Towards **Net-Zero Buildings**

Towards Net-Zero Buildings

A practical pathway

An eBook from the Schneider Electric™ Sustainability Research Institute

May 2022

Breaking the decarbonization deadlock

1 A turning point

2 Align and scale

3 Decarbonize

4 Digitize

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7 Schneider Electric™ Sustainability Research Institute

Foreword

Sustainability Research Institute

Breaking the building decarbonization deadlock

We are in a deadlock.

Buildings can play a key role in combatting climate change. The construction and operation of buildings is responsible for 38% of global emissions, and there is an urgent need for solutions to help accelerate the decarbonization of the built environment to limit the global temperature rise to below 1.5°C.

The general consensus is that innovation could help over time, even though one has to admit decarbonization would ultimately come at a net cost for society. This argument is not new and is in fact widely consensual across the various research organizations focused on the topic. This is, however, also the reason why conversations have fallen in some form of a deadlock, as it is politically unacceptable to impose an additional burden on communities which already struggle to make ends meet.

The magnitude of the transition is such that it often faces significant infrastructure challenges. The rapid electrification of end-uses, for instance, is faced with an even more rapid need to build up the supporting power infrastructure, in which lag could prevent a necessary turnaround.

All being considered, the grand plans around a 30-year energy transition face numerous challenges that are likely to make it more hectic than often imagined.

However, there is a solution.

In 2022, the World Economic Forum, with the contributions of Schneider Electric and a coalition of decarbonization pioneers, released the Building Value Framework, which aims to show that decarbonization, if designed correctly, is in fact a source of value creation for the economy and communities.

This is the meaning of this study which demonstrates that we can act now toward the decarbonization of buildings.

1

A turning point

There is a pathway for buildings to not only reach carbon neutrality but also to provide significant co-benefits for people and the economy.

A turning point for building ecosystems

Decarbonizing buildings is a key step to achieving a net-zero future; however, today's investment decisions often overlook this.

Schneider Electric and the World Economic Forum have developed a model to highlight the broader benefits that result from integrating non-financial values into investment decisions while also evaluating how digital technologies can enable the net-zero transition.

The framework is designed for practical use, to better equip decision-makers with the relevant know-how to make faster, more inclusive, and more sustainable investments.

Jean-Pascal Tricoire
Chairman and Chief Executive Officer
Schneider Electric

Paving the way for Buildings of the Future

TOGETHER WITH THE WORLD ECONOMIC FORUM, we defined the Building Value Framework, as a bold operational barometer for decision and action.

It has been developed and validated through case studies to understand the investment decisions and evaluate outcomes in real projects. From this process, key insights and a practical checklist focusing on reducing operational emissions have emerged to maximize value creation, as illustrated through the presented cases.

It can be applied in diverse contexts across different types of building assets and used at any point in the investment planning and decarbonization timeline.

I wish you a pleasant reading.

The role of buildings in combatting climate change

10%
of buildings have integrated decarbonization technologies.[1]

2%
of buildings have truly cutting edge decarbonization technologies with digital.[1]

1%
of buildings are net-zero.[1]

Cities are the frontline.

Cities account for over 70% of CO_2 emissions. Buildings are the largest contributor to emissions in cities, responsible for 50-70% of city emissions and 38% of global emissions.[2]

75% of emissions come from operations

generated from building systems (e.g., heating, ventilation and air conditioning, lighting, and IT servers). The remaining 25% come in the form of embodied emissions — carbon generated from the manufacture of building materials, construction, and internal furnishings.

An urgency to scale to transform urban building stock toward a net-zero economy.

- The current pace of economic growth and population rise in emerging economies will lead to a doubling of global building floorspace from new construction over the next 40 years.
- Net-zero by design is not limited to new construction, as over 2/3 of the buildings already existing will still be standing by 2050. Retrofit and refurbishment projects are critical in the movement to decarbonize. In Europe, between 1-1.5% of all building stock is being renovated every year.
- However, to meet the goals of the Paris Agreement, the rate of deep renovations needs to reach 3% a year.

Decarbonize and digitize at end use.

- Net-zero buildings are an essential tool in achieving global emissions goals. In addition, as energy systems evolve toward net zero, buildings will play a larger role in the energy system.
- Matching electricity supply to demand is a balancing act, and buildings can host new distributed resources, store power, and optimize demand to help strike this balance.
- Investing in decarbonization technologies, digitalization, and city ecosystem services maximizes value creation for all stakeholders.

1 – BSRIA - HVAC Market 2022.
2 – IEA - Empowering Cities for a Net Zero Future – July 2021

Existing technologies can bring carbon abatement at a net benefit to consumers.

Fossil fueled
Grid-tied and fossil fuel-based gen sets for backup power

Low electrification
Furnaces and boilers for heating
Gas-powered water heaters, ovens, and burners

Manual control
Manual controls, gas meters, inefficient lighting, shutters, heating systems, and air conditioners

Clean electricity
Self-generation with rooftop solar panels and energy storage

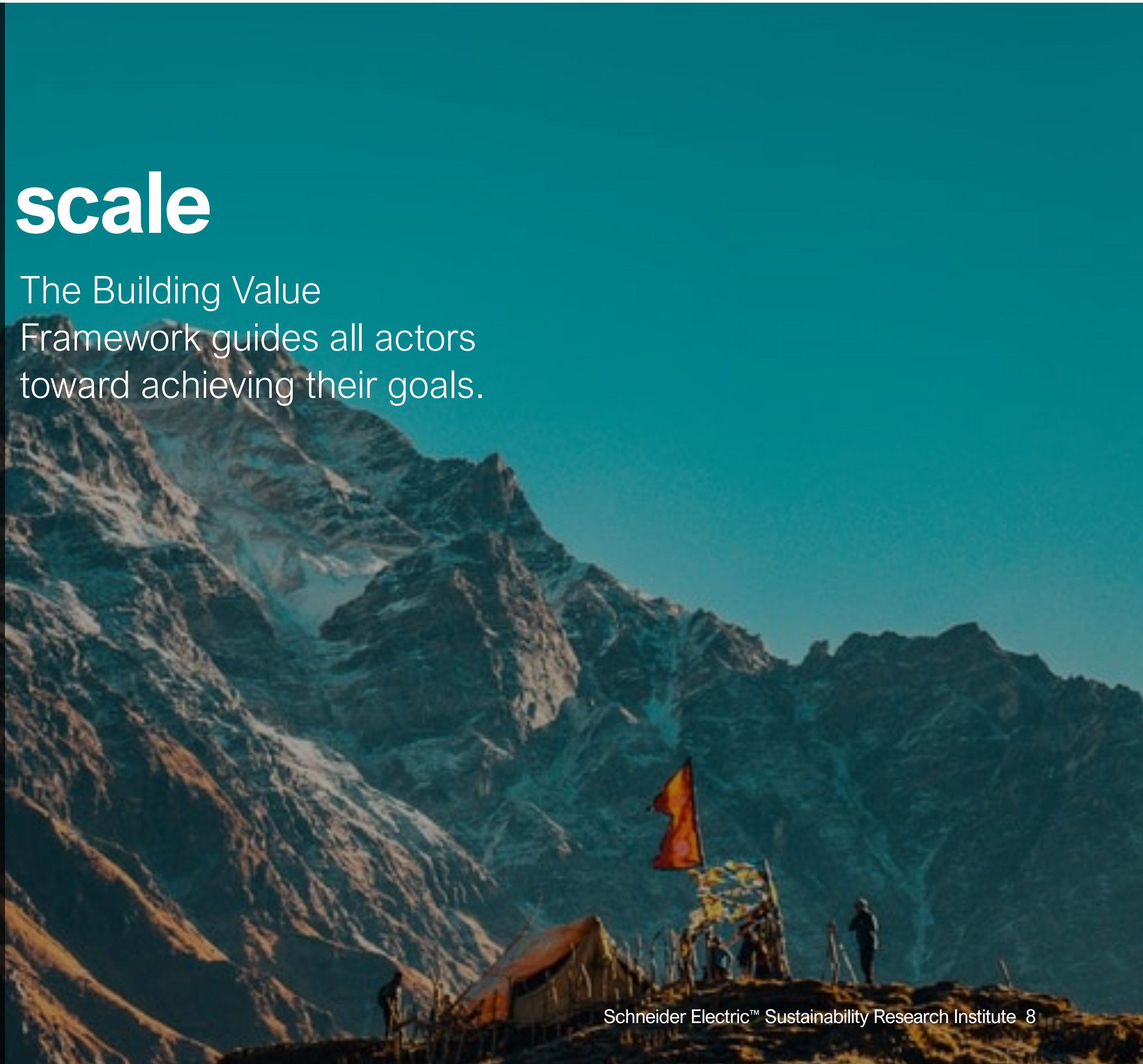
Electrification at end use
Heat electrification for spaces and water heating

Digital efficiency
Active energy efficiency with IoT zone control combined with energy monitoring systems

Impact [3]

÷2 to ÷3	Carbon emissions $kgCO_2/m^2/y$
÷2 to ÷3	Total energy spend USD/ m^2 /y
-30 to -50%	Total energy demand kwh/m^2/y

3 – Sustainability Research Institute — 2022



2 Align and scale

The Building Value Framework guides all actors toward achieving their goals.

Align and scale efforts for decarbonization

Following COP26, 1,000 cities plus nations and businesses have taken net zero commitments.

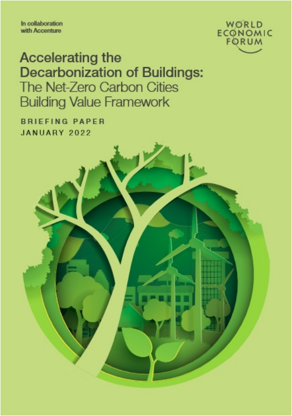
Action agendas for delivering on these commitments is essential.

The World Economic Forum is collaborating with 70 public and private sector stakeholders, across 10 different sectors, to deliver action agendas and drive momentum for the needed transformation.

WITH OVER HALF OF THE WORLD'S POPULATION living in cities and producing over 70% of carbon emissions, cities play a key role in combatting climate change. The construction and operation of buildings are a massive contributor of global emissions, and there is an urgent need for solutions to help accelerate the decarbonization of the urban built environment to limit the global temperature rise to below 1.5°C.

Although some leaders in sustainable buildings have started to consider social and environmental impacts in their decision-making, many obstacles to investment in net-zero buildings still relate only to financing.

The World Economic Forum's Net-Zero Carbon Cities Building Value Framework seeks to accelerate investment by overcoming these barriers.[4]



4 – NZZC Building Value Framework (2022)

An integrated framework

The framework proposes that a more holistic decision-making approach, which recognizes the importance of social and environmental outcomes and system performance, is key to increasing capital flow toward decarbonization solutions.

The framework guides decision-makers to connect nonfinancial benefits such as "user satisfaction" and "systemic value efficiency" and correlate them with reducing risk or increasing return on investments.

The Building Value Framework has been developed and validated through case studies to understand the investment decisions and evaluate outcomes in real projects. From this process, key insights and a practical checklist (focusing on reducing operational emissions) have emerged to maximize value creation, as illustrated through the presented cases.

First, it is vital to invest in decarbonizing technologies and combine them to optimize impact. For example, the Belgian real estate company Extensa used complementary solar and geothermal technologies to renovate and refurbish an old railway station in Brussels. This project demonstrates how bundling these technologies greatly impacts flexibility and system resilience.

Second, investment in digital can maximize the benefits of decarbonizing technologies. In a case study from Turin, Italy, the municipality collaborated with Enel X, a leading smart energy service provider, to retrofit municipal buildings for energy efficiency and on-site renewable generation. Integrating these with a digital platform added value to the project by enabling data-driven management decisions across the municipal system.

Third, investing in city ecosystem services and equipping buildings with distributed renewable power generation, storage and smart energy management solutions can enhance local resilience and accelerate decarbonization across cities without the need for disruptive grid upgrades.

The flexibility of the Building Value Framework means it can be used for the retrofit and refurbishment of existing buildings, as well as for the construction of new buildings.

The urgency to transition the world's cities toward a net-zero carbon future is abundantly clear. The Building Value Framework presents an approach to help accelerate the investments needed to deliver a greener urban built environment.

Shifting the dialogue with a common language

THERE IS A NEED FOR AN OPERATIONAL ENABLER as a bold barometer for decision and action to reach goals specified in existing metrics (ESG, LEED, and WELL), triggering ESG investments funds and achieving certifications, investments, and decarbonization goals.

Its core is to provide an optimal view through:

1. An easy-to-use assessment tool for existing buildings or as a fast-check for new buildings, associated with a solution guide revealing ROI, decarbonization potential per technology and co-benefits, as well as a non-competing tool toward existing labels, speeding up investment decision and massification of works in sustainable buildings.

2. ESG aligned, with low number of attributes to allow easy-to-do self-assessment, which make it green finance comprehensive, and contributing to earning key marks for ratings and certifications.

Governments / Cities / Corporations

Investment funds, RE financing

Asset/RE portfolio management

Building Level

RE development Design firms

Construction Contractors

Building owners

Property & Facility management

Long term Commitment / Target	Toolset for investment and actions	Existing Performance Certification or Green Reporting
Science Based Targets for Cities / Thriving Cities Initiative SCIENCE BASED TARGETS DRIVING AMBITIOUS CORPORATE CLIMATE ACTION	WORLD ECONOMIC FORUM	C40 CITIES
Net Zero Carbon Buildings Commitment / Advanced Net Zero (WGBC) WORLD GREEN BUILDING COUNCIL	ESG compatible	GRESB
	Green Finance trustable	Specific labels
	Triggering investment from both Finance and Business stakeholders	Labels / Ratings for audit and certification CASBEE, U.S. GREEN BUILDING COUNCIL USGBC, BREEAM
	Usable as a first-level easy-to-use assessment tool	WELL / R2S SRI / Wiredscore

Revealing the value

The Building Value Framework evaluates social, economic, environmental, and energy system outcomes resulting from investments in decarbonization solutions.

ALTHOUGH TRADITIONAL FINANCIAL OUTCOMES have historically driven investment decisions in the building ecosystem, many industry leaders are increasingly recognizing non-financial considerations and often include outcomes such as environmental and social impacts in building construction, valuation, and acquisition decisions.

However, the World Green Building Council's recent "Beyond the Business Case" report[5] has found that the most substantial obstacles to investment in sustainable buildings still relate to financing, with 53% of respondents citing higher upfront costs, either real or perceived, as the biggest barrier.

The Building Value Framework helps tackle this barrier by contextualizing the value of sustainable buildings to include environmental and social benefits, as well as improvements to system performance. It aims to accelerate decarbonization investments by providing co-benefits at the same time, going beyond the usual vision of seeing the investment as a fixed cost.

5– WGBC "Beyond the Business Case" – See Bibliography

Focusing on decarbonization investments that maximize value creation

Click on an lever to discover value creation.

DECARBONIZE

1 ELECTRIFY WHAT YOU CAN

2 DISTRIBUTED POWER AND SOLAR

3 ACTIVE ENERGY EFFICIENCY

DIGITIZE

4 MONITOR ENERGY CONSUMPTION

5 DESIGN FOR CONNECTIVITY

6 OPTIMIZE WITH BUILDING MANAGEMENT

7 OPTIMIZE LIFE CYCLE WITH BIM

AUGMENT

8 SUPPORT GRID AND LOCAL COMMUNITIES

9 CONTRIBUTE TO CLEAN MOBILITY

The operational checklist guides you toward Net-Zero buildings.

