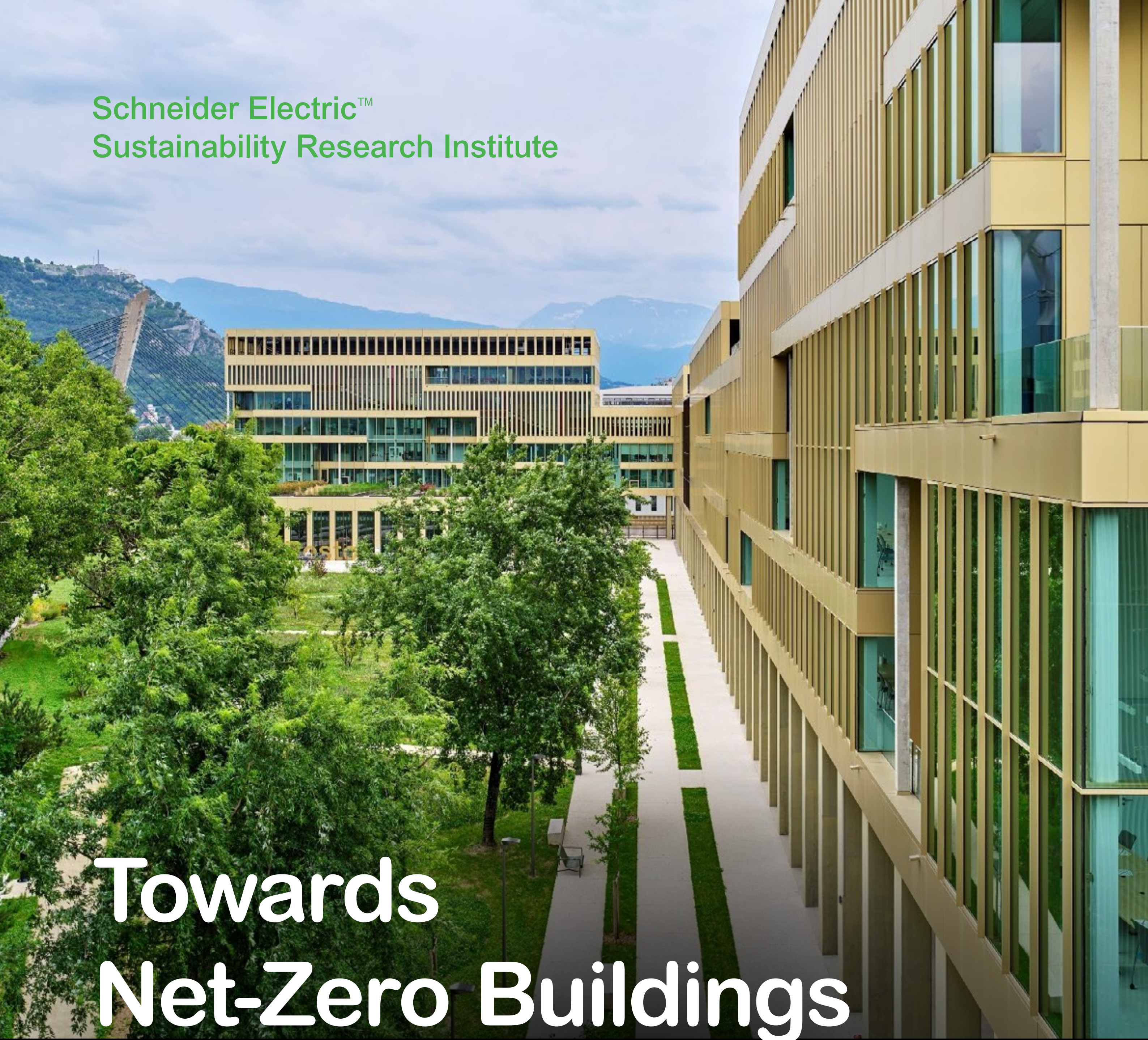

Schneider Electric™
Sustainability Research Institute

Towards Net-Zero Buildings

Exploring the IntenCity case

March 2023

Life Is On | Schneider Electric

Introducing the Schneider Electric™ Sustainability Research Institute

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Global awareness for a more inclusive and climate-positive world is at an all-time high. This includes carbon emissions as well as preventing environmental damage and biodiversity loss. Nation states and corporations are increasingly making climate pledges and including sustainability themes in their governance. Yet, progress is nowhere near where it should be. For global society to achieve these goals, more action and speed is needed.

