiatives within the "Lighting our Neighborhood" Program. This initiative has reached 100 of Salvador's 163 neighborhoods, and 75,000 poles in Salvador will have LED lights by the end of 2020. The Public Lighting Office (DSIP), a department of the Municipal Public Order Secretariat of Salvador, leads the Program. This initiative has many advantages in terms of light and energy efficiency. It reduces consumption by 50%, improves quality and durability, and increases the sense of security in neighborhoods.

## Salvador's "Lighting our Neighborhood" Program installs LED lamps to improve economy, efficiency and security (provided by C40 Cities)

Replacing lamps with LED lighting makes the public lighting system more efficient as they can reach 50 to 100 thousand hours of operation, while other types of lamps can only manage around 30 thousand hours. LED lighting has a luminous efficiency up to five times higher than incandescent lights. This makes maintenance costs much lower helping the Municipal Government decrease its energy consumption tariff. Simultaneously, as LED lights are more powerful at lighting the streets, they also help to reinforce public safety and improve pedestrian visibility at night. In addition, LED luminaires are easy to control via a remote management system, reducing operating costs and avoiding CO2 emissions from car trips to the poles.

According to the director of Public Lighting in Salvador, the program changed the concept of public lighting in the city as it promoted the democratization and modernization of lighting to entire neighborhoods, including some of the most peripheral neighborhoods, bringing LED light to all streets and alleys, including the installation of new poles. The program was not started in wealthy neighborhoods, but in vulnerable ones, where there is usually a higher rate of problems related to violence. Public lighting brings, in addition to the quality of life, a greater sense of security for those who walk the streets at night.

The process for replacing LED lights starts with a field study conducted by DSIP teams to understand the needs of each location. This includes the number of lights and installation requirements to ensure that the whole neighborhood and its inhabitants receive adequate public lighting. In addition, the Municipal Government issues public notices for the purchase of lighting fixtures through price registration to reduce costs and be able to reach more neighborhoods.

## The Global Lighthouse Network initiative on Smart manufacturing launched by the World Economic Forum

The World Economic Forum[64] launched the Global Lighthouse Network initiative on Smart manufacturing in 2018. Since its inception, the network has grown to include 132 member sites selected by an independent expert panel. This includes 29 new lighthouses in 2022 and the designation of seven sustainability lighthouses. The network spans industry sectors from consumer-packaged goods, process industries and advanced industries, to pharmaceutical and medical products. Just as they have since the network's inception, these sites have demonstrated impact across operational performance indicators, including sustainability, productivity, agility, speed to market and customization.

Some examples of smart manufacturing impact into sustainability are presented below.

Finally, these factors lead manufacturers not only to reduce the environmental footprint of their plants and products, but also to ask their subcontractors and suppliers to reduce theirs.

## Reduce the environmental footprint of the whole supply chain

In the automotive industry, manufacturers are forcing their subcontractors in the mechanical engineering, plastics, tire and paint industries to decarbonize their products. ARKEMA is offering bio-sourced plastics, while MICHELIN is reducing the fuel consumption of vehicles using its tires by working on their manufacture and on the performance of its subcontractors, to whom it offers support in terms of training and ISO 50001 certification.

In packaging, companies such as SMURFIT KAPPA, with its Better Planet Packaging program, aims to reduce the amount of packaging used for products such as carton packs for food and drink products.

Sectors such as roof tiles (the process requires heating and drying the tiles) are actively seeking to decarbonize their processes in order to remain environmentally competitive with products such as slate.
This reduction in the environmental footprint is leading to different strategies among manufacturers in the same sector: anticipate and differentiate, follow or wait. The L'Oréal group (cosmetics) aims to reduce its CO2 emissions, water consumption and waste by 60% over the period 2005-2020.