WORLD ECONOMIC FORUM with the support of Schneider Electric

Decarbonize

1. Electrify what you can
2. Make use of distributed power generation and solar
3. Install active and passive energy efficiency technology

Digitize

4. Monitor energy consumption
5. Design for the connectivity and interoperability of deployed assets
6. Optimize energy use with building management systems
7. Optimize life cycle efficiency with building information modeling

Augment

8. Design to support the grid and local energy communities
9. Contribute to clean mobility by installing smart electric vehicle charging

Measurable outcomes

Total energy demand	Carbon emissions	Optimized Paybacks (Years) and TCO
Kwh/m²/y	$kgCO_2$/ m²/y	USD/ m²/y

Co-benefits

- Sustainability
- Resiliency
- Efficiency
- People

The self-assessment tool aligns efforts to scale.

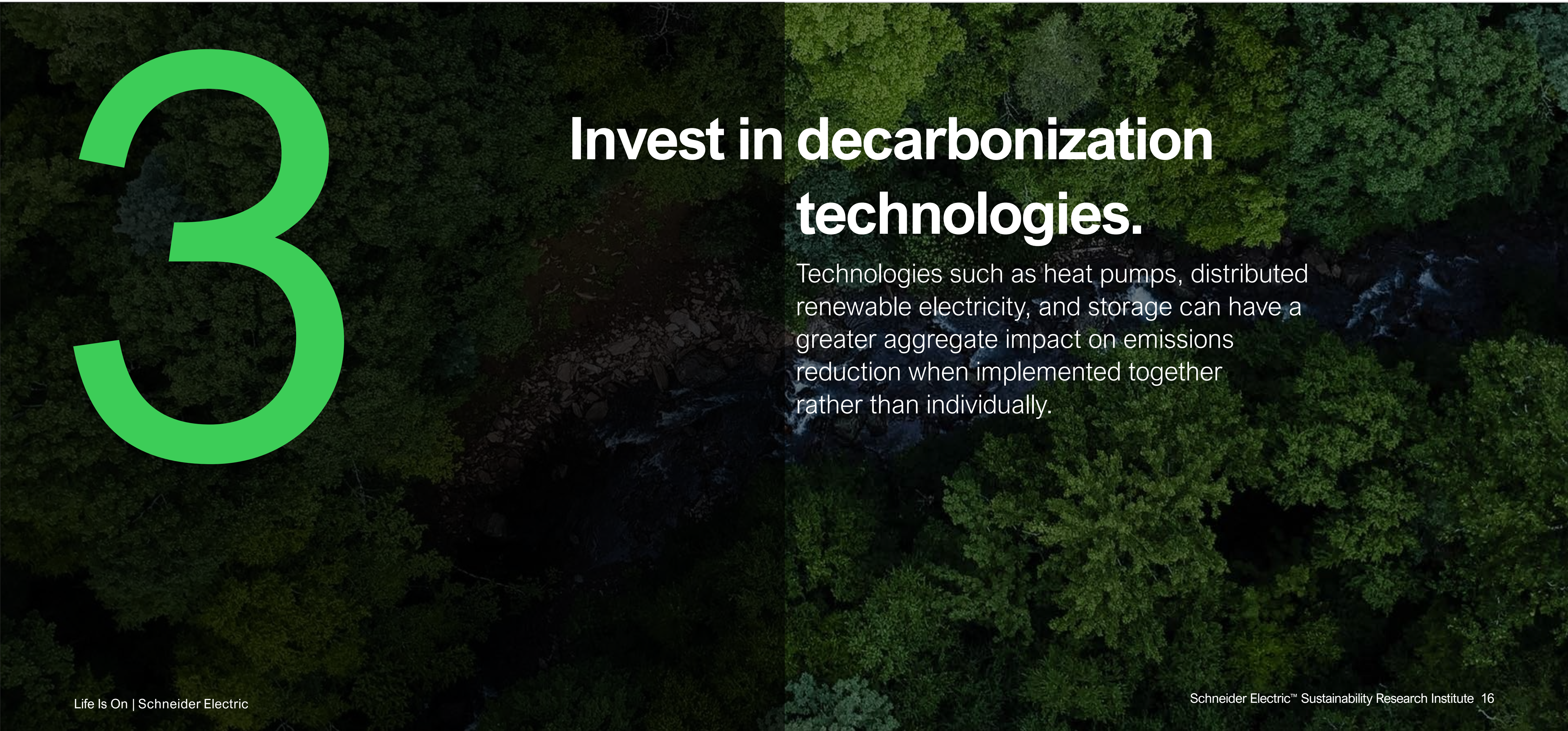
Impact on value creation (1: medium, 2: high, 3: extra)

Value	Operational check-list	Decarbonization Score	Your Score	Sustainability	Resiliency	Efficiency	People
DECARBONIZE 1	Fossil heating	0					
	Stand Heat Pumps	1					
	Smart Heat Pumps / Smart Grid Ready	2		3	2	3	1
DECARBONIZE 2	Grid electricity	0					
	Onsite Solar	1					
	Onsite Solar with self consumption storage	2		3	3	3	2
DECARBONIZE 3	No passive nor active efficiency	0					
	Passive Technology	1					
	Passive + Building Automation with Room Control	2		3	3	3	3
DIGITIZE 4	No energy monitoring system	0					
	Dashboarding	1					
	Monitoring of energy per use + Analytics & IA	2		2	2	3	2
DIGITIZE 5	No connectivity	0					
	Basic connectivity	1					
	Integrated connectivity : IP, Cyber, Governance	2		2	3	2	2
DIGITIZE 6	No BMS	0					
	Standard BMS	1					
	Integrated BMS (Building Operating System)	2		3	3	3	3
DIGITIZE 7	No BIM	0					
	BIM in Design & Build	1					
	BIM all along the life-cycle + integration with BMS	2		3	2	3	2
AUGMENT 8	No optimization	0					
	Local optimization	1					
	Local optimization with front-of-the-meter grid/system services	2		2	3	2	2
AUGMENT 9	No EV charging	0					
	Simple charging	1					
	Local optimization + control system + Building energy services	2		2	3	3	3

How to use it practically

… to maximize value creation

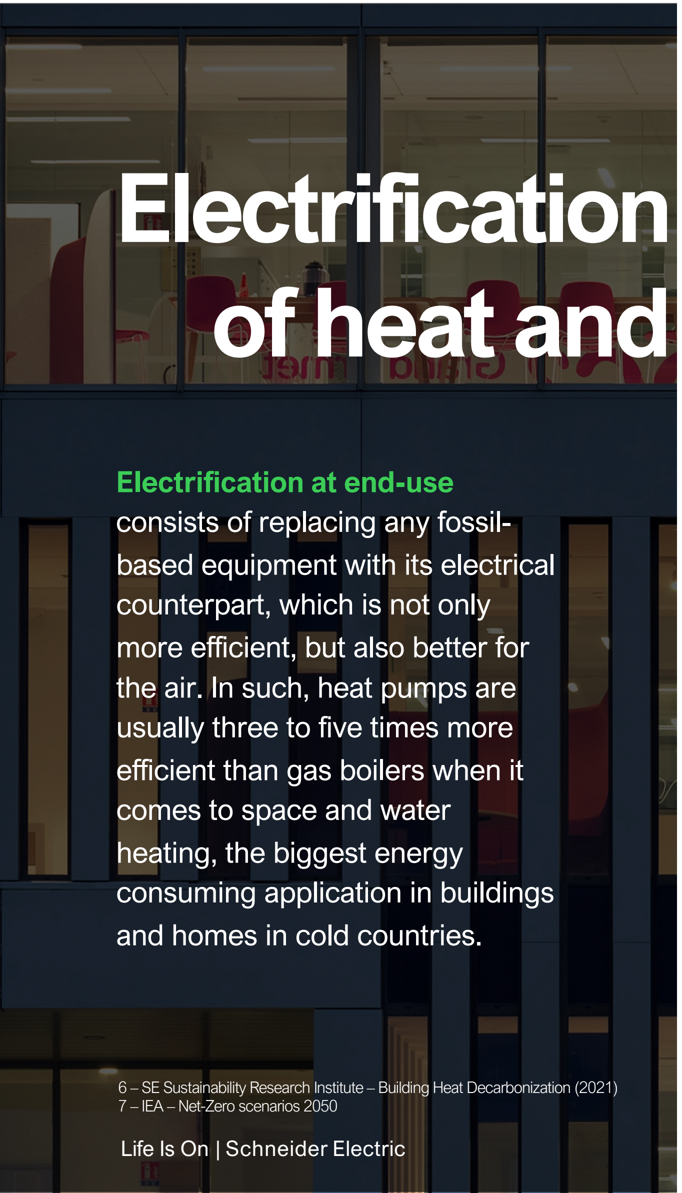
- Identify quickly what are the key investments for Decarbonization.
- Bundle for maximum impact and co-benefits creation.
- Check directly the value creation for the four categories of:
  1. Sustainability
  2. Resiliency
  3. Efficiency
  4. People
- Get up to speed in your investment decision and massification of works for sustainable buildings.

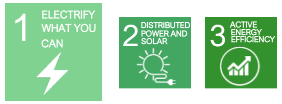


3

Invest in decarbonization technologies.

Technologies such as heat pumps, distributed renewable electricity, and storage can have a greater aggregate impact on emissions reduction when implemented together rather than individually.





Electrification of heat and space heating

Electrification at end-use consists of replacing any fossil-based equipment with its electrical counterpart, which is not only more efficient, but also better for the air. In such, heat pumps are usually three to five times more efficient than gas boilers when it comes to space and water heating, the biggest energy consuming application in buildings and homes in cold countries.

Heating corresponds to 45% of total building energy demand,[6] representing around 3GtCO_2/y of carbon emissions.

Electrified heating solutions will become more competitive in the mid-term future, following improvements in heat pumps and possible lower electricity costs.

HEAT PUMPS ARE THE FASTEST SPREADING heating technology in the net-zero emissions scenario by IEA.[7]

Heat pumps meet no more than 7% of global heating needs in buildings. To be in line with net zero, however, 600 million heat pumps need to provide 20% of global heat demand for buildings by 2030.

More economic than oil heating

Oil heating is economically less viable than electrified heating solutions – in both retrofits and new builds – especially once current electricity tax distortions are removed. Given its much worse environmental impacts, the displacement of oil heating for electric is therefore a smarter choice.

The residential opportunity

In new builds there is a strong economic case for the installation of heat pumps, over gas heating systems, especially if supported by taxation reforms. Switching is also largely economically competitive in retrofits once air-conditioning needs, largely forgotten in today's debate, are included in the equation.

A game changer for commercial buildings

The displacement of gas with electrified heating solutions already makes sense economically in Asia and parts of Europe.

Technology outlook

Continuous improvements in heat pump energy performance and cleaner power generation, the coverage is drastically growing. Rapid reductions in emissions from electricity supply in the NZE mean that 100% of the heat pump stock has lower emissions than natural gas-fired condensing boilers by 2025.

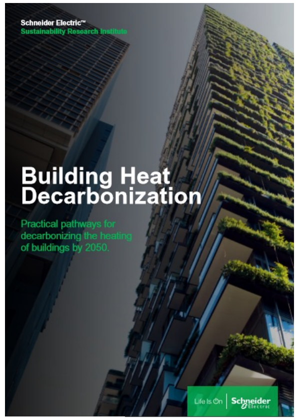
Ambitious commitments related to end-use equipment efficiency (e.g., MEPS), emissions (e.g. mandating a share of renewable energy in primary energy use for heat production for buildings) and flexibility (e.g. using smart-readiness labels and incentivizing heat storage in water tanks and district energy networks) can take advantage of the synergies gained by using sustainable heating products to achieve multiple climate goals.

6 – SE Sustainability Research Institute – Building Heat Decarbonization (2021)
7 – IEA – Net-Zero scenarios 2050

1 ELECTRIFY WHAT YOU CAN · 2 DISTRIBUTED POWER AND SOLAR · 3 ACTIVE ENERGY EFFICIENCY

Electrification of heat and space heating

	Key benefits Standard technology – heat pumps	Maximum value through digital
Sustainability	No emissions at end-use	Ready for decarbonized sources integration, such as renewable energy
Resiliency		Ready for heat storage flexible control through grid signals (e.g., DSM)
Efficiency	X3 to X5 more efficient than gas boilers on space and water heating	Ready for optimized control of heating system based on local predictions (e.g., through model predictive control)
People	Quick heating	Ready for individual room control with communication and occupancy detection



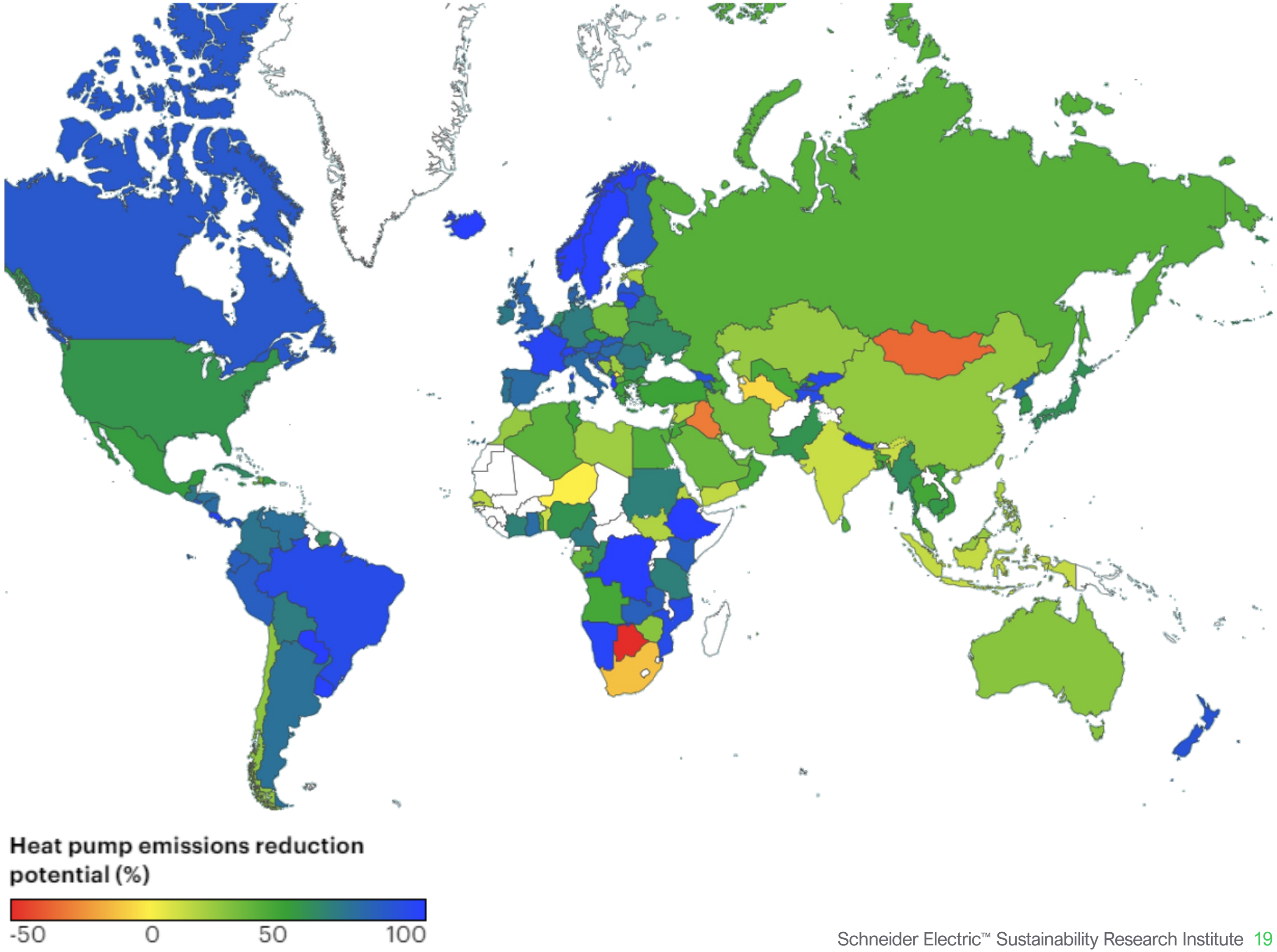
Link to the study from the Schneider Electric™ Sustainability Research Institute