How can we convert momentum into reality?

By aligning action with United Nations Sustainable Development Goals. By leveraging scientific research and technology. By gaining a better understanding of the future of energy and industry, and of the social, environmental, technological, and geopolitical shifts happening all around us. By reinforcing the legislative and financial drivers that can galvanize more action. And by being clear on what the private and public sectors can do to make all this happen.

The mission of the Schneider Electric™ Sustainability Research Institute is to examine the facts, issues, and possibilities, to analyze local contexts, and to understand what businesses, societies and governments can and should do more of. We aim to make sense of current and future trends that affect the energy, business, and behavioral landscape to anticipate challenges and opportunities. Through this lens, we contribute differentiated and actionable insights.

We build our work on regular exchanges with institutional, academic and research experts, collaborating with them on research projects where relevant. Our findings are publicly available online, and our experts regularly speak at forums to share their insights.

Set up in 2020, our team is part of Schneider Electric, the leader in the digital transformation of energy management and automation, whose purpose is to bridge progress and sustainability for all.

In this study, we have a deep look into the IntenCity building, Schneider Electric's new flagship building located in the Scientific Polygon (Presqu'île) of Grenoble, France.

We share the lessons learned from two years of experimentation, highlighting four key insights for practical actions towards the necessary acceleration of buildings decarbonization.

Gwenaelle Avice-Huet
Chief Strategy and Sustainability Officer, Schneider Electric

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SVP Climate and Energy Transition Research, Head of the Sustainability Research Institute, Schneider Electric

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Executive summary

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Key Insight #1

IntenCity has a cumulated carbon footprint 5 time less than an average European building over a 60-year life cycle.

- In addition to being an efficient building, IntenCity is also a highly decarbonized building, whose implemented solutions allow a virtuous trajectory towards Net-Zero carbon in operation, as the cumulated carbon footprint is 5 time less than an average European building on a 60-year life cycle, with less than **5% of its total cumulated carbon emissions coming from operations**.
- The combined implementation of active energy efficiency (enabled by digital controls), smart electrification of heating, and onsite solar (and storage) offers magnified benefits as the access to near-zero marginal-cost electricity from onsite solar completely changes the paradigm of heat electrification, while **offering to onsite solar the opportunity to maximize self-consumption, as the digital controls are optimizing the use of onsite solar and improve the efficiency in heating use** (through smarter controls).
- We emphasize the **importance of quantifying the in use embodied carbon** (alongside upfront embodied carbon and operational carbon), and to consider this aspect as a key element during the design phase, by having a strong attention to the durability, the reusability, as well as the maintainability and circularity potential of the material and equipment.

Key Insight #2

Building IntenCity right from scratch rather than renovating old sites generates as much CO_2 emissions over a 60-year life cycle.

- In the local context of the Grenoble Metropole urban projects, the combined effects of sites mutualization and energy efficiency efforts are making **IntenCity project as carbon intensive as a multi-facility renovation project**, while additionally creating extra and positive externalities (mobilities, food, waste, transportation, health, and well-being), thanks to efficient design and collaboration across the value chain.
- In a broader perspective, this brings a crucial element in urban choices. Indeed, in certain contexts (considering parameters such as the building age, its physical integrity, its impact capacity in decarbonization of a retrofit…), **the efficiency of design and construction for new buildings is so powerful that they potentially offer as many opportunities for decarbonization as a renovation package.**

Key Insight #3

IntenCity provides 10% of carbon savings over the average Schneider Electric employee carbon footprint per year.

- The combined effects of buildings & low carbon urban projects are impacting positively the decarbonization journey of an employee working on the Grenoble's metropolitan area, while **generating an enhanced range of services at the user level.**
- **The mutualization of five sites in one new build as well as positive effects of integrated services provide up to 10% carbon-savings at user level**. It is also offering new opportunities and synergies in mobility, infrastructures optimization, competences, homogenizing sobriety practices, managing health and well-being at work in a homogeneous manner.

Key Insight #4

Decarbonization does not come with a cost penalty.