| | | | | | |
|---|---|---|---|---|---|
| **Western Digital** Penang, Malaysia | Western Digital achieved a reduction in energy of 41%, in water consumption of 45% and in material waste of 16% through a vertically integrated smart factory. Fourth Industrial Revolution technologies, such as IOT sensors, digital twin modeling, an analytics-powered plant management system and lights-out automation with machine learning increased their sustainability impacts, while the site has grown at a 43% compound annual growth rate (CAGR) in the last four years. This concerted effort enabled the Malaysia Green Building Index certification for the site. | Smart energy usage optimization via real-time IIoT applications | ▼ | 39.9% | GHG (Scope 2) |
| | | Lights-out automation with digital twin capacity optimization for sustainability | ▼ | 45.6% | Energy usage in production assembly |
| **Johnson & Johnson Janssen** Cork, Ireland | Janssen Sciences Ireland has been long supporting regional initiatives for sustainability improvement and is now enabling the corporate 2030 pledge of carbon neutrality. Through Fourth Industrial Revolution-enabled real-time release, adaptive process control and other sustainability efforts, the site has optimized its processes and reduced carbon emissions per kg of product by 56%, while the site footprint was expanded by 34% to meet the growing business needs. | Digital twin of sustainability | ▼ | 32% | $CO_2$ avoidance |
| | | IIoT real-time sensor-based data aggregation for energy, emissions, waste and water management | ▼ | 43% | Material waste |
| **Schneider Electric** Le Vaudreuil, France | Schneider Electric Le Vaudreuil has implemented Industrial IoT IIoT) sensors connected to digital platforms, unlocking data to optimize energy management (25%), reduce material waste (17%) and minimize $CO_2$ emissions (25%) with the objective to be net zero by 2025 without offset and ahead of the global Schneider Electric pledge. The smart factory is equipped with a zero-reject water recycling station connected to cloud analytics and monitored by an AI model to predict process drifts and to globally achieve 64% water reduction. | Sustainability optimization powered by advanced digital solutions | ▼ | 27% | Energy used for compressed air |
| | | AI-powered process control | ▼ | 22% | Sludge waste |

[64] World Economic Forum, 2022, 2023

Over the period 2015-2025, the BEL group (industrial cheese-making) aims to divide its water consumption by 4, reduce its energy consumption by a third and use two-thirds renewable energy. This group is very active in this area, in particular with the support of EDF, and sees these actions as a differentiating factor compared with much larger competitors.

The BOSCH group (equipment manufacturer, Industry 4.0 project, one of the leaders in Germany) aims to reduce its $CO_2$ emissions by 20% and increase its energy efficiency by 20% over the period 2007-2020. The LAFARGEHOLCIM Group (Cement) aims to reduce its CO2 emissions by 40% over the very broad period 1990-2030.

The MICHELIN group (tires) aims to reduce its environmental footprint by 50% and its logistics $CO_2$ emissions by 10% over the period 2005-2020, and to support 70% of its suppliers in improving their environmental footprint.

The SOLVAY group (Chemicals) is taking a number of steps to reduce the environmental footprint of its products, in particular by introducing an internal $CO_2$ cost into its investment projects.

In April 2021, SCHNEIDER ELECTRIC launched the Zero Carbon Project with the goal to reduce by 50% supplier operational emissions (scope 1 and 2) by 2025. Today, over 1,000 companies have joined the initiative. So far, an initial survey showed that more than 70% of suppliers engaged have not yet quantified their GHG emissions, so a first important step is for them to develop a robust GHG accounting tool. The initiative provides capacity building, thought leadership, resources and handholding to program participants and helps them set and achieve their carbon reduction targets. The suppliers are encouraged to quantify their carbon emissions, adopt ambitious decarbonization goals and deploy action plans to achieve them.
The Zero Carbon Project cultivates exchange of best practices by a variety of live engagements and training sessions organized on a regular basis. It leverages expert knowledge and experiential learning on decarbonization from Schneider to support suppliers. Additionally a dedicated web portal has been introduced. This portal provides a single-window access to all thought leadership, research, training materials, case studies, decarbonization levers, and tools for quantification of GHG emissions. More information on this project available here:

https://www.se.com/ww/en/about-us/sustainability/zero-carbon-project.jsp

## Brilliant Planet : flexibility and efficiency for a carbon capture industrial process developed in Morocco

Brilliant Planet, an innovative company focused on low-cost, algae-based carbon capture utilizes microalgae grown in open-air pond-based systems to sequester carbon on a gigaton scale, offering a cost-effective and quantifiable method. This process can capture up to 30 times more carbon than the equivalent forest area, aligning with global energy and climate goals recognized by the UN Intergovernmental Panel on Climate Change.