Electrification of heat
Outlook from IEA

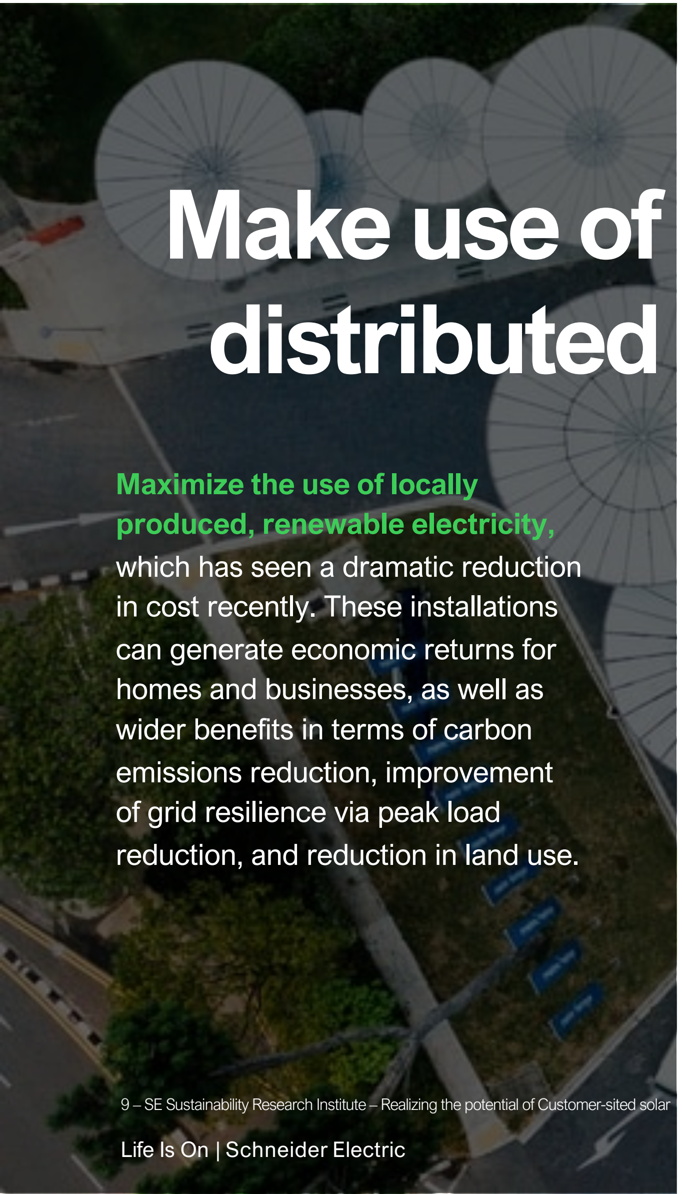
"Heat pumps could satisfy 90% of global heating needs with a lower carbon footprint than gas-fired condensing boilers.[8]

A massive decarbonizer

In 2020, electric heat pumps still met no more than 7% of heating needs in buildings globally, yet they could easily supply more than 90% of global space and water heating at a lower CO_2 emissions level – even taking the upstream carbon intensity of electricity into account – than condensing gas boiler technology (which typically operates at 92-95% efficiency).



8 – Heating in Buildings analysis - IEA



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Make use of distributed power generation and solar

Maximize the use of locally produced, renewable electricity, which has seen a dramatic reduction in cost recently. These installations can generate economic returns for homes and businesses, as well as wider benefits in terms of carbon emissions reduction, improvement of grid resilience via peak load reduction, and reduction in land use.

It is easier to deploy solar panels on rooftops than to get permits to building large farms: Distributed Generation accelerates the decarbonization of the power system.[9]

CENTRAL TO THE DECARBONIZATION EFFORT IS THE POWER SYSTEM, which is simultaneously the sector most responsible for carbon emissions and the one most likely to decarbonize first.

The decarbonized power system of the future will look fundamentally different from the power systems from the past. Thanks to the rapidly falling costs of solar technology, for the first-time consumers in various parts of the world can now economically generate some of their own power. This has mobilized new sources of capital to invest in the customer side of the energy transition while delivering economic benefits to customers and grid operators and creating local employment opportunities.

As energy storage costs fall, a second transition is beginning, where customer-sited solar combined with storage can begin to provide greater benefits to the power system in terms of energy balancing, grid services, and increased resilience. Furthermore, as net-zero goals drive greater electricity demand in transport and buildings, customer-sited energy resources could play an even more important role in optimizing local energy supply and demand.

Technology outlook

Pairing solar and storage creates extra-value

Locally generated clean electricity combined with on-site solar and storage limits operating emissions, lowers operating costs, and enables near-autonomy from grid energy.

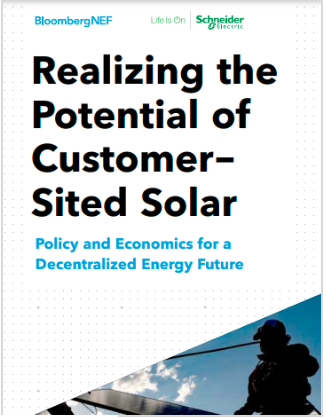
Taken alone, clean electricity generation technologies could not generate the same benefit to system resilience and flexibility.

Integration of smart and bidirectional charging stations provides an extra-value by leveraging vehicle electrification as a source of flexibility.

9 – SE Sustainability Research Institute – Realizing the potential of Customer-sited solar

1 ELECTRIFY WHAT YOU CAN
2 DISTRIBUTED POWER AND SOLAR
3 ACTIVE ENERGY EFFICIENCY

Make use of distributed power generation and solar



Link to the study from the Schneider Electric™ Sustainability Research Institute

	Key benefits Standard technology – onsite solar	**Maximum value** through digital
Sustainability	Emissions reduction	Ready for accelerating decarbonization of electricity
Resiliency	Resilience in the form of back-up during a blackout	Ready for additional resilience benefits with storage
Efficiency	Decreased bills and reduce grid congestion	Ready for capturing new revenue streams by providing services to the grid (e.g., capacity, energy, ancillary services…)
People	People engagement as environmentally friendly	Ready for offering users the ability to consume more of their solar generation

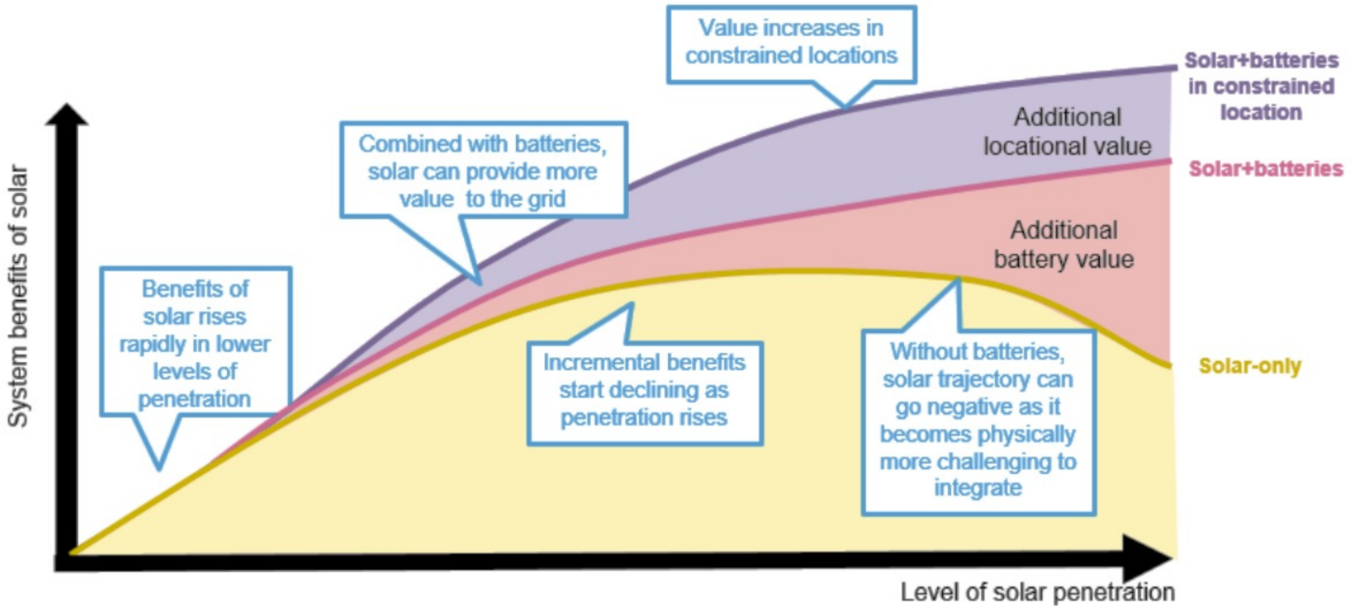
Distributed power generation and solar

Outlook from BloombergNEF

> Customer-sited solar paired with flexibility can deliver further system benefits.[9]

Encouraging pairing for extra-value

A structural dynamic and key focus from Schneider Electric and BloombergNEF report, "*Realizing the Potential of Customer-Sited Solar,*" is what happens in the longer term when customer-sited solar reaches high penetrations. As solar penetrations grow in a region, there comes a point where aggregate solar production in the daytime approaches the total electricity demand of the region. Clearly, beyond this point, adding more solar ceases to add value to the overall electricity grid, as the energy is not needed at the time it is produced.



Source: Bloomberg NEF. Note: this is merely illustrative. The actual levels of penetration and benefits will depend by market and grid infrastructure.

9 – BloombergNEF, Realizing the potential of Customer-sited solar

1 ELECTRIFY WHAT YOU CAN | 2 DISTRIBUTED POWER AND SOLAR | 3 ACTIVE ENERGY EFFICIENCY

Install active and passive energy efficiency technology

Energy efficiency technology provides significant opportunities such as reducing energy waste and associated carbon emissions – this being for new build or renovation, homes, or buildings. Energy consumption reduction can range from 10 to 60% typically, depending on geographies and quality of existing of assets. While passive means focus on building envelope, active means focus on operational emissions reduction by deploying sensors and automation systems to provide heating, cooling, and lighting when and where it is needed only.

10– SE Sustainability Research Institute – Cracking the Energy Efficiency case in Buildings

Energy efficiency is widely considered a critical option to accelerate the decarbonization of the economy by 2050. Digital solutions are key to crack the energy efficiency dilemma and bring significant benefits, often underestimated, by conventional research.[10]

3 takeaways on active energy efficiency

1 – Carbon abatement

Digital efficiency solutions bring 20-30 percent carbon abatement across the building stock.

2 - Payback

Active energy efficiency brings highly competitive paybacks and cost savings for consumers, well below 8 years in average. The hospital and retail sectors offer the most attractive paybacks, below 5 years.

3 – Global and transverse reach

All regions show significant potential, even though the economic equation is more attractive in Europe (with paybacks ranging around 5 years in average). The age and associated performance of buildings have also a strong impact on the carbon abatement potential of digital solutions. Active energy Efficiency benefits however applies across all the current building stock.

Technology outlook

toward active hyper-efficiency

The International Energy Agency estimated in its 2021 net zero scenario publication a potential for digital solutions of 0.35GtCO_2/y abatement over the global building stock by 2050, focusing on direct emissions alone (heating and cooking, around 3GtCO_2/y today), or around 10-12 percent of total abatement (the rest of energy efficiency savings coming from conventional works on building envelopes and equipment).

1 ELECTRIFY WHAT YOU CAN
2 DISTRIBUTED POWER AND SOLAR
3 ACTIVE ENERGY EFFICIENCY

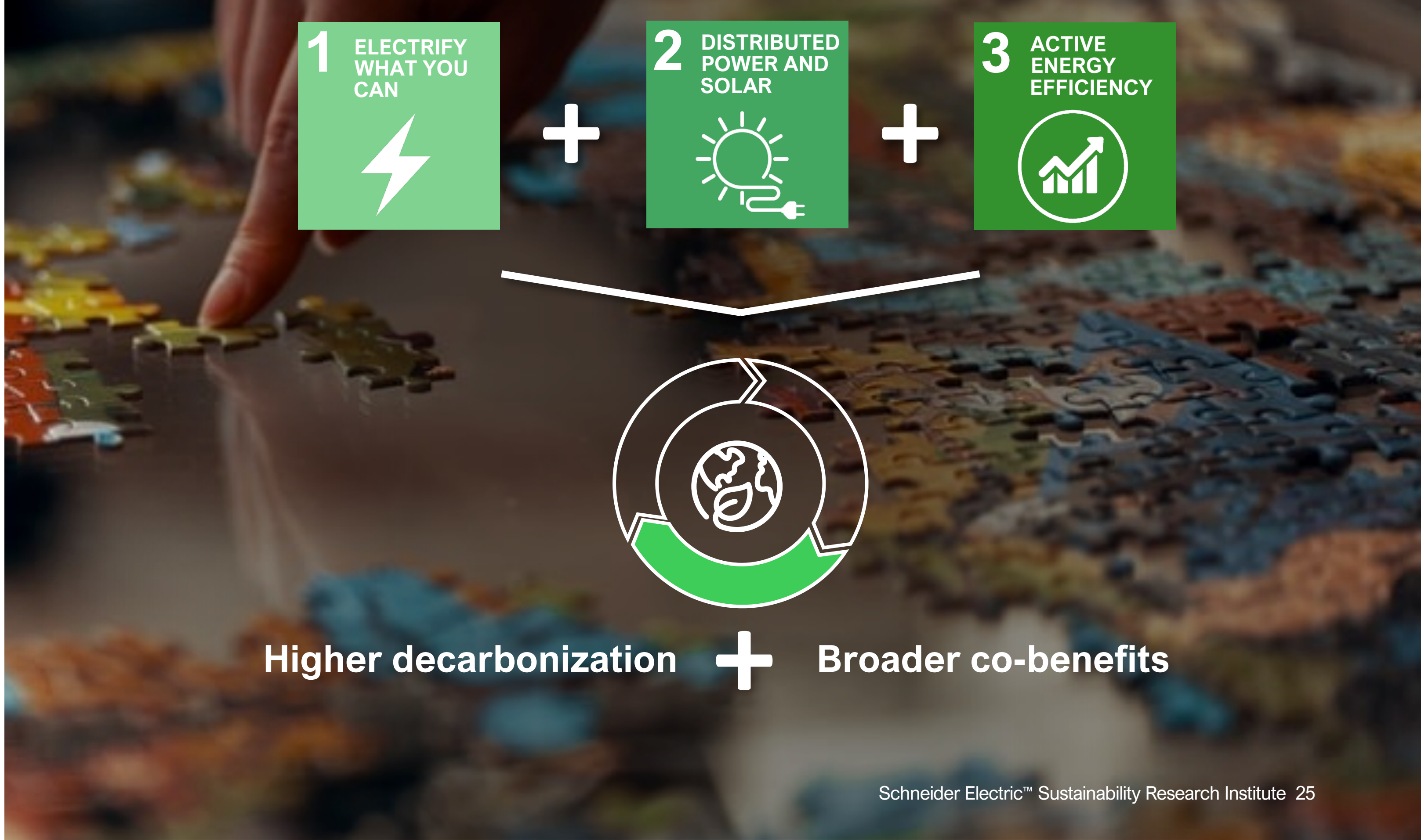
Install active and passive energy efficiency technology

	Key benefits Standard technology – passive	Maximum value through digital (active technology)
Sustainability	Compliance to building standard certifications	Ready for tracking real-time CO_2 data for emissions reporting and automatically adjust HVAC setpoint based on environmental conditions and space utilization
Resiliency	Efficiency on space heating and cooling	Ready for responding proactively to increased grid demand through distributed energy resources (DER) and building system control
Efficiency	Reduce thermal leakages	Ready for preventing rebound effect of energy demand to dwelling uses, and to address discontinuities of the building use, such as time of use (occupancy) or space of use (zoning)
People	Increase comfort	Ready for providing better comfort, such as pre-condition meeting rooms with HVAC/Lighting start-up sequences

Link to the study from the Schneider Electric™ Sustainability Research Institute

Maximize value creation by bundling

Electrification of heating, distributed renewable electricity, storage, and active energy efficiency have greater impact on emissions reduction when implemented together rather than individually.