- The **Total Cost of Investment of IntenCity**, which is the additional cost of the electrification and digitization technologies to reach Net-Zero operational emissions is less than 2% of the total cost of the building, which basically leads to the fact that it is yet practically possible to decarbonize with accessible costs while creating value at the district and user levels, as well as for the entire value chain.

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IntenCity, at the heart of innovation

A key component of the urban decarbonization.

- IntenCity is Schneider Electric's new flagship building located in the Scientific Polygon (Presqu'île) of Grenoble, France. It is a building of 26,000 m^2, part of a vast project of reorganizing Schneider Electric's facilities in the city of Grenoble which began in 2016. It's objective: to regroup around 5,000 workers spread out over 13 different sites into 4 major buildings.

- The aim is to reduce the group's carbon footprint, by choosing environmental-friendly buildings, reducing inter-site travel, by strengthening cross-department team collaboration as well as with public and private sector organizations in the area such as R&D, Universities, and laboratories. An operating model based on a partnership which is now essential to amplify innovation and development.

A practical use case towards Net-Zero buildings.

- To effectively decarbonize the built environment, we first must understand all sources of carbon emissions over the full life cycle of buildings. By measuring the full carbon footprint of IntenCity, we contribute to the larger movement towards accurate life cycle carbon calculation and reporting for the building industry.

- By looking closely to the whole life cycle carbon of the building, we highlight that the level of decarbonization in its operations is extremely high, showing the path to what the industry could implement to limit the effect of climate change and reach a 1.5°C trajectory.

- Over the two years during which the building was operated, we have confirmed the evident ability of modern solutions to drastically optimize energy use and its ssociated costs. The recent 2022 results are very convincing as the building is now achieving levels of energy efficiency that the building industry has rarely experienced.

The view from the World Building Council for Sustainable Development

Roland Hunziker
Director, Built Environment & Member of the World Building Council for Sustainable Development Extended Leadership Group

I congratulate the Schneider Electric™ Sustainability Research Institute for this excellent piece of analysis on how we can significantly reduce emissions from buildings today! What is particularly important is the transparency and openness of the analysis, based on a full life-cycle approach and exploring the dynamic relationships and tradeoffs of reducing emissions from building operations as well as from the materials and equipment that are needed to achieve that.

There are few key learnings that stand out of this analysis:

- We need to conduct whole life carbon assessments on every building project, whether new build or renovation, to identify the best emission reduction strategies. And we need to do it based on a commonly agreed reporting methodology, such as WBCSD's Building System Carbon Framework used in this case.
- The analysis of where the emissions occur over the full lifetime of buildings is very important: By achieving very high levels of energy efficiency, almost 95% of emissions come from the embodied carbon emissions during construction (ca. 60%), and importantly from embodied carbon during the use phase (ca. 35%). This shows the importance of analyzing all emissions occurring over the full life cycle, and particularly also focusing on the technologies and equipment needed to achieve such high levels of efficiency.
- The case study contains an important comparison of renovating existing buildings vs. building new. There are inevitable trade-offs, and this analysis transparently addresses these and explains how the chosen solution has been prioritized. It is very important to conduct this analysis with a full life cycle approach and at a systemic level to consider the impacts of repurposing or demolishing older buildings.
- The IntenCity project is best-in-class for operational emissions over a 60-year life cycle and it achieves a good performance on up front embodied carbon. It is quite possible that with an even stronger focus on holistic design and material choices, the up-front carbon profile could have been even lower, as the analysis reveals. This shows that a halving of up-front carbon emissions over today's average is absolutely possible if a focus is placed on this issue.
- Lastly, by providing an analysis of carbon emissions reduction at the level of the individual user, this case study provides important insights into strategies to holistically reduce emissions from building use, mobility patterns as well as food, goods and the related waste streams generated by a typical urban work life pattern (here in the case of France, but not untypical for middle class lifestyles around the world).

The Schneider Electric™ Sustainability Research Institute is clearly showing how we can achieve already today the levels of carbon emissions reductions we need to halve total emissions from the built environment by 2030, a global imperative. Because for the built environment, 2030 is today!