After eight years of research, including trials in Morocco, Brilliant Planet is developing a scalable platform for global deployment. Schneider Electric's EcoStruxure Automation Expert, a software-centric universal automation system, will be implemented by Platinum Electrical Engineering. This solution offers flexibility and efficiency for a carbon capture process that requires scaling as needed, enabling cost-effective and resource-efficient expansion for Brilliant Planet. Platinum Electrical Engineering's expertise in this technology and recent recognition as Schneider Electric's Global EcoStruxure Partner of the Year make them an ideal system integrator for this project, showcasing the potential of trusted partnerships in advancing sustainability and industrial automation.

To develop a heat pump producing heat at 120°C, the researchers started with a commercial machine operating with the fluid R134a. The developments involved changing the refrigerant (R245fa) and the compressor lubricating oil. The condenser was also modified. Thanks to the laboratory's testing facilities, the performance of this heat pump has been fully characterized. The temperature of the heat source was studied between 45°C and 80°C, and the heat pump produced heat between 70°C and 120°C. Over this very wide temperature range, the COP recorded ranged from 1 to 8.

## Industrial high-temperature heat pumps to improve the efficiency of heat production

Since 2008, on the Renardières site, EDF R&D labs have been working on the emergence of an industrial high-temperature heat pump sector, in partnership with equipment manufacturers. The aim of this work is to demonstrate the feasibility and performance of high-temperature heat pumps, using components mastered by the sector, on an industrial scale close to the thermal megawatt. The laboratory has two water loops that enable the source and need for heat to be simulated experimentally. Temperatures and flow rates can be adjusted, enabling a wide range of situations to be tested in terms of the energy supplied at source and extracted when required.

Following these tests, the heat pump was installed on the Ghent district heating network. In winter, this network distributes heat up to 105°C, which justifies the choice of a very high-temperature heat pump. The source of heat, at a temperature of around 60°C, comes from energy recovery from cogeneration equipment. The project, which is modest in size compared with the needs of the heating network (400 kWth), improves the efficiency of heat production by 2.5%.

The PACO project is a very high-temperature heat pump using water as the refrigerant. In this case, water was chosen as the refrigerant to achieve higher temperatures while maintaining excellent energy performance. In addition to its excellent environmental performance, compared with synthetic refrigerants (no impact on the greenhouse effect or the ozone layer), water achieves very good coefficients of performance. The technical difficulty lies in compressing this fluid, which is not very dense and requires very large volumes of gas to be compressed. This collaborative project involving academic and industrial partners has made it possible to build a prototype supplying 600 kW of heat (around 1 tonne/h of steam), demonstrating that it is possible to use a source of temperature at 90°C and produce heat at almost 140°C with a COP close to 5.

TRANSPAC is a transcritical heat pump designed for drying operations up to 150°C. Currently at the stage of a research project financed by ADEME, this technology patented by EDF has been used to produce a reduced-scale 30 kW thermal model that validates the concept. In certain configurations often found in industrial dryers, this heat pump can achieve a COP that is almost double that of a standard machine. The first industrial-scale heat pump, with a thermal capacity of 500 kW, was designed and commissioned on an industrial site in April 2023. The drying market is very large. It accounts for around a quarter of all fuel used for energy purposes. The heat source used for the heat pump is contained in the extraction of fumes. This contains almost 90% of the energy supplied to the dryer. The heat produced by the heat pump is used to heat the fresh air or the products to be dried. This is a highly favorable situation for the integration of heat pumps, because the heat source and the heat requirement are part of the same process, and are therefore concomitant. What's more, this kind of equipment operates for long periods of time, 8,000 hours a year, for example in drying plants in the paper industry.