Impact vs. ROI of decarbonization technologies

Maximize value creation by bundling.

Without bundling

Taken one by one, decarbonization technologies offer diverse options in term of ROI and decarbonization impacts.

Decarbonization impact ($ktonCO_2$) / ROI	Long ROI > 15 years	Average 5 to 10 years	Short ROI < 5 years
High	Roof-top Solar Wall insulation	Energy Monitoring Heat Pumps Building Management	
Medium		Energy storage Roof/ceiling insulation	
Low	Window glazing		EV charging

Impact of bundling

Extra value of bundling

Decarbonization impact ($ktonCO_2$) / ROI	Long ROI > 15 years	Average 5 to 10 years	Short ROI < 5 years	Extra ROI < 3 years
Extra			Smart heat pumps + Distributed energy resources + Storage + Digital	
High	Roof-top Solar Wall insulation	Energy Monitoring Heat Pumps Building Management		
Medium		Energy storage Roof/ceiling insulation		
Low	Window glazing		EV charging	

Toward decarbonized buildings

Kallang Pulse, Singapore

1 ELECTRIFY WHAT YOU CAN + 2 DISTRIBUTED POWER AND SOLAR + 3 ACTIVE ENERGY EFFICIENCY

100%
renewable electricity: 80 solar panels on site and off site solar

28%
yearly energy consumption decreased in 3 years

122,000 kWh
of electricity savings and 3,700 m³ of water per year from 2018 to 2020

Awarded BCA Green Mark Platinum building (GM: 2021)

- Awarded Leadership in Sustainability & Performance by SGBC-BCA (2019)
- Increased brand recognition and improved on CSR

Full retrofit of office building

- Schneider Electric retrofitted its existing and 25-year-old office building into a green and sustainable facility to convert into its new East Asia and Japan headquarters in Singapore.
- Cushman & Wakefield crafted end-to-end design and project management solutions to deliver workspaces that enabled Schneider Electric to cut its carbon footprint.

Key investments to make the vision reality

Distributed power generation and solar

- The building runs on 100% renewable electricity (80 solar panels on site + off site solar through PPA) since April 2021.
- The chiller plant acting as a centralized cooling system, providing a portion of air conditioning in the building's HVAC systems. Hyper-efficiency reached thanks to a magnetic bearing chiller incorporating variable speed drives regulating air flow speed according to demand, helping to achieve higher efficiency rating.

Energy efficiency technology

- Optimized design of the building façade, tiles and windows allowed to meet a high Envelope Thermal Transfer Value (ETTV) to ensure energy performance.
- 5,000+ IoT-enabled connected product data and meteorological weather forecasts are aggregated in real time at the level of the automation system to improve energy efficiency and overall system performance.

Toward decarbonized buildings

Kallang Pulse, Singapore

1 ELECTRIFY WHAT YOU CAN + 2 DISTRIBUTED POWER AND SOLAR + 3 ACTIVE ENERGY EFFICIENCY

Asset outcomes	City outcomes

To transform an existing building into the first retrofit to achieve carbon neutrality in Singapore

Emissions reduction
Minimized embodied carbon
Minimized operating carbon
Maximized use of locally generated clean electricity

Environmental improvement
Minimized water usage
Minimized waste
Increased biodiversity

To perform sustainable initiatives, waste management, no single use of plastic, energy saving, biodiversity, carbon neutrality, and renewable energy

To offer a comfortable and productive environment for the occupants, while adapting to the local environmental conditions

User satisfaction
Health, well-being, and productivity improvements

Systemic value efficiency
Improve efficiency
Improve flexibility
Improve resilience
Improve grid services

Socio-economic improvement
Job creation
Lower energy costs to consumers

To make an energy efficient building as energy equipment becomes older and the energy needs increase

Key outcomes

Financial and non-financial

Distributed power generation and solar

- Non-financial: Carbon and energy neutral, 100% Solar
- Financial :
  - ✓ Rent increase
  - Revenue increase
  - ✓ OPEX reduction
  - CAPEX reduction
  - ✓ Asset Value increase
  - ✓ Compliance cost reduction
  - Financing cost reduction
  - ✓ Brand value increase

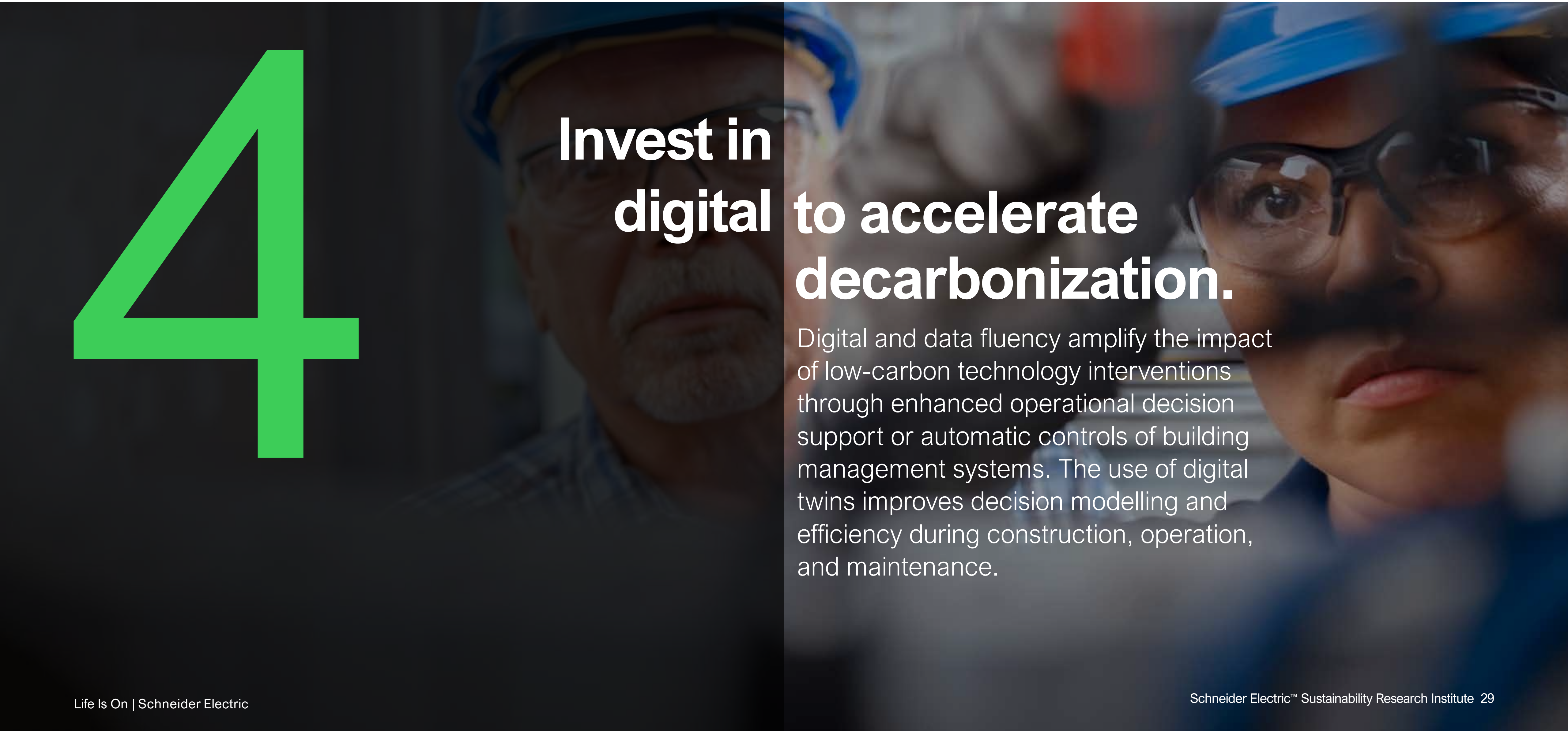
Switching from fossil fuels to renewable energy became more economically viable since the local government liberalized the electricity market. The building was able to take advantage of a reduction in solar energy prices to reach its goal of carbon neutrality earlier than expected.

Energy efficiency technology

- Non-financial: 28% less energy consumption per year, optimized comfort of workers
- Financial:
  - Rent increase
  - Revenue increase
  - ✓ OPEX reduction
  - CAPEX reduction
  - ✓ Asset Value increase
  - ✓ Compliance cost reduction
  - ✓ Financing cost reduction
  - ✓ Brand value increase

Reduction in energy consumption is done with consideration of comfort. The building is equipped with 1.200 Schneider Electric devices, including various sensors monitoring and collecting data such as temperature, humidity, noise, and light levels.

To achieve sustainable energy efficiency, connected smart sensors were integrated and data analytics to continuously monitor and control the energy management of the building was performed.



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Invest in digital to accelerate decarbonization.

Digital and data fluency amplify the impact of low-carbon technology interventions through enhanced operational decision support or automatic controls of building management systems. The use of digital twins improves decision modelling and efficiency during construction, operation, and maintenance.

Monitor energy consumption

Measuring all buildings' sources of consumption provides insight to make informed decisions that improve performance, converts data into action and unlocks building's potential with energy visualization and analysis tools, and provides the end user the awareness of its behavior to engage into a more sustainable use of the building.

Conventional energy efficiency measures may lead to a rebound effect, energy monitoring technologies are a key resource to mitigate this effect, maintain performance and control the effect over time.[10]

ENERGY MONITORING AND management are often confused with energy-saving implements to conserve available energy. However, energy management is a much more comprehensive topic to deal with, it includes the process of controlling, monitoring, and conserving energy.

3 Core functions

- Metering and collecting the data for energy consumption
- Finding opportunities to implement methods of saving energy
- Analysing and interpreting the meter data to measure the efficiency of an energy management system

Benefit 1: Lower costs

With escalating rates of power, energy, and building management equipment can be time-consuming. The selected system must have enough arrangements and monitoring features to cut the cost by efficient power saving and fault detection.

Benefit 2: Risk mitigation

The selected system must be predictive in nature in order to symbolize opportunities of power preservation by reducing the power demand and to reduce the risk of power shortage. Also, systems offer security from theft and fraud as well, through access control systems.

Technology outlook

Digitizing power: Facts and figures

22% of fires in a facility are due to electrical failures, and 50% of electrocutions occur within buildings.

70% of power quality disturbances originate within buildings leading to 30-40% of downtime incidents.

Compliance with energy efficiency standards can improve energy intensity by up to 10% and add up to a 15% premium in building price.

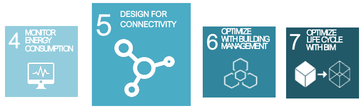
10 – SE Sustainability Research Institute – Cracking the Energy Efficiency case in Buildings

Monitor energy consumption

4 MONITOR ENERGY CONSUMPTION | 5 DESIGN FOR CONNECTIVITY | 6 OPTIMIZE WITH BUILDING MANAGEMENT | 7 OPTIMIZE LIFE CYCLE WITH BIM

	Key benefits Standard technology	**Maximum value** Energy monitoring at end use
Sustainability	Implement an energy performance methodology	Ready for identifying sources of energy savings and designing energy performance action plans for regulatory compliance and site optimization.
Resiliency	Optimization of subscribed powers	Ready for monitoring hourly consumption, limit rebound effect, monitoring of the actual savings of energy performance and ROI quantification
Efficiency	First level of alarms in the event of malfunctions	Ready for integrating smart heat pumps and microgrid management, including load control and advanced alarms in case of drifts or unusual behavior
People	Raising user awareness	Ready for providing user mobile applications with recommandations and insights

Link to the study from the Schneider Electric™ Sustainability Research Institute



Design for the connectivity and interoperability of deployed assets

Getting access to and easily share data with any equipment, IoT sensors, and building management systems (HVAC management / space management / workplace management) at building facility level to ensure sustained performance, as a critical way to build the best energy management strategy.

Buildings must be able to communicate with various environments and a wide range of equipment in order to deploy user services, address the issues of shared energies, home support, mobility and workplace optimization.

The quality of design and execution of a building infrastructure and the performance of its ecosystems, taken individually, is not enough. The ability to communicate without limits and without technological barriers is paramount.