Roland Hunziker
Director, Built Environment & Member of the World Building Council for Sustainable Development Extended Leadership Group

The view from the World Green Building Council

Victoria Burrows
Director, Advancing Net Zero,
World Green Building Council

I am a firm believer in the power of proving the possible by demonstration, and the power of industry collaboration.

As businesses and governments globally seek to navigate the dual crises of climate and biodiversity, it is more important than ever to have tangible examples of buildings that break the mould, challenge the business-as-usual approach and demonstrate that with today's technologies, we can deliver better buildings and better lifestyles for those who use them.

Businesses who adapt to these challenges will be best placed to respond to stakeholder expectations in the future. This research shows that opportunities are enhanced by cross-sector collaboration to achieve a common goal.

We are grateful to Schneider Electric™ Sustainability Research Institute for sharing their honest and practical insights from this analysis so that others may be inspired to embark on their own decarbonisation journey and understand the savings opportunities that lie within their real estate assets.

As a signatory to WorldGBC's Net Zero Carbon Buildings Commitment, Schneider Electric has committed to be carbon neutral in operations by 2025 and are engaging with suppliers and wider industry toward a net zero supply chain by 2050. In sharing this research, it demonstrates how future, ambitious targets can already be achieved with the right approach, tools, and by strengthening the business case.

Today, decisions must not be informed only on a financial basis, but by conscious choices that quantify and value carbon impacts, holistic design, social impact, and potential for circular choices that improve the way we build. By interrogating every possible aspect of a new or existing building, energy and resource efficiencies can be optimised. This shift is critical for achieving best-in-class outcomes seen at IntenCity. The building meets most of WorldGBC's 2030 targets today, eight years ahead.

We urgently need to scale these solutions to ensure that this sort of practice, engagement and open industry collaboration is the norm. I implore others to be inspired to follow this leadership.

Because we cannot solve this challenge alone!

Victoria Burrows
Director, Advancing Net Zero, World Green Building Council

2 Exploration #1: Decarbonization at building level

Purpose and methodology

In this first exploration, we perform a Whole Building Life Cycle Assessment (WBLCA) of IntenCity, and we discuss the embodied and operational carbon impacts of the building on a 60-year life cycle.

As it is essential to base our research with a robust and internationally recognized reference, we take, for this study, the World Building Council for Sustainable Development (WBCSD) Carbon Framework referential[(3)] – which is shared and approved by the World Green Building Council (WorldGBC). **This referential is accepted as a high-quality referential of the sector**, defining six layers and six stages for Whole Building Life Cycle Assessment.

We compare the IntenCity carbon emissions for 60 years (named Building #1: IntenCity, Grenoble, FR[(2)]: All-electric, all-digital) with three new building use cases (#2, #3, #4) from the WBCSD and one (Building #5) representing an European average.

- Building #2: All Electric office in London, UK[(3)]: all-electric, high-digitized new built from 2020. LEED certified.
- Building #3: Mixed-use Building in Copenhagen, DK[(3)]: modern-design reversible building with multiple uses.
- Building #4: Business office in London, UK[(3)]: a recent new built from 2016, LEED V4[(1)] certified.
- Building #5: Standard new Building in Europe[(2)]: we define it as the current standard of the European sector.

Key insight #1

IntenCity has a cumulated carbon footprint 5 time less than an average European building on a 60-year life cycle

First, we perform the assessment on the building by itself.

Blue columns (A1-A3, A4-A5, B1-B5, C) represent the embodied carbon, the green column (B6-B7) shows the operational carbon.

Figure 1 – IntenCity – Whole Building Life Carbon Cycle Assessment

Intencity Whole Life Cycle Assessment 60 years metric: $kgCO_2e/m^2$	BUILDING STAGES						
	PRODUCTS	CONSTRUCTION	USE	END OF LIFE	USE	EMISSIONS	BEYOND LIFE
BUILDING LAYERS	A1 – A3	A4 – A5	B1 – B5	C	B6 – B7	All stages	D
Structure Substructure and superstructure	250	10	20	5		285	-63
Skin Façade	140	3	40	1		184	-35
Space Plan Partitions and internal finishes	20	1	20	0		41	-5
Services Building Services, energy and water use	150	2	250	1	45	447	-75
Stuff Fittings, furnishings and equipement (FF&E)	10		20			30	-3
Site emissions Waste, electricity and fuel		40				40	
Building carbon emissions Embodied and operational	**570**	**55**	**350**	**8**	**45**	**1028**	**-180**