## Synergies between industrial players in the north of France to reduce their ecological footprint

Since 2019, the Communauté Urbaine de Dunkerque in the north of France has been supporting the EPIFLEX project led by EDF R&D in partnership with Mines Paris as part of a call for projects from ADEME. This project, based on an innovative methodology, identifies

concrete solutions for energy and material synergies (water, heat, cold, CO2, H2) that make economic sense, notably through the use of innovative processes.

The project is supported by the Grand Port Maritime (local port authorities), which is keen to see the Dunkerque industrial port zone - France's biggest CO2 emitter - embark on a low-carbon transition in order to ensure the long-term viability of the sites that occupy it and attract new industries with high added value for the region. Thanks to the EPIFLEX approach, the local authority is in a position not only to organize synergies between industrial players to help them collectively reduce their ecological footprint, but also to identify the "missing links" that need to be convinced to set up there to transform the waste of some into resources for others and complete the virtuous circle of the circular economy.

The EPIFLEX approach involves several stages:

5. Identifying the region's problems and targeting the industrial companies most interested in setting up symbioses.
6. Solicitation of all the industrial companies in the area concerned to collect quantitative and qualitative data on energy, water and materials.
7. Modelling industrial flows (requirements and availability) of heat, cooling, industrial and drinking water and H2.
8. Identification of synergies by means of a technical and economic trade-off, comparing the investment costs associated with the gains in operating costs, with the operating costs of manufacturers without the symbioses.
9. Development of a set of relevant scenarios based on several sets of assumptions: energy costs, governance, improvement of industrial processes, deployment of a heating network, arrival of new industrial sites in the area, etc…
10. Seeking funding to implement the solutions chosen by the region.
11. Implementing practical solutions.

The technical and economic calculations were carried out using PHOENIX decision-support software, designed by EDF R&D and capitalizing on models developed over the last 10 years in the field of energy-material integration on the scale of an industrial process and an area. Based on all the flows in the area and economic data, it can be used to establish economically viable solutions while guaranteeing the technical feasibility of the solutions.

The synergies identified mainly concern heating, cooling and water, with significant potential gains:

1. 1.3 TWh/year of waste heat recovered
2. 587,000 m3 of drinking water saved/year
3. 410,000 m3 of industrial water saved/year

## Increase the modal share of cycling in France

In France, since the 1980s, the modal share of cycling has steadily declined. It fell from 4.5% in 1982 to 2% in 2008, and stagnated nationwide until the latest surveys in 2018. However, while the modal share of cycling is stagnating nationwide, it is increasing in major French cities: in Strasbourg, the modal share of cycling rose from 6% to 7.5% - in Rennes from 3% to 4% between 2000 and 2008 - in Grenoble from 2.5% to 4% between 2000 and 2010. Cycling is used mainly for commuting, which is the main driver of its growth. Cycling is more prevalent for journeys to the city center, and less for outward journeys.

Concerning suburbs and rural areas, the trend is the opposite: the daily use of bicycles is increasingly reduced and remains a leisure and sporting activity. In these areas, electrically-assisted bicycles (EABs) appear to be a mobility solution that is becoming more easily established in local lifestyles. Indeed, in 2017, the market for EABs doubled, but it's mainly in rural and suburban areas that they've taken root. While bicycles are seen as an alternative to walking and public transport in urban areas, EABs are more easily substituted for cars, with much greater distances covered (8 km) than for conventional bicycles (4 km). EABs are also more popular with older people, women and in hilly areas. The rise of active modes and micromobility is one of the main trends influencing the future of mobility.

The year 2020-2021, with the exit of the COVID crisis, marked a considerable boom in cycling and active mode travel. During the spring of 2020, the number of cyclists increased by 29% compared with the same period in 2019. This boom in cycling differs according to the type of territory but is nonetheless very much in evidence: in urban areas, cycling increased by 29% on weekdays, compared with 14% in suburban areas. Every time there is a crisis, such as the public transport strikes in winter 2019, cycling increases, only to fall back slightly above its initial level. Regarding the effects of the health crisis, the trend seems more sustainable. The profile of home-to-work cyclists is also broadening: young people represent 45% of cyclists after the first lockdown, compared with 35% before; similarly, the health crisis has brought about a rebalancing in the gender of cyclists (now 50% are women, compared with 34% in 2019); moreover, the profile of cyclists is changing geographically, with 29% now living in the suburbs, compared with 22% before the health crisis.