Digital platform as the building's nervous system.[11]

- For operators, facility managers, property managers: Through a more standardized operating environment that facilitates the operating processes of the building and its services, optimizing maintenance operations and offering new services to the occupants at lower cost over time
- For construction, engineering, equipment suppliers and service providers: By providing a framework and a methodology to help deploy interoperable and evolutive solutions which take full advantage of the building IP infrastructure and allow the deployment of a rich set of services
- For developers and designers: By ensuring that the building is at its best capacity to deliver a wide range of services, flexible and adaptable, and will satisfy user needs as their needs may evolve overtime
- For owners, asset managers: By ensuring flexibility and adaptability of the building over time according to user evolving needs, and/or evolution of market demand, thus contributing to maximizing the value of the property and preventing premature obsolescence
- For the occupants: As workspaces, residential spaces, common or shared spaces evolve, offers a digital backbone with flexible services adapted to their needs, and is open to external innovations, such as those brought by IoT

11 – Schneider Electric – EcoStruxure Building Graph

Design for the connectivity and interoperability of deployed assets

	Key benefits Standard technology – connectivity	**Maximum value** Integrated connectivity: IP Network, interoperability, cybersecurity, digital governance
Sustainability	Foster the use of integrated solutions with lower OPEX impacts	Ready for enhancing sustainability value of assets by capitalizing on its value in use and protect the Building from obsolescence
Resiliency	Provide a first level of cybersecurity	Ready for providing connectivity redundancy and data flow exchanges protection between services, networks and equipments: optimizing OPEX costs of data management
Efficiency	Gather data by category (electricity, HVAC, occupancy…)	Ready for enabling rezoning of spaces and OPEX optimization maintenance for future connected equipments
People	Allow to provide basic services	Ready for delivering a wide range of services to satisfy users as their needs may evolve overtime

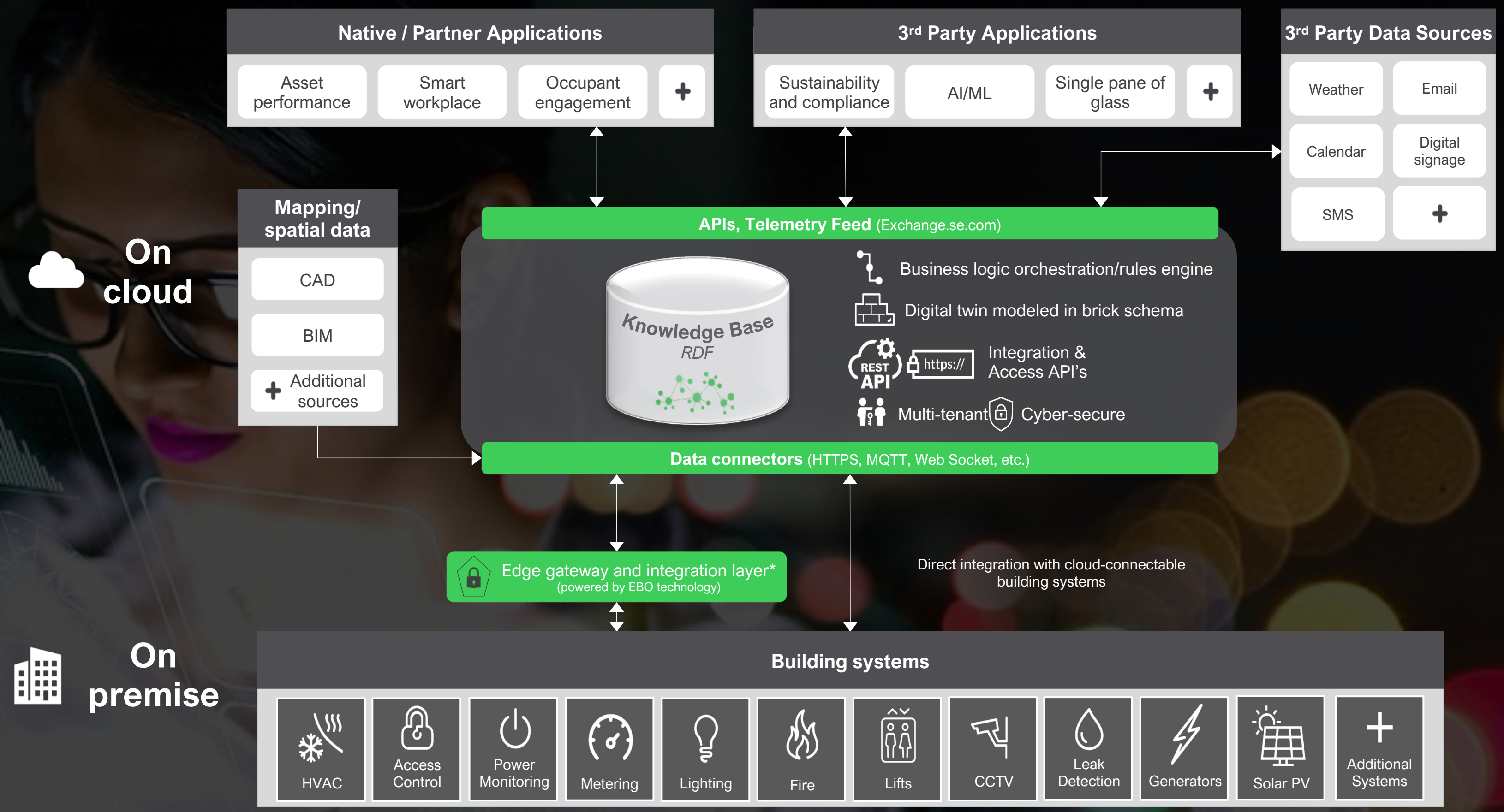
Link to the view from Schneider Electric Building Graph

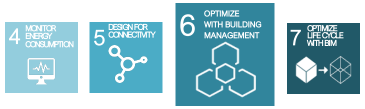
High connectivity and interoperability remove the complexities of integration with building systems for control, as well as complexities of accessing building data in closed and siloed environments.

Design for connectivity

The 5 foundations of a building ready for services

1. 3 independent layers: Equipment, infrastructure, and services as 3 independent layers
2. Systems interoperability: Use of web services and open APIs to facilitate communication between independent 3rd party solutions
3. Building network based on IP: An IP-based Internet Protocol network to transport data, the building's "4th fluid"
4. Open access to data: Interfaces allowing control and information functions to be accessible both inside and outside buildings
5. Security: Data protection, resiliency, IT, and network security





Optimize energy use with building management systems

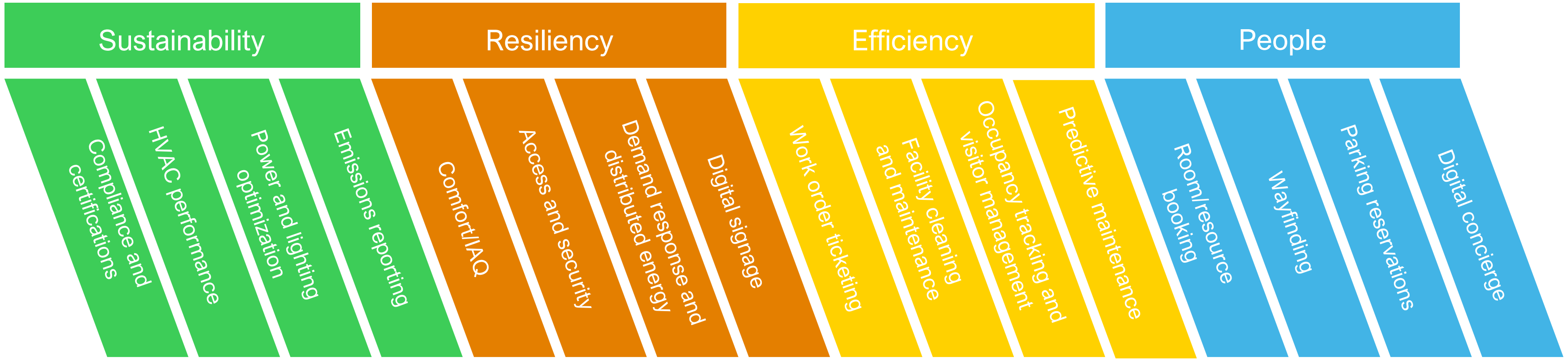
Providing the fundamentals for optimizing decisions and providing services.

Leverage building management system as a service use cases generator.

Leveraging the data potential of the building

The building management system makes possible to take informed decision with customer-tailored indicators considering customer priorities such as decarbonization, energy cost minimization, and local power resilience.

These systems should also incorporate advanced technologies to provide the best performance: dynamic data analysis, benchmarking, predictive technologies and artificial intelligence, as well as offering storage capacity.



4 MONITOR ENERGY CONSUMPTION | 5 DESIGN FOR CONNECTIVITY | 6 OPTIMIZE WITH BUILDING MANAGEMENT | 7 OPTIMIZE LIFE CYCLE WITH BIM

Optimize energy use with building management systems

	Key benefits Standard technology	**Maximum value** Integrated building management system (building operating system)
Sustainability	Compliance and certifications, HVAC performance, power, and lighting optimization	Ready for achieving a high level of compliance and certifications, green labels, brand value, emissions reporting
Resiliency	Access and Security, primary level of cybersecurity	Ready for supporting air quality management, post-COVID compliance, demand response and distributed energy, digital signage, high level of cybersecurity
Efficiency	Work order tracking, visitor management	Ready for providing remote building operations, facility cleaning and maintenance, occupancy tracking and optimization, predictive, and proactive maintenance
People	Local comfort devices only (lighting, temperature, ventilation)	Ready for delivering a wide range of services mobile apps, wayfinding, parking reservation, room/resource booking

Link to the study from the Schneider Electric™ Sustainability Research Institute

Optimize energy use with building management systems

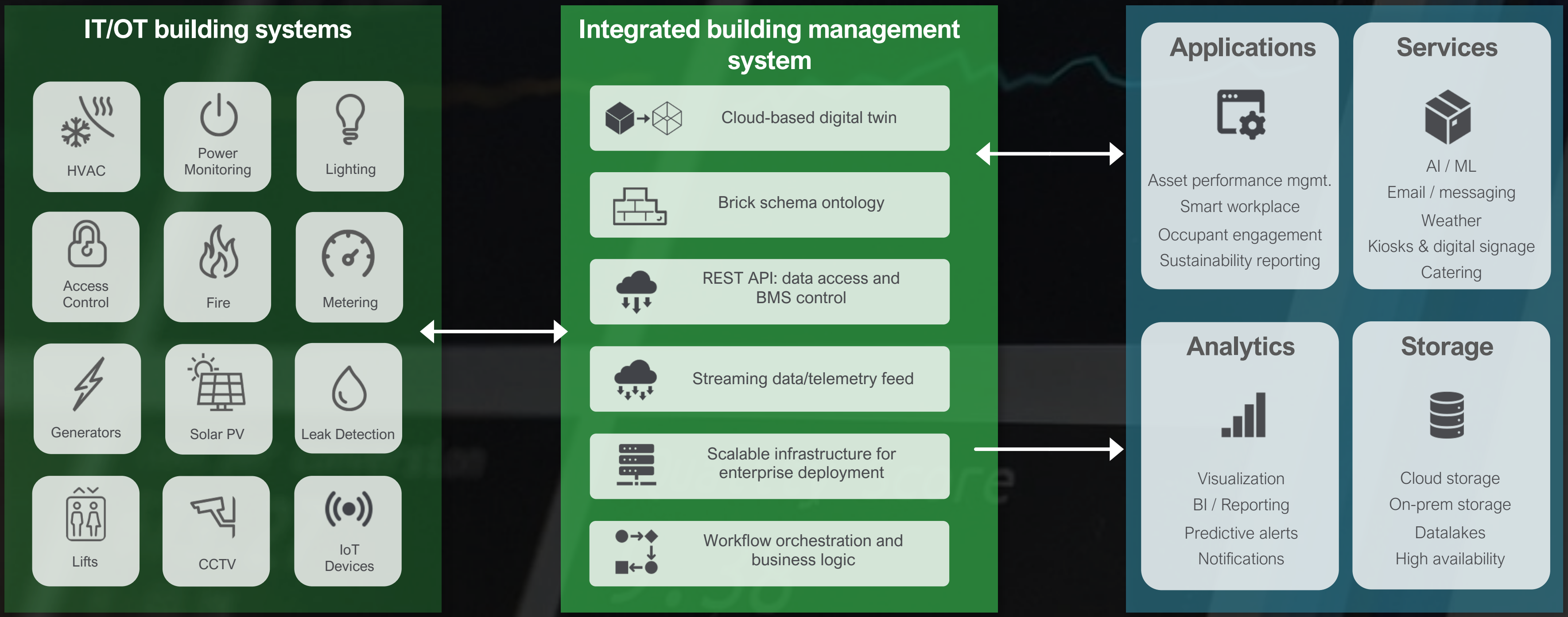
Building management system unlocks opportunities for building stakeholders via use-case driven applications.

Key foundations

REST APIs for access to building systems and data

Digital twin ontology modeled in brick schema

Data connectors enabling system-agnostic integration



Optimize life cycle building efficiency with information modeling

Deploying digital twins is key to enable the best from the building: optimizing the whole building design, minimizing costs and reducing waste at build phase, bringing greater efficiency and shorter project lifecycles, providing more opportunities for prefabrication and modular construction, and efficiently managing sustainability in operation.

BENEFITS OF BUILDING INFORMATION MODELING

The way a building is designed and erected directly impacts the costs to operate and maintain that building over its entire life cycle as well as its emissions. Therefore, real estate investors and building owners have a big financial and operational stake in how these processes are done.

Improve building design.

BIM creates a combined digital model of the building structure and all its internal systems. There are also building energy modeling (BEM) tools with help choose the best materials and designs to optimize the energy efficiency of an asset. Advanced 'generative design' uses AI-based machine learning to suggest design alternatives.

Given the right inputs, this can save tremendous amounts of time in laying out different aspects of the building, as well as delivering optimized design choices that the designer alone may not have otherwise conceived.

Save designers and contractors time and cost.

Design can be very manual, tedious, and repetitive. BIM saves time by automating design steps using known rules and established processes. Information about all systems is captured within a digital workflow. Detailed, accurate digital models are shared with everyone involved in the design-build process, which encourages collaboration and avoids duplication. BIM also includes cost and time dimensions that help building contractors more accurately estimate costs and more efficiently sequence construction.

Reduce risks.

By sharing accurate information, all parties can catch and correct any errors and omissions in design documentation. Having accurate component and system information enables "clash detection" that reduces conflicts among mechanical, electrical, and structural aspects of the building.

Simplify operation and maintenance.

Beyond guiding design and construction, the final building model becomes a "digital twin" that can help facility, maintenance, and energy management teams optimize building operation. A digital twin provides accurate details about each infrastructure as well as a building's expected energy performance. Equipment can be located faster and continuously updated with operational, diagnostic, and historical data. Integration with energy management enables predictive maintenance and reduced response time to operational risks.

4 MONITOR ENERGY CONSUMPTION
5 DESIGN FOR CONNECTIVITY
6 OPTIMIZE WITH BUILDING MANAGEMENT
7 OPTIMIZE LIFE CYCLE WITH BIM

Optimize life cycle building efficiency with information modeling

	Key benefits Standard technology – BIM in design and build	**Maximum value** BIM operation and maintenance, complete integration with the building management system
Sustainability	Contribute to build net-zero carbon buildings	Ready for contributing to an ambitious energy waste and carbon footprint strategy (certifications in real-time)
Resiliency	Better coordination and clash detection	Ready for streamlining maintenance and repairs thanks to dynamic visualization of issues
Efficiency	Model based cost estimation, visualize projects in preconstruction, increase productivity with prefabrication, improved scheduling/sequencing cost	Ready for supporting the future missions of facility management (energy contracts, Performance contracts)
People	Improve onsite collaboration and communication for higher construction performance	Ready for supporting the enrichment of services for the users and the tenants, creating value for owners

Toward digitized buildings

Intencity Grenoble, France

4 MONITOR ENERGY CONSUMPTION + 5 DESIGN FOR CONNECTIVITY + 6 OPTIMIZE WITH BUILDING MANAGEMENT + 7 OPTIMIZE LIFE CYCLE WITH BIM

100%
energy neutral thanks to rooftop-solar largely compensating consumption (0,9 GWh/year)

20KWh/m²/y
energy consumption for workspaces

103/110
LEED Certification target

Reaching 103/110 on the LEED Certification international framework

Awarded Leadership in Sustainability & Performance by SGBC-BCA (2019) / Increased brand recognition and improved on CSR.

Two unique levers

- All electric: extremely frugal thanks to efficient electrical production (solar) and uses (heat pumps, lighting, EV, geothermal energy) and end monitoring of all electrical uses
- All digital: Digital twin plus IoT everywhere to allow the building to adapt in real time and as close as possible to user needs

Key investments to make the vision reality

Energy monitoring and building management systems

- Electricity consumption is tracked for each equipment and along all the electrical system.
- Presence and luminosity sensors are disseminated all over the building, while working spaces are equipped with sensors measuring temperature, hydrometry, and CO_2 rates.
- Granular control in the building through a unique real-time data management platform fed by an incredible amount of data from sensors and meters.