IntenCity has an overall carbon impact on a 60-year lifecycle of 1028 $kgCO_2e/m^2$ ~ 1tCO_2e/m^2

- Performance on operational carbon: **45 $kgCO_2e/m^2$**. This can be brought further down to zero by:
  - Integrating the hypothesis of 'Net Zero electricity' from "Gas et Electricité de Grenoble" utility contract[4)].
  - Activating advanced services, flexibility and microgrid at site-level.
- Performance on embodied carbon: **920 $kgCO_2e/m^2$**.
  - We evaluate a part of 'Product' (A1-A3) embodied carbon: 570 $kgCO_2e/m^2$, mainly related to the structure and the services layers, to comply fully to the new French RE2020 regulation.
  - We identify a non-negligeable part of 'In use' (B1-B5) embodied carbon – the carbon needed to maintain the building fully functional over time: 350 $kgCO_2e/m^2$.

IntenCity is reaching a high level of decarbonization, meeting most of the WorldGBC 2030 targets today, 8 years ahead

- The Advancing Net Zero (ANZ) is WorldGBC's global programme working towards total sector decarbonization by 2050.
- The Net Zero Carbon Buildings Commitment (the Commitment) requires that by 2030, new developments and major renovations are built to be highly efficient, powered by renewables, with a maximum reduction in embodied carbon and compensation of all residual upfront emissions.
- In such, IntenCity is on the path to reach the Commitment 2030 targets on operational carbon.
- Moreover, IntenCity is complying with the WorldGBC Whole Life Carbon vision objectives on embodied carbon.

Second, we compared the IntenCity WBLCA with some selected use cases, representative of European benchmarks.

Figure 2 – Five use cases – Whole Building Life Carbon Cycle Assessment

IntenCity vs. 4 European use cases Whole Life Cycle Assessment 60 years metric: $kgCO_2e/m^2$	BUILDING STAGES						
	PRODUCTS	CONSTRUCTION	USE	END OF LIFE	USE	EMISSIONS	BEYOND LIFE
	A1 – A3	A4 – A5	B1 – B5	C	B6 – B7	All stages	D
USE CASE **#1** IntenCity	570	55	350	8	45	**1028**	-180
#2 New Electric office building, London, UK	622	45	352	8	620	1647	-207
#3 New mixed-use building, Copenhagen, DK	840	37	476	33	692	2078	-335
#4 New Office Building, London, UK	504	41	389	6	1512	2452	-227
#5 New Standard European Building	950	50	570	20	3300	4890	-265

IntenCity operational carbon emissions (B6) are 60 times lower than an average European new build building[2]

- Thanks to the combination of green electrification, digitization, electrification at end use and continuous commissioning.*
- This is 7 times lower than a new build electrified building in London[2] (Use Case #2).
- Additionally, IntenCity has reached its own energy efficiency objectives after two years of operations.

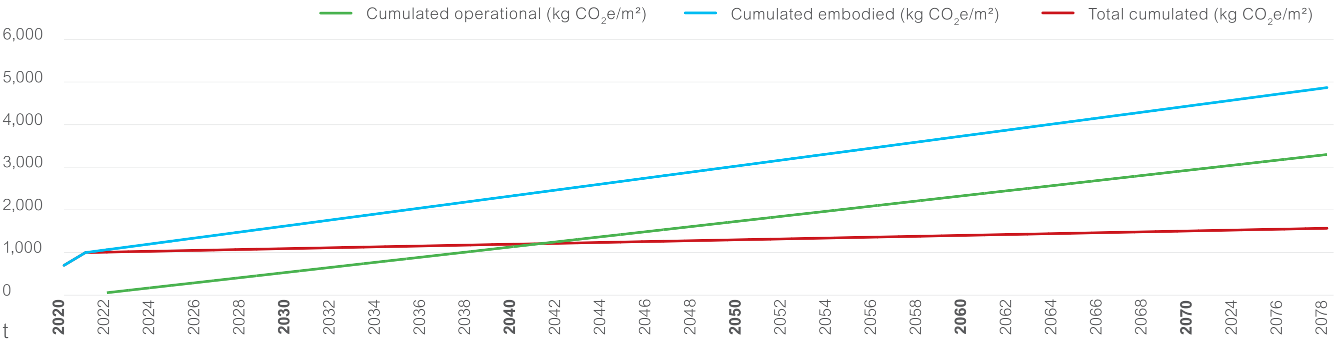
Less than 5% of IntenCity total cumulated carbon emissions come from operations on a 60-year life cycle