What about sustainability for 2030? The French government has set a target of 9% modal share for bicycles by 2030. According to an ADEME survey carried out prior to the health crisis, this target is achievable if major investments are made in all local authorities to complete the territorial network by creating 100,000 km of cycle paths within 10 years. Cycling is directly correlated with the availability of dedicated infrastructure. Without major changes in public policy, current trends in cycling suggest a modal share of 3.5% in 2030.

## Energiesprong : a global alliance to develop simple Net Zero Energy Buildings

The European Energiesprong movement aims to develop new, ambitious and simple standards for energy renovation, in order to make zero-energy guaranteed renovation accessible to as many people as possible. Created in the Netherlands in 2012 it has been deployed in the UK, Germany, Italy, California and Canada. In 2013, Energiesprong brokered the “Stroomversnelling” deal between Dutch building contractors and housing associations to refurbish 111,000 homes to NZE.

Energiesprong relies on ambitious specifications based on 4 key requirements:

1. Guaranteed Zero Energy for 30 years
2. Work carried out very quickly and on an occupied site
3. Priority given to occupant comfort and satisfaction
4. Economic equilibrium achieved on an overall cost basis and without subsidies, in the long term

## Johannesburg - Green Bonds Fill Gaps in Financing Climate Projects. Provided by C40 Cities

Johannesburg’s 2014 green city bonds scheme has secured finance for investments in a suite of projects, mitigating climate change and creating a more resilient city.

Cities across the world are experiencing difficulties in securing financing for green urban development, resulting in unrealized projects. Green bonds have helped Johannesburg overcome this barrier by providing access to additional funding and tapping into a new base of socially responsible investors. According to the World Bank, investors are increasingly looking to green bonds, with investments in these programs tripling to $35 billion between 2013 and 2014.

As the first emerging market city to issue green city bonds, Johannesburg is a front-runner in finding innovative funding sources for climate action. The $143 million worth of green bonds sold in 2014 fill gaps in much-needed development finance for projects within energy, water, waste, and transportation. The funding will help implement the city’s climate change mitigation strategy and accelerate projects.

One project financed by the bonds is a 16 km extension of the Rea Vaya Bus Rapid Transit system, which will result in 10 new stations, and 5 km of walking and cycling lanes. Due to the successful 2014 issuance, the city has become a global role model and has shared its approach to green bonds with cities across the world. Johannesburg is planning to issue new green bonds to finance further climate action.

## Kampala, Dar es Salaam and Durban - Capital investment plans. Provided by C40 Cities

In recent years, several cities such as Kampala, Durban and Dar es Salaam, started to develop ‘Climate-Smart’ capital investment plans that look to integrate climate mitigation and adaptation more effectively into long-term capital investment planning. As a result, projects are designed from the outset to provide carbon reduction and resilience-building benefits to the municipality. These plans are currently under development by each city, but could help these cities more effectively mainstream mitigation and adaptation into their long-term development.

Kampala has been developing and implementing, with the support of the World Bank and other agencies, a new capital investment plan that takes into account the carbon and climate-impact risk aspects and implications of new projects. As a result, potential issues are identified while projects are still in initial stages of development, and preference is given to those projects that are more resilient and low-carbon.

The city of Dar es Salaam is also implementing a similar system, but is at an earlier stage of development. The city of Durban has identified the need to prioritize low-carbon and climate resilient projects in its budget planning. As of December 2015, the city is exploring the measures it can put in place in the annual budget planning process, with the intention of implementing these measures in the 2016-2017 budget cycle.