Life cycle efficiency through BIM

- Data driven design and build of the building via BIM modelling and energy modelling
- Building design done by anticipating future use cases and formalizing the objectives in a collaborative performance specification
- Two-year commissioning phase to calibrate the Digital Twin virtual model with physical insights and to grab the full Building energy efficiency potential at operations

Toward digitized buildings

Intencity
Grenoble, France

4 MONITOR ENERGY CONSUMPTION + 5 DESIGN FOR CONNECTIVITY + 6 OPTIMIZE WITH BUILDING MANAGEMENT + 7 OPTIMIZE LIFE CYCLE WITH BIM

Asset outcomes	City outcomes

To develop an energy positive building with 100% decarbonized energy

Emissions reduction
Minimized embodied carbon
Minimized operating carbon
Maximized use of locally generated clean electricity

To reach a high standard of circularity using underground water to improve heating and cooling efficiency

Environmental improvement
Minimized water usage
Minimized waste
Increased biodiversity

To offer a comfortable and productive environment for occupants, while complying to sanitary regulations

User satisfaction
Health, well-being, and productivity improvements

Systemic value efficiency
Improved efficiency
Improved flexibility
Improved resilience
Improved grid services

Socio-economic improvement
Job creation
Lower energy costs to consumers

To have a resilient building that is interconnected to its digital environment and well defended against cyber risks

Key
outcomes

Financial and non-financial

Energy monitoring and building management systems

- Non-financial: efficient and resilient
- Financial :
  - ✓ Rent increase
  - Revenue increase
  - ✓ OPEX reduction
  - ✓ CAPEX reduction
  - ✓ Asset value increase
  - ✓ Compliance cost reduction
  - Financing cost reduction
  - ✓ Brand value increase

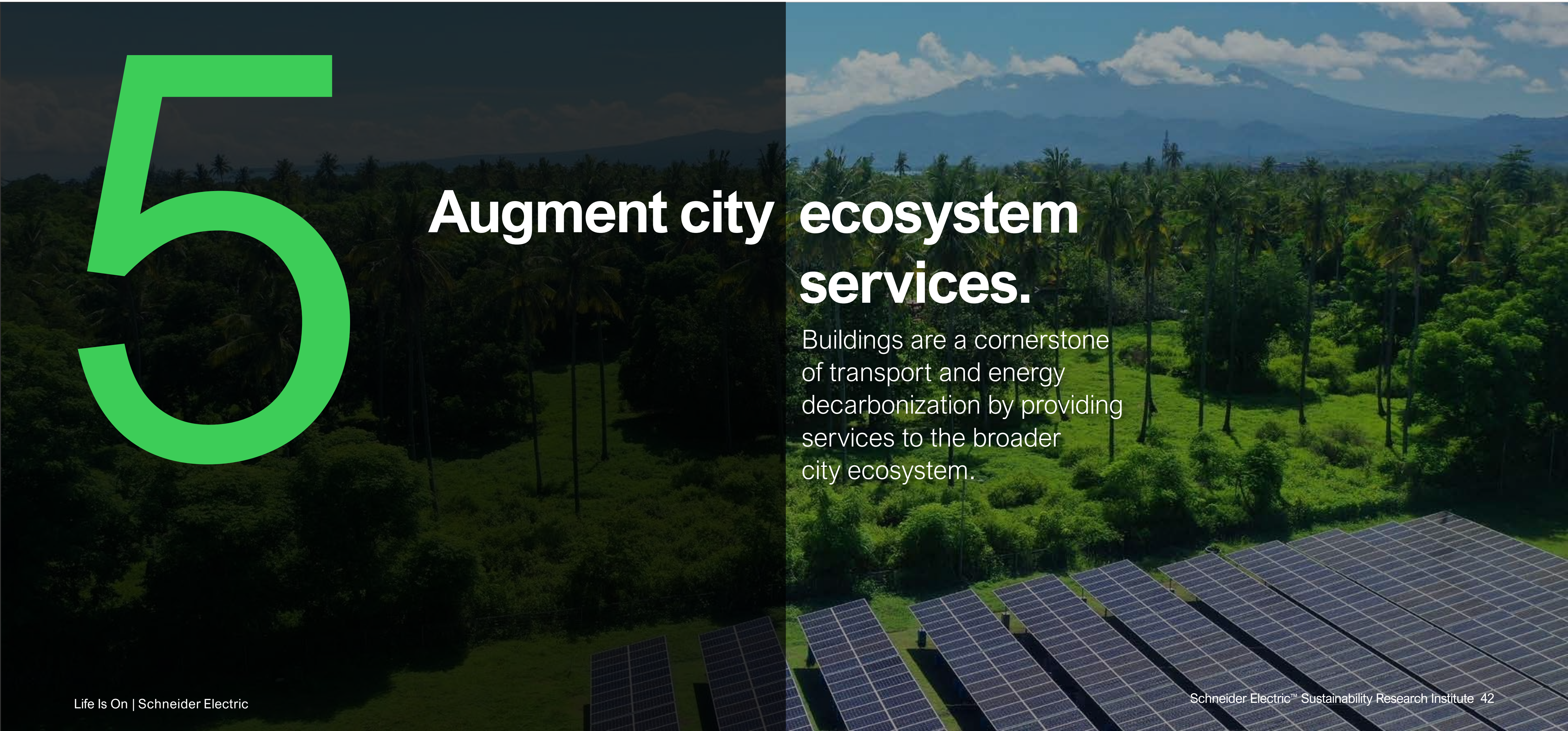
Data-driven maintenance and operation of the buildings and its equipment's increases energy efficiency and reduces operating expenses, by leveraging several thousands data points every minutes

Building resiliency by design: to anticipate remote operations, power reliability, enhanced cybersecurity, increased asset protection and prepare the building's flexibility

Life cycle efficiency through BIM

- Non-financial: Data is managed across the life cycle to limit frictions and allow conscious choices
- Financial:
  - Rent increase
  - Revenue increase
  - ✓ OPEX reduction
  - ✓ CAPEX reduction
  - ✓ Asset value increase
  - ✓ Compliance cost reduction
  - Financing cost reduction
  - ✓ Brand value increase

Energy simulation in design helps to determine the right alchemy between comfort and efficiency and limit the frictions in the build phase.



5 Augment city ecosystem services.

Buildings are a cornerstone of transport and energy decarbonization by providing services to the broader city ecosystem.

8 SUPPORT GRID AND LOCAL COMMUNITIES

9 CONTRIBUTE TO CLEAN MOBILITY

Design to support the grid and local energy communities

Leveraging deployment of on-site distributed energy resources like solar and storage or load controls, grid-connected buildings can act as a key energy resource of the broader energy system. They can support the electrical grid operation by providing congestion relief services, frequency stability services, or local and grid resilience. They can also contribute to local renewable communities and therefore optimize decarbonization at district level.

THE UNFOLDING OF DISTRIBUTED GENERATION is a true game changer for the building stock and the supporting grid infrastructure, with four key outcomes.

A key alternative[12]

Distributed generation can offer a key alternative to expensive (and slow) grid upgrades, helping to fast-forward the electrification of the stock.

The cost question

A key reality of grid infrastructure is that costs are not even across different uses. The cost of low-power distribution infrastructure is generally higher (per kW) to that of high-power lines. Since the bulk of the distributed generation potential lies within individual households, maximizing it there optimizes the necessary investment in infrastructure on low-power infrastructure, reducing overall grid costs for all involved. This would be particularly relevant in rural areas, and notably constitutes a key alternative to natural grid development in new economies.

A new energy producer

In many areas, we are likely to see buildings (or districts) turning into energy centers, i.e., producing more energy than they consume over the course of a day (even after including storage provisions for optimized self-consumption).

As such a transition materializes, the way distribution grids are designed, and their role, will significantly evolve. The grid of the future is likely to resemble more of a platform than the traditional distribution delivery system we have known for decades.

Value for the consumers

More importantly, such provisions also lead to significant savings on energy expenses for consumers. As tipping points are reached, and new business models emerge, this evolution is likely to become inevitable.

80%
of Australian rooftops would be eligible for solar development

30%-60%
of total energy on average is needed for heating and cooling within building premises[2]

12 – SE Sustainability Research Institute – Distributed generation

Design to support the grid and local energy communities

Link to the study from the Schneider Electric™ Sustainability Research Institute

	Key benefits Standard technology – local optimization	Maximum value Local optimization with front-of-the-meter grid/system services
Sustainability	Support electrification for less emissions	Ready for demultiplying electrification and decarbonization across buildings and districts
Resiliency	On site storage of electricity (e.g., electric battery) for assets operations even when issue on the grid	Ready for optimizing off-grid operations
Efficiency	Scheduling electricity consumption (plug loads, white goods, etc.)	Ready for optimizing grid electricity demand through predictive energy needs
People	Lower electricity rates through grid optimization	Ready for sharing energy better and alleviating energy scarcity/poverty across districts

Contribute to clean electricity mobility by installing smart electric vehicle charging

EV cars will spend most of their time parked at home or at work.

Making buildings EV ready with smart charging infrastructure ensures to minimize energy bills. Moreover, it will support EV deployment by reducing impact on the electrical grid.

Decarbonizing road transportation thanks to Electric Vehicles (EVs) is already deeply transforming the mobility industry. This trend will accelerate in the decades to come at rapid pace.

But for this major shift to play out with actual benefits to society, one of the major challenges to be tackled remains that of EV charging.[13]

The inevitable growth of the electric vehicle industry

Electric vehicles (EVs) penetration is accelerating, with no sign of slowdown in the coming years. This represents a fundamental transformation of the automotive industry and the broader mobility ecosystem.

Tapping into the potential services provided by these chargers, smart charging will play a critical role into removing bottlenecks and accelerating adoption.

Yet, extensive analysis of the potential added value of smart charging remains scarce. Besides, most existing policies have so far focused on public charging infrastructure, even though about 90% of the chargers are expected to be installed in households and commercial buildings.

Smart charging in buildings generates tremendous additional savings.

Consumers can save up to 70%, especially when time-of-use tariffs (Energy), demand charge (Power), and self-consumption are included.

EV smart charging is not only a major enabler of the decarbonization of mobility, at cost, but also of that of buildings and global energy systems.

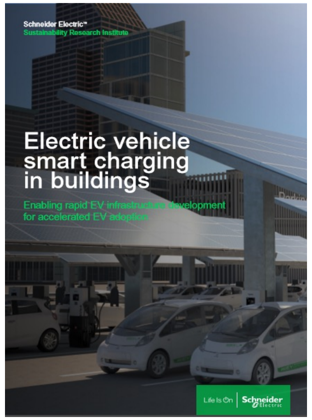
Smart EV charging coupled with flexible sources and loads bring further decarbonization and cost benefits.

13 – SE Sustainability Research Institute – EV in Buildings

8 SUPPORT GRID AND LOCAL COMMUNITIES

9 CONTRIBUTE TO CLEAN MOBILITY

Contribute to clean electricity mobility by installing smart electric vehicle charging



Link to the study from the Schneider Electric™ Sustainability Research Institute

	Key benefits Standard technology – EV equipment (simple charging) at building level	**Maximum value** EV equipment with control system activated and connected to the backbone network of the building with building energy services
Sustainability	Accelerate Electrical Vehicle update	Ready for minimizing carbon at charging
Resiliency		Ready for reducing the peak power needed for charging EVs by up to 30% thanks to load management systems
Efficiency	Provides cost benefits compared to public charging across most cases	Ready for helping reduce transmission and distribution grid costs by focusing on the end user behavior
People	Convenience and costs of charging	Ready for providing additional revenues

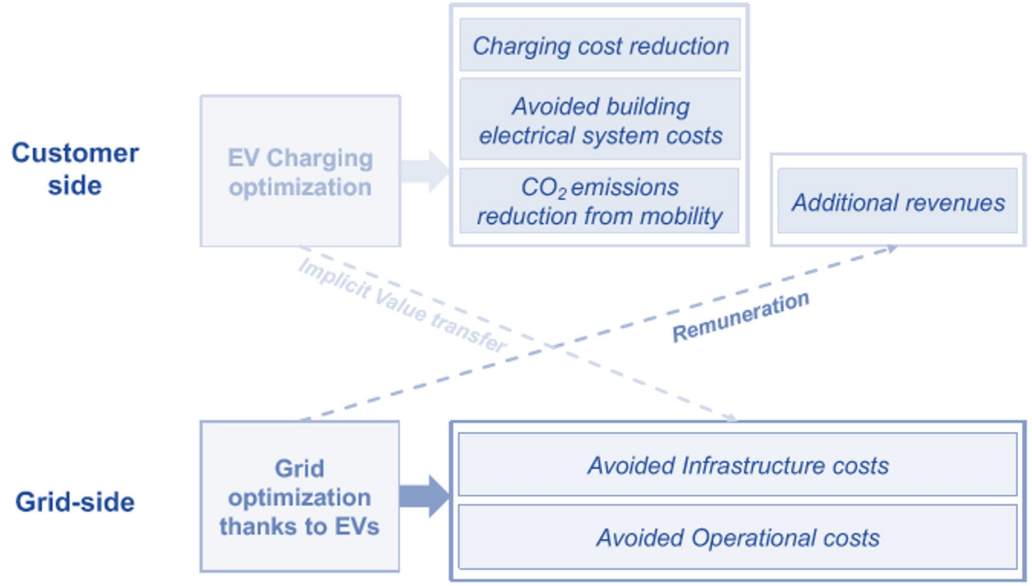
Contribute to clean electricity mobility by installing smart electric vehicle charging.

Smart charging at building level provides significant economic benefits, creates value and optimizes the grid infrastructure.

The end user, broadly defined as the category which incurs costs (charging Capex and charging bill) has the most direct interest in opting for the cheapest charging solution. In residential dwellings, the end-user is usually the house owner. In other cases, the end-user may be the building owner, the tenant or a mobility service provider.

Key actors are the Distributed System Operator (DSO), the Transmission System Operator (TSO), and in a European context, the Balance Responsible Parties (BRP).

Smart charging also reduces whole system costs by lowering infrastructure needs and optimizing operations. Namely, lowering peak power demand would have material impact on expensive and carbon-intensive peak units (often gas and coal-fired power plants). It would also reduce the need for expensive and material-intensive grid upgrades.



Sources of customer and grid benefits from smart charging

Toward augmented buildings

ABC project multi-dwelling

8 SUPPORT GRID AND LOCAL COMMUNITIES + 9 CONTRIBUTE TO CLEAN MOBILITY

100% solar
photovoltaic sails placed on the roof supplies electricity

70%
energy autonomy (self consumed) with a positive annual energy balance

2/3
reduction in water consumption from the city network

Reaching the E4C2 label

- ABC building was labeled the highest level (E4C2) of the dual Energy/Carbon emissions experimental building regulation E+C-.

Sustainable

- 688 photovoltaic panels, 1130 m² of photovoltaic panels are installed on masts on the roof. They provide both solar protection and electricity production.
- The energy produced by the huge photovoltaic sails placed on the roof, is stored thanks to batteries and supplies electricity to the building, housing and heating.

Key investments to make the vision reality

Improved efficiency and resiliency at district level

- The electricity produced by the solar farm, managed by local DSO is stored in batteries to be available in the evening, when residents are present in their homes.
- The approach will continue over the next two years to guide and support residents in reducing their consumption, sorting waste and promoting the co-construction of collective actions.

Engaging the communities

- A digital application allows each inhabitant to monitor in real time on their smartphone, the consumption of their home and the behavior of their building.
- Home control systems to aggregate and provide insights for users in order to make their behaviors sustainability-driven, sufficiency with people sensitive to paying attention to not overconsume.
- Sensors measure the performance of buildings in real time and show them in the application as each apartment has connected smart meters for water and electricity.

Toward augmented buildings

ABC project multi-dwelling

8 SUPPORT GRID AND LOCAL COMMUNITIES + 9 CONTRIBUTE TO CLEAN MOBILITY

Asset outcomes	City outcomes
Emissions reduction *Minimized embodied carbon* *Minimized operating carbon* *Maximized use of locally generated clean electricity*	
Environmental improvement *Minimized water usage* *Minimized waste* *Increased biodiversity*	

User Satisfaction	**Systemic value efficiency**	**Socio-economic improvement**
Health, well-being, and productivity improvements	*Improvde efficiency* *Improved flexibility* *Improved resilience* *Improved grid services*	*Job creation* *Lower energy costs to consumers*

To develop a comprehensive approach to minimize embodied carbon and cut operating carbon

To improve the quality of sorting. composting, associated with the presence of a greenhouse and vegetable gardens, to enable the recovery of bio-waste and green waste

To engage the residents into a virtuous circle, guide and support residents in reducing their consumption, sorting waste and promoting the co-construction of collective actions

To make a success of this operation through commitment and collective ability to adopt new ways of living, managing energy, sorting waste and living together

Key outcomes

Financial and non-financial

Improved efficiency and resiliency at district level

- Non-financial: Heat Pumps, photovoltaic panels A+++ household appliances, low-carbon concrete, weber cork external insulation
- Financial:
  - ✓ Rent increase
  - Revenue increase
  - ✓ OPEX reduction
  - ✓ CAPEX reduction
  - ✓ Asset value increase
  - ✓ Compliance cost reduction
  - Financing cost reduction
  - ✓ Brand value increase

Building resiliency by design: to anticipate remote operations, power reliability, enhanced cybersecurity, increased asset protection and prepare the building's flexibility

Engaging the communities

- Non-financial: Socio-economic improvement and user satisfaction
- Financial:
  - Rent increase
  - Revenue increase
  - ✓ OPEX reduction
  - ✓ CAPEX reduction
  - ✓ Asset value increase
  - ✓ Compliance cost reduction
  - Financing cost reduction
  - ✓ Brand value increase

The ABC concept places the inhabitant at the heart of the structure: pooling of equipment, information and management system, modularity of certain spaces. The involvement of residents plays a central role in the success of this residence. The success of its operation is based on their commitment and their collective ability to adopt new ways of living, managing energy, sorting waste, traveling and living together.

6

Building value for all

Building value for all

For investors and owners

- Financial viability of investments
- Minimize transaction risk
- Reduce risk as green taxonomy compliant
- Increase the value of the property
- Decrease OPEX expenses
- Easiness of recertification
- Easy to make self assessment of building portfolio

For design and build

- Develop innovation
- Regulatory compliance
- Secure required financing
- Limit inefficiencies and frictions
- Manage overruns and risks
- Provide high brand value
- Create its own specificity in the market

For OPEX leaders

- Limit Carbon impact
- Ensure contract profitability
- Operate efficiently
- Comply for certification
- Reduce Opex with green assets
- Increase tenant retention
- Upsell services

For users and dwellers

- Socio-economic improvement
- Job creation
- Lower energy costs to consumers
- User satisfaction
- Health and well-being
- Community productivity
- Next generation ready

Offices Retail Healthcare Education Hotels Residential

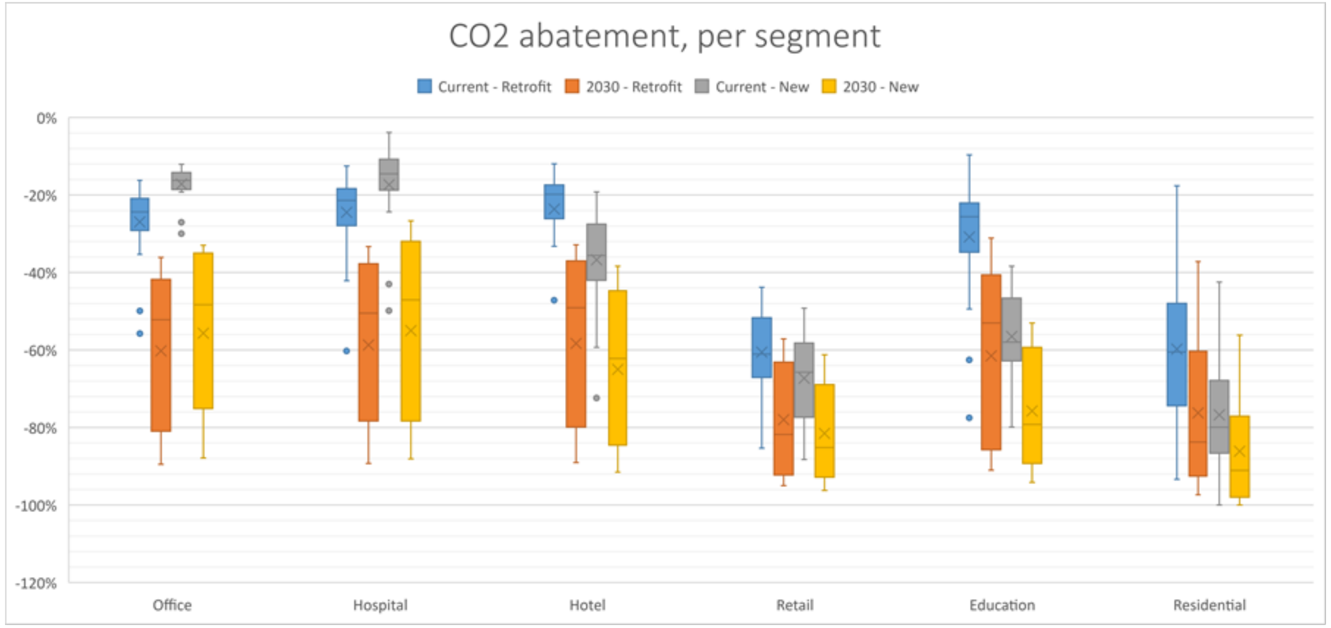
Building value for all

The decarbonization of buildings leads to net savings for building dwellers.

The potential for CO_2 abatement and energy savings is highest in the retail and residential segments.

In the current situation for retrofits (blue bars), service buildings (outside of retail) show lower carbon abatement potential, at around 20-30% average, compared to retail and residential ranging at 60%.
The potential for abatement in new constructions (in current situation, grey bars) is higher in most segments, except in office and hospital buildings. This is related to the differentiated contribution of various solutions to carbon abatement

- New constructions have more efficient envelopes, reducing the impact of active energy efficiency and electrification, compared to retrofits.
- New constructions have however a greater penetration of onsite solar, increasing its impact significantly (but not in highly verticalized buildings, where the potential remains low compared to overall energy demand).
- By 2030 (orange and yellow bars), the performance increases strongly. This is essentially related to the lower carbon intensity of grid-retailed electricity, which improves the carbon abatement potential of heat electrification. The carbon abatement potential then ranges above 60%-80% across the entire stock.



CO_2 abatement per region [11]

11 – Sustainability Research Institute – Net Zero Carbon Buildings - A practical pathway Paccou/Petit (2022)

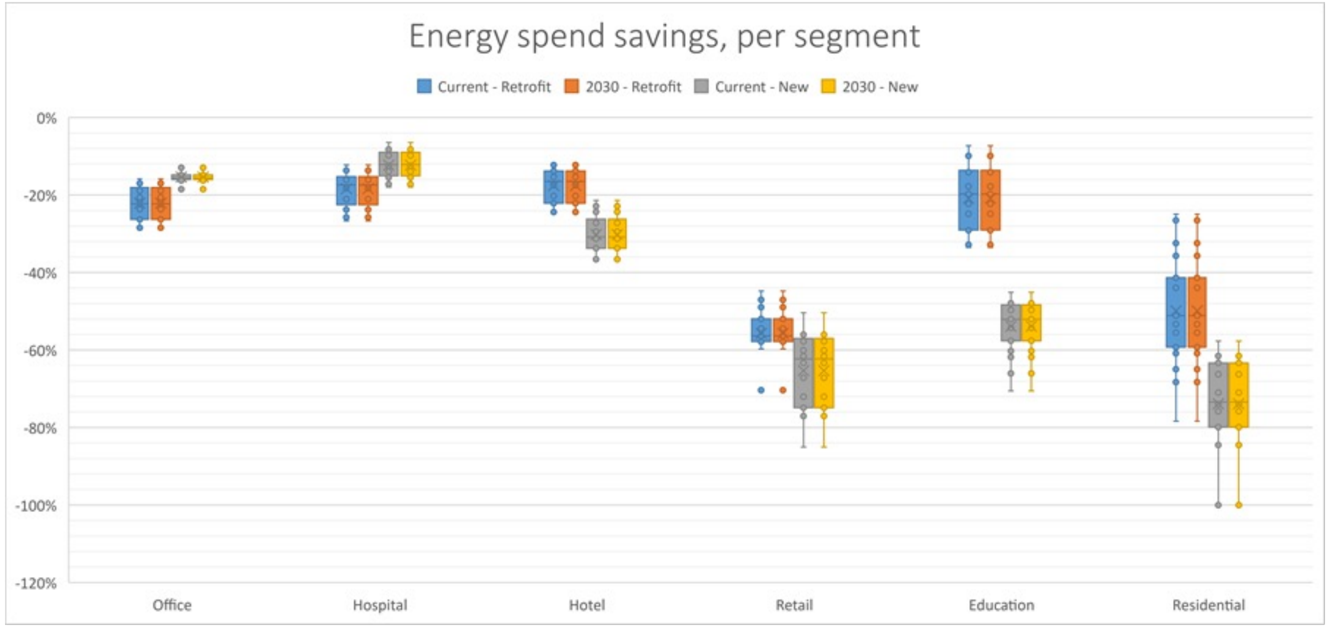
Building value for all

The decarbonization of buildings leads to net savings for building dwellers.

The potential for CO_2 abatement and energy savings is highest in the retail and residential segments.

In terms of energy spend

- Similar patterns emerge as those of carbon abatement potential, with annual savings ranging around 20-30% for service buildings (outside retail), and a greater potential at around 60-70% for retail and residential.



Energy spend savings per segment [11]

11 – Sustainability Research Institute – Net Zero Carbon Buildings - A practical pathway Paccou/Petit (2022)

Building value for all

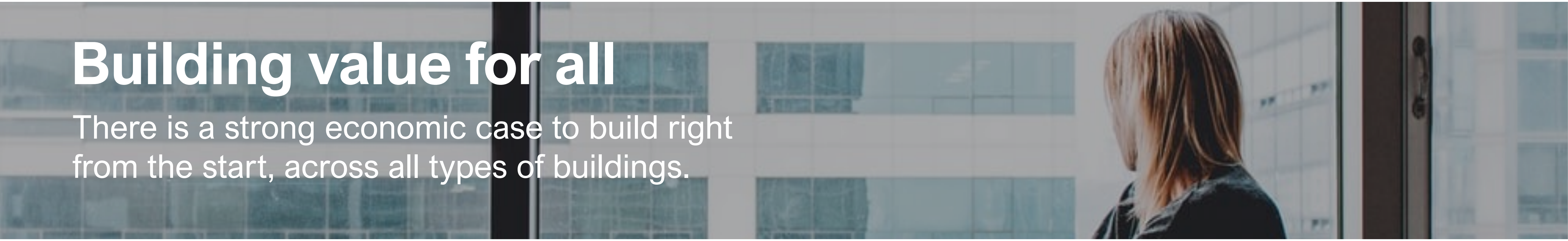
There is a strong economic case for retrofitting service buildings

Retrofits: a strong payback equation in service buildings

- Paybacks are defined by the actual upfront additional cost (from the deployment of active energy efficiency and digital controls, onsite solar and storage, and the differential cost of switching to a heat pump) divided by annual savings, and is expressed in years.
- Service buildings show paybacks typically around or below 10 years on average. In other words, there is a very strong economic rationale to deploying such approach, already.
- Residential buildings (individual households, single family) show much higher paybacks. This is likely where the bulk of the support is required (outside of luxury segments which will likely rely on different drivers of adoption). The full implementation of the buildings of the future profile generates for a typical 150m2 home around 1,000-2,500USD of annual savings, but comes at an extra upfront investment of around 30-40kUSD.
- By 2030, the reduction in capex improves the overall equation. This is particularly visible in the residential segment. This is however not enough (in average) to reach a self-sustaining equation (for the same home, the initial investment reduces to around 20-30kUSD).

Paybacks for retrofits, per segment[11]

11 – Sustainability Research Institute – Net Zero Carbon Buildings - A practical pathway Paccou/Petit (2022)

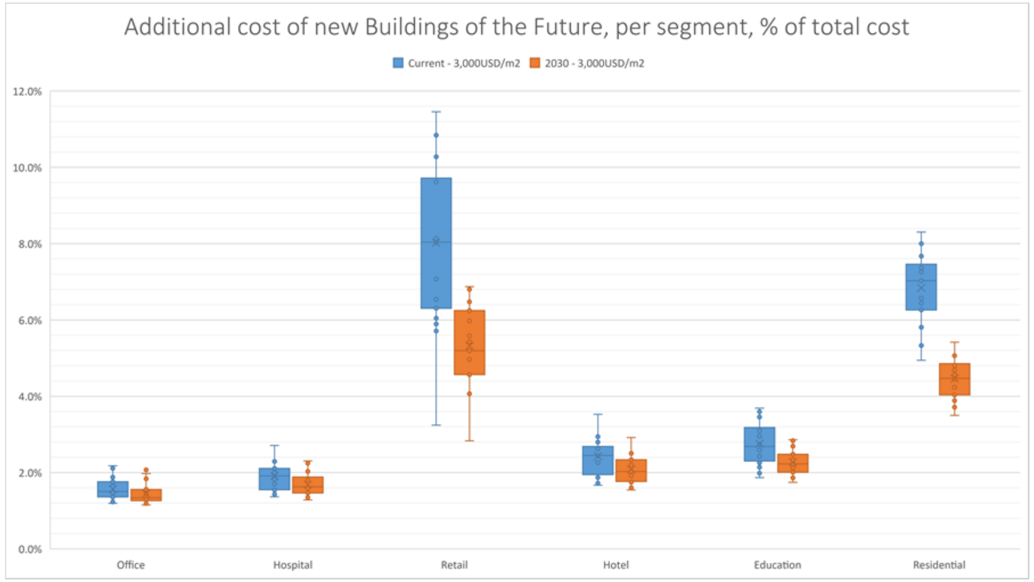


Building value for all

There is a strong economic case to build right from the start, across all types of buildings.

New constructions: low impact on new construction total costs

- For new constructions, we retrieve the total impact of additional upfront investment on the total cost of acquisition and plot here only the data for the scenario of an average suburban area.
- For service buildings (outside retail), the additional upfront cost typically ranges well below 4%, a figure which falls to 2030 toward 2-4%. The impact of building right from the start is thus negligible.
- For retail and residential, the additional upfront cost is also very dependent on the costs of onsite solar and storage, and the impact is higher. It ranges below 10% today but equally falls to 2030 to 5-6%.