A 'climate-smart' capital investment plan is a relatively new concept and as such, its results have yet to be fully demonstrated. The main benefit it provides is to help ensure that climate change implications (positive and negative) of projects will be considered extremely early in the process of their design and implementation, encouraging cities to more effectively achieve their climate change goals and avoid the need for costly retrofits in the future. In Kampala, observers have noticed a change in the types and designs of projects being put forward for consideration as a result of the new processes, with mitigation and adaptation being considered in their design. For example, greater consideration is being given to the location and vulnerability of new facilities such as hospitals and municipal buildings. Historically, only aspects such as the cost and availability of land would have been considered, though now, for example, the likelihood of flooding is also assessed.

The creation of capital investment plans is an extremely important part of a city's move towards achieving an investment-grade credit rating. Integrating climate change into the planning process will also help cities to achieve their low-carbon, climate resilient goals more cost-effectively, as potential measures are generally cheaper and easier to build in at the design stage of a project than to retroactively introduce once the project has been built. It can also help avoid potentially costly mistakes by identifying potential risks early on e.g. building a project in a location that will become increasingly vulnerable to flood risk or erosion over time.

## Impactful sustainability for youth initiatives across the world

**Singapore:** The Singapore Youth for Climate Action (SYCA) has developed many activities such as workshops, talks, and focus group discussions,  aimed at young people. This youthled initiative aims to shed light on the importance of climate action andinfluence policies within Singapore to ensure and advocate a sustainable future for the Lion city.

**Japan:** The Japan Youth Ecology League (Eco-League) is a network of environmental activities led by young people. It is the largest network of its kind in the country, consisting of 150 groups with 2,000 members. Their goals include the development of networks, of human resources, and communication with society. Through their activities, they aim to foster a sense of community among young individuals interested in environmental issues and create opportunities for sharing updates, engaging in discussions, and organizing study groups on environmental topics.

**India:** The Indian Youth Climate Network (IYCN) has united young people and youth-oriented organizations to combat climate change. With a vision to tap into the passion and energy of young people and connect them with policy makers, IYCN strives to build a movement based on solutions and offers hope for a sustainable future.

**Canada:** The Canadian Youth Climate Coalition (CYCC) combines its forces to organize actions, influence government policies, and implement concrete solutions at the local, provincial, federal, and international levels. Through itswork in schools and communities throughout the country, it strives to build a just and prosperous transition towards a new Canada that prioritizes climate stability and sustainability.

**UAE:** In the Middle East, and the United Arab Emirates, The Future Sustainability Leaders (FSL) Program is a year-long initiative designed to connect university students and young professionals with global business leaders, policymakers, and technology pioneers. The program aims to provide participants with the latest sustainability best practices, core knowledge, skills training, work experience, and networking opportunities.

**France:** LES COLLECTIFS is a network of professional citizens created to transform companies from the inside, in particular through collectives of committed young employees. Together, they represent 120 corporates in France and 10,000 employees. They carry out concrete initiatives within companies to "transform them from within". 3 main pillars of action are used: Raising awareness and training, changing internal practices, and advocating responsible reorientation of business models.

**South Africa:** Project 90 by 2030 has been driving change. Young South Africans are striving to reshape the way people live and strengthen their relationships with the environment. They are focused on a couple of key areas such as energy efficiency, renewable energy, sustainable waste management, and water conservation.

**UAE:** The Student Energy Summit 2023 in Abu Dhabi gathered 600+ young people from all around the world to reimagine the future of energy. It is the largest youth-led conference prioritizing young people as key stakeholders in energy transition. Taking placefrom November 29- December 1, 2023, it empowered the next-gen energy leaders and showcaseed the UAE's success story with energy transition.

**United Kingdom:** Scouts Go Solar, is a worldwide environmental partnership between greenspace, the world scout movement, and Solafrica, in collaboration with Kandersteg International Scout Centre in Switzerland. Its aim is to train solar ambassadors so they can organize solar energy activities for young people globally.

**Nigeria:** SE4ALL initiative in Nigeria, aims for universal access to modern energy services, doubling energy efficiency, and increasing renewable energy's share in the global mix by 2030. Governments, private sectors, and civil society  collaborate to drive transformation change and promote sustainable energy action.