Additional cost of New Buildings, per segment

11 – Sustainability Research Institute – Net Zero Carbon Buildings - A practical pathway Paccou/Petit (2022)

A practical pathway to Net-Zero

What should be prioritized:

- The combination of active energy efficiency, heating electrification and onsite solar, enabled by digital controls, thus increases the potential of decarbonization of the building stock, while reducing energy spend from building dwellers.
- Heating electrification is more economically compelling (and less carbon intensive) when supplied with onsite solar, while it drives more demand for self-consumption of onsite solar, maximizing its potential.
- Active energy efficiency enables a more rationale and efficient use of heating while it provides the key resource to properly balance onsite solar and optimize its use.
- At the same time, the actual electrification of heating and increased provisions from onsite solar offer significant flexibility in load management at the building level, what improves the economic equation and offers additional flexibility support to the supply infrastructure.

We thus argue this positive and self-reinforcing combination provides a new avenue for a successful and rapid decarbonization of the building stock, effectively breaking the decarbonization deadlock. In other words, the only way to effectively solve modern problems is to embrace modern solutions and modern approaches. To make this transition successful, barriers to adoption must however be removed. We find that the economic equation is a no-brainer across the service building stock (outside retail), both for retrofits and new builds. Mandates to adoption appear here as an obvious route going forward. The economic equation is however much more complex in residential. The impact on new constructions remains limited overall, particularly on higher class assets, and it is also expected to further improve by 2030.

Supporting policies will play a role to facilitate the transition of lower-class assets until the economics of such solutions reach compelling levels with scale. Retrofitting the existing stock of residential households is however the key issue going forward. While, again, it may prove less of an issue for higher class assets (especially as such provisions will ultimately support asset prices on the mid-term), and could therefore be mandated, the key issue will remain that of lower-class assets, which will require specific support and incentives, as well as continuous innovation, notably around onsite solar and storage implementation. This is also a critical matter of energy justice, as benefits are not naturally evenly distributed, and as lower-income categories of the population are also the ones who suffer the most from high energy bills.

Split incentives (e.g. building owner vs building dweller) are probably one of the largest barriers to adoption. Regulations and mandates can help alleviate some of these issues. The availability of competencies and of the right value chain will also play a fundamental role in bringing costs down to better levels and should therefore be a critical point of focus. In that regard, mandates on new constructions (standards) and targeted and phased retrofits[4] are key enablers to dramatically accelerate the ramp up of the value chain. To conclude, a key takeaway is also that, while there is a clear route toward successful and overall positive decarbonization of the building stock, this transition, likely growing naturally as the economics become more obvious, could also leave aside lower-income categories of the population, who ultimately suffer the most from high energy bills. 50-100 million people in Europe would face what the European Union calls energy poverty.

In the United States, out of the 50 million low-income households, energy burden can be, in some cases, as high as 30% of global budget. Moreover, these categories of population are often renting their household (around 59% of low-income households in the United States), what constitutes a key barrier to adoption[5] (split incentives). While governments have a key role to play into fostering adoption across the building stock (what ultimately makes great economic sense for investors and dwellers alike), a targeted focus on low-income households will remain critical.

[4] See notably a best practice in the Netherlands: Energiesprong (2022), This Dutch construction innovation shows it's possible to quickly retrofit every building. The initiative targets to be "subsidy-free" by as early as 2025.

[5] European Commission (2022), Energy Poverty

US Department of Energy (2022), Low-income community energy solutions

Toward all-electric, all-digital residential

Archetype: Single-family house
2 stories, 150 sqm

Highlights

- In residential, the share of heating is much larger than in commercial sectors.
- As a direct consequence, the electrification of heat and the inherent energy savings from switching to heat pumps provide larger savings.
- Another key driver of optimization is the penetration of distributed generation, on both energy spend and carbon emissions.

Impact

Retrofit

÷ 2-3 Carbon emissions* ($kgCO_2/m^2/y$) & Total energy spend ($USD/m^2/y$)

New build

÷ 4-10 Carbon emissions* ($kgCO_2/m^2/y$) & Total energy spend ($USD/m^2/y$)

All buildings

-50 to -60% Total energy demand ($Kwh/m^2/y$)

*Current levels of grid carbon intensity

Toward all-electric, all-digital offices

Archetype: Office building
10 stories, 45,000 sqm

Highlights

- In offices, the main driver of carbon abatement is the implementation of digital controls, with more limited contribution from distributed generation (limited potential in vertical buildings) and heat electrification.
- It is worth to note, however, that the share of electrification in global carbon abatement is bound to increase over time as grid-electricity carbon intensity drops.
- New offices show lower energy savings compared to their retrofit counterparts, ranging around 20% for both energy spend and carbon intensity, due to the inherent efficiency of envelopes.

Impact

Retrofit

-30% Carbon emissions* $kgCO_2$/m2/y & Total energy spend USD/m2/y

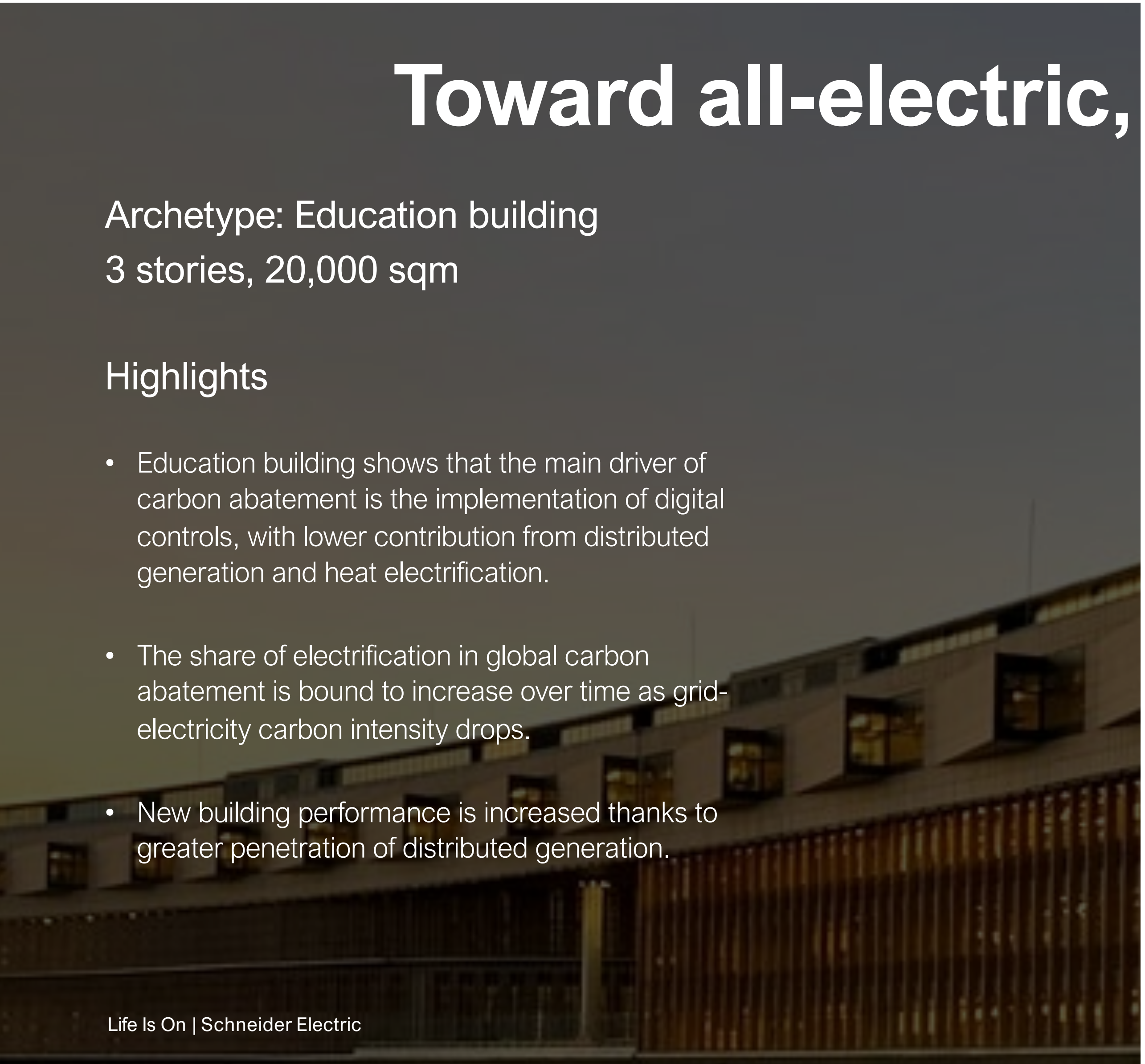
New build

-20% Carbon emissions* $kgCO_2$/m2/y & Total energy spend USD/m2/y

All buildings

-15 to -40% Total energy demand Kwh/m²/y

*Current levels of grid carbon intensity



Toward all-electric, all-digital education

Archetype: Education building

3 stories, 20,000 sqm

Highlights

- Education building shows that the main driver of carbon abatement is the implementation of digital controls, with lower contribution from distributed generation and heat electrification.
- The share of electrification in global carbon abatement is bound to increase over time as grid-electricity carbon intensity drops.
- New building performance is increased thanks to greater penetration of distributed generation.

Impact

Retrofit

-30% Carbon emissions* $kgCO_2$/m2/y & Total energy spend USD/m2/y

New Build

÷ 2 Carbon emissions* $kgCO_2$/m2/y & Total energy spend USD/m2/y

All Buildings

-25 to -45% Total energy demand Kwh/m²/y

*Current levels of grid carbon intensity

Toward all-electric, all-digital retail

Archetype: Retail building

1 story, 2,000 sqm

Highlights

- In the retail sector, the potential of distributed generation is much larger (one large horizontal building with significant suitable rooftop capacity for PV), helping to reduce energy costs and associated carbon emissions.
- On retrofit, retail shows carbon emissions and energy spend reduced by around 2-3 times.
- On new build, performance is enhanced thanks to greater penetration of distributed generation.

Impact

Retrofit

÷ 2-3 Carbon emissions* $kgCO_2$/m2/y & Total energy spend USD/m2/y

New Build

÷ 3-4 Carbon emissions* $kgCO_2$/m2/y & Total energy spend USD/m2/y

All Buildings

-25 to -50% Total energy demand Kwh/m²/y

*Current levels of grid carbon intensity

Toward all-electric, all-digital hospitals

Archetype: Hospital building

6 stories, 20,000 sqm

Highlights

- In hospitals, the main driver of carbon abatement is the implementation of digital controls, with lower contribution from distributed generation and heat electrification.
- The share of electrification in global carbon abatement is bound to increase over time as grid-electricity carbon intensity drops.

Impact

Retrofit

-20-30% Carbon emissions* kgCO$_2$/m2/y & Total energy spend USD/m2/y

New Build

-15-20% Carbon emissions* kgCO$_2$/m2/y & Total energy spend USD/m2/y

All Buildings

-20 to -35% Total energy demand Kwh/m^2/y

*Current levels of grid carbon intensity

Toward all-electric, all-digital hotels

Archetype: Hotel building

4 stories, 4,000 sqm

Highlights

- Hotels show that the main driver of carbon abatement is the implementation of digital controls, with lower contribution from distributed generation and heat electrification.
- Again, the share of electrification in global carbon abatement is bound to increase over time as grid-electricity carbon intensity drops.

Impact

Retrofit

-20-30% Carbon emissions* kgCO_2/m2/y & Total energy spend USD/m2/y

New Build

-30-40% Carbon emissions* kgCO_2/m2/y & Total energy spend USD/m2/y

All Buildings

-30 to -35% Total energy demand Kwh/m^2/y

*Current levels of grid carbon intensity

Proven results for all buildings, retrofit and new build

Start your decarbonization journey anytime.

	Retrofit Kallang Pulse	New build Intencity	Multi-dwelling ABC Project
Decarbonize			
1. Electrify what you can.	X	X	X
2. Make use of distributed power generation and solar.	X	X	X
3. Install active and passive energy efficiency technology.	X	X	X
Digitize			
4. Monitor energy consumption.	X	X	X
5. Design for the connectivity and interoperability of deployed assets.	X	X	
6. Optimize energy use with building management systems.		X	
7. Optimize life cycle efficiency with building information modeling.		X	
Augment			
8. Design to support the grid and local energy communities.			X
9. Contribute to clean mobility by installing smart electric vehicle charging.	X	X	X

The operational check list guides you toward impactful investments.

Decarbonize

1. Electrify what you can. — Cut your emissions and end use, with x3 to x5 more efficiency.
2. Make use of distributed power generation and solar. — Decarbonize your electricity and generate new revenues.
3. Install active and passive energy efficiency technology. — Maximize your Buildings efficiency while optimizing comfort.

Digitize

4. Monitor energy consumption. — Optimize consumption and end-use and limit rebound effect.
5. Design for the connectivity and interoperability of deployed assets. — Implement a cybersecure AI-ready platform for advanced data analytics.
6. Optimize energy use with building management systems. — Transform your Buildings into a platform of digital services.
7. Optimize life cycle efficiency with building information modeling. — Build and operate your Buildings with a 360° view.

Augment

8. Design to support the grid and local energy communities. — Demultiply decarbonization through electrification, at lower cost.
9. Contribute to clean mobility by installing smart electric vehicle charging. — Minimize carbon at charging while providing additional revenues.

7

Schneider Electric™ Sustainability Research Institute

Schneider Electric™

Sustainability Research Institute

Schneider Electric's purpose is to empower all to make the most of our energy and resources, bridging progress and sustainability for all. At Schneider, we call it **Life Is On.** Schneider Electric's mission is to be the digital partner for Sustainability and Efficiency. The company provides energy and automation digital solutions with cutting edge technologies and services in homes, buildings, data centers, infrastructure and industries.

Sustainability is core to our mission and our approach is underpinned by the triple bottom line of people, planet, and prosperity. We actively research and advocate on the future of energy, industry, cities, transportation, globalization, and the digital economy. In 2021, we formally launched the Schneider Electric™ Sustainability Research Institute to engage global society toward accelerating the energy transition, decarbonization, and sustainability in line with the United Nations Sustainable Development Goals.

The Schneider Electric Sustainability Research Institute values collaborative research across all stakeholders. We seek synergies to advance sustainability pathways, policy recommendations, knowledge, and leadership from local to global levels. To date, our body of work includes collaborations with numerous academics, national laboratories, NGOs, and industry coalitions.

In 2021, we published a study on global decarbonization scenarios. These scenarios demonstrate tangible pathways to achieve a global warming trajectory compatible with the Paris climate goals. This report exemplifies our approach: departing from more conventional scenarios that focus on infrastructure developments (supply-side driven transitions), it centers around consumers and businesses transformations (demand-side driven transitions) and explores which pathways are more likely to trigger rapid adoption.

Based on these results, we put forward that there is no needed arbitrage between human progress and climate change mitigation. In fact, we argue, there will be no climate change mitigation if it does not build on human progress.

With insights on how global demand can alter tangible routes toward global sustainability, our 2022 priority areas include key transformations and sustainability pathways for the built environment, several carbon intensive industrial sectors, corresponding infrastructure impacts, and evaluation of social and environmental factors for corporations. For access to our research, please visit our website.

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