Professor Madhavi Srinivasan
Executive Director, Energy Research Institute at Nanyang Technology, Singapore

“I love the phrase “We do not inherit Earth from our ancestors, but we just borrow it from our next generation”. And for the next generation, it is their world, and they are very, very passionate about it.

Students are excited about the challenge. As a generation, they’re growing up hearing about sustainability, climate change and, for them, it’s a very natural thing to do - to find solutions. It’s not something that they want to put off. It’s something that’s part of them, is the way I see it. I’ve had many students ask why me can’t we put in more light sensors, or can’t we time them better?  I find that they are the ones who go to the next level to say, hey, why can’t we do this? Let’s do more of this. Students are pushing this a lot more than other generations. I think students in general are very sustainability conscious.

## Private Sector Engagement: Schneider Electric Go Green Competition Program

Schneider Electric Go Green competition is a global innovation competition for students to develop bold ideas to accelerate sustainability in energy management and automation. The competition is open to undergraduate and graduate students from all over the world, studying in a variety of fields, including business, engineering, and marketing.

To participate in the competition, students form a team of two to four members, choose one of the competition challenges and submit their idea in the form of a business case. The competition is different every year and in 2023 the challenge  was:Reinventing the Future of Green Buildings. In previous years, the competition covered topics such as Empowering Smart and Sustainable Cities, Decarbonizing Industrial Processes and Democratizing Access to Energy.

Selected teams usually receive mentorship from Schneider Electric leaders to help them improve their solution and polish proposals and presentations. Regional winners have the opportunity to pitch their idea to a global jury panel and compete for the chance to win a 10,000 Euro cash prize, an internship at Schneider Electric, and go on an international trip .

The Schneider Electric Go Green competition is a great opportunity for students to showcase their creativity and innovation, and to make a real impact on the future of sustainability. It is also a great way to learn about the latest technologies and trends in the energy management and automation industry, and to network with potential employers.

## Les Collectifs: Atlas des actions

LES COLLECTIFS, a network of young professional citizens created to transform companies from the inside and representing 10,000 young employees in France, has launched a knowledge base, written by the members themselves, carried out by groups throughout France.

The fact sheet provides "instructions for use", while the comments provide individual feedback. Every young employee willing to take action in his or her company can select a subject (actions on products and services, awareness-raising and training, actions on internal practices, collective organization, etc..) and introduce his or her constraints (budget, time allocation) and the tool will generate an action sheet. More than 61 action sheets have been registered already and a simplified printable version in a deck of cards format is also available.

## Community & Academia Engagement: Student Energy Summit 2023 & Japan Youth Ecology League

Having taken a quick look at different initiatives focused both on sustainability and energy efficiency, let's compare two of them: The Japan Youth Ecology league (Eco-League) and the Student Energy Summit 2023.

Both initiatives share common ground in their emphasis on youth involvement, and mainly aim to empower the young generation to play an active role in shaping a sustainable future. To add to that, both share a goal of promoting and advocating for sustainability.

The Student Energy Summit 2023's strength is its ability to bring together young people from all over the world. This cross-cultural collaboration allows for a wide range of perspectives on energy-related issues. The summit also prioritizes youth empowerment, ensuring that young people have a voice in shaping future energy policies.

By contrast, we notice that Eco-League's strength lies in its localized, not international impact. By focusing primarily on Japan, the initiative can concentrate its efforts on engaging with local communities, fostering grassroots environmental awareness, and mobilizing young people towards sustainability. This national focus allows Eco-League to build strong connections with communities and develop environmental leaders at the local level.

We can see how both the Student Energy Summit 2023 and the Japan Youth Ecology League (Eco-League) exemplify the significance of involving young people in environmental sustainability efforts. While the summit focuses on global energy challenges and collaboration, Eco-League concentrates on fostering ecological initiatives within Japan.

The Summit and the Eco-League are excellent examples of how great initiatives from around the world each have their individual strengths which, when combined, produce the best results and have the greatest possible impact. Collaboration and the exchange of proven models can open the door for more global, comprehensive strategies for youth-led environmental sustainability initiatives. These efforts may encourage transformative acts and build a greener, more sustainable world for future generations by combining their distinct capabilities.

# Appendix 2: Jobs descriptions

## Jobs with Impact

As any other economic activity, energy efficiency will benefit from and be transformed by the rise of digital technologies. The jobs of tomorrow are unlikely to resemble those of today. We suggest here, as a thought experiment, what some future jobs could look like.

It is probably worth acknowledging here that none of these jobs are distant science fiction. In fact, most of them already exist in some form, and as technology development accelerates, they will likely be the new jobs of the decades to come.

### Job Description 1 – the Digital Energy Manager

The Digital Energy Manager plays a crucial role in ensuring both site productivity and occupants' well-being.

The mission of the Digital Energy Manager is to manage all energy-related activities on a given building or industrial site. This includes optimizing energy demand depending on weather-related and occupancy conditions, but also optimizing the use of alternative energy resources, such as distributed generation, energy storage systems and electric vehicles, in coordination with the utility, and in case of emergency situations.

The Digital Energy Manager relies on an integrated digital suite of tools to interact in real-time with the energy system on site, as well as AI-aided APIs to develop routines to further optimize building performance.

She/He reports to the site manager.

Education: Bachelor of Science, specialization in energy systems or computer sciences.

### Job Description 2 – the Connected Energy Efficiency Contractor

The Connected Energy Efficiency Contractor executes integrated renovation projects in households. She/He is responsible for the quality of the delivery as well as meeting time commitments and overall customer satisfaction.

The Connected Energy Efficiency Contractor is in charge of deploying, within one retrofit, all the upgrades of a specific project, including the installation of new heating systems, distributed generation and storage, new electric appliances and digital controls within a home.

She/He relies on the company's integrated digital project management tool, as well as portable 3D-manufacturing machines to perform necessary manufacturing operations on site. The Connected Energy Efficiency Contractor also works in real-time synchronization with offsite support through our augmented reality platform.

Education: no college degree needed. Professional training in energy and electrical installation services.

## Job Description 3 – the Digital House Builder

The Digital House Builder explores new building designs and smart retrofits to minimize the environmental (and carbon) footprint of buildings. She/he uses AI and advanced simulation capabilities to better design, leverage advanced material toolboxes, etc.

The Digital House Builder is the next generation of house builder. The target is to deliver new housing services (be they entirely new housing or upgrades) within an average of less than four weekse.

She/He leverages our AI-aided housing design tool to provide design services to the customer upfront and adjust the scope of the project. She/He then oversees the full construction process with our machine learning additive construction machine. She/He is responsible for the timely and safe execution of works on site, and the final site acceptance by the customer.

Education: no college degree needed.
Professional training in construction required.

## Job Description 4 – the Sustainability Architect

The Sustainability Architect is responsible for overseeing new commercial building designs for the company.

The role involves driving the design process of a new building construction in a collaborative way with the customer. She/He uses our collaborative AI design platform.

The mission of the Sustainability Architect is to meet customer expectations while ensuring the construction is zero-carbon with a minimal environmental footprint. Our AI design platform helps to run hundreds of simulations by day to proactively combine customer expectations with environmental constraints, leveraging better physical layouts, more efficient structural approaches and new materials and energy resources.

Education: Bachelor of Arts, Architectural design

## Job Description 5 – the Digital Supply Chain leader

The Digital Supply Chain leader plays a crucial role in optimizing supply chain flows for the company.

She/He uses our digital traceability platform which provides a real-time overview of all material flows across the company, inward from suppliers and outward to customers.

Her/His mission is to optimize supply chains within a given area of service. Aided by the digital traceability platform, the Digital Supply Chain leader primarily monitors daily operations, but is also responsible for developing alternative routes to cope with disruption risks, as well to optimize these flows to increase speed and reduce costs.

The Digital Supply Chain leader reports to the Director of Supply Chains.

Education: Bachelor of Science, Engineering

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