- For a new European building built today, the break-even point, which is the point where cumulated operational carbon emissions exceed (or break even with) cumulated embodied carbon emissions, is of the order of 20 to 25 years.
- One decade ago, this break-even point was even lower at around 5 to 10 years.

*The assumption taken for the European use case is an Energy Use Intensity (EUI) of 220 kwh/m²/y with an average carbon intensity for Europe of 0,25.

Average European building, cumulated CO_2 emission, 60 years

Figure 3 – Cumulated carbon emissions of an average standard European new building

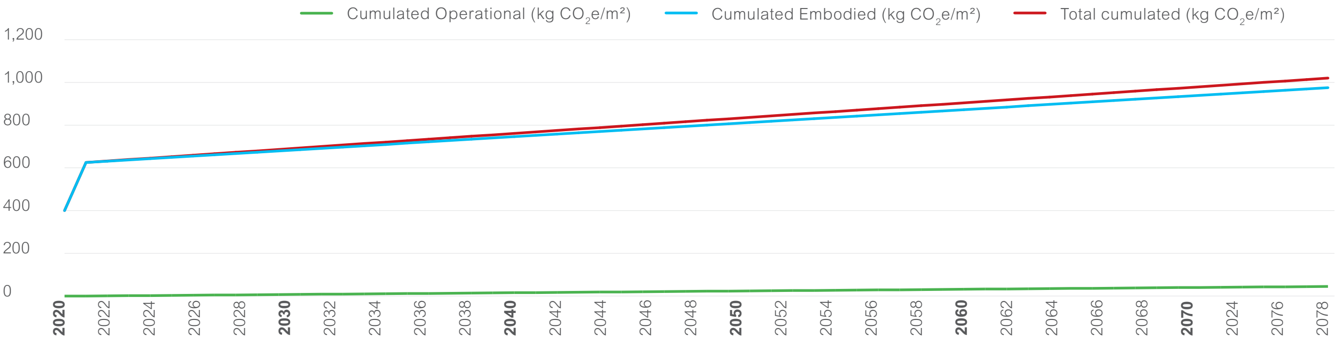


On IntenCity, 95% of the carbon emissions are coming for the embodied carbon

- Hence, **Net-Zero in operations is now technically and practically feasible over a 60 years life-cycle.** To build Net Zero Carbon buildings, the remaining challenges remains that of embodied emissions.
- IntenCity is highly specific as **its cumulated carbon trajectory does not have a break-even point**. It is worth to note that in absolute value, in addition the embodied carbon impact of IntenCity is lower than the European benchmark, which is an important progress.
- Parallelly, the relative value of this embodied carbon versus the operational emissions is shifting the traditional paradigm of 2/3 of emissions coming from operations, as the current level is yet a ratio of embodied/operational 20/1 versus the traditional 2/3.
- IntenCity upfront embodied carbon: 625 kgCO_2e/m² on 60 years is roughly aligned with 2030 recommended targets from WBCSD[(3)].
- It is worth also to note that the A4 – A5 carbon footprint (55 kgCO_2e/m^2) is even higher than the European average, as the site construction was delayed by one year, and thus generated inefficiencies in the construction and consequently an increase of construction embodied carbon (higher carbon contributor was the re-commissioning of the facade).

IntenCity, cumulated CO_2 carbon emissions, 60 years

Figure 4 – Cumulated carbon emissions of IntenCity.



Learnings #1

Massive decarbonization of operations is achievable now

- Taking stock of the potential of modern technologies now available, we find that the combination of 1) Distributed generation + 2) Active Energy Efficiency systems + 3) Electrification at end use (especially Heating), is offering a massive carbon reduction opportunity in the operation phase.

The new paradigm of embodied carbon in use

- Looking at the upfront embodied carbon, **we confirm that a large part of the emissions is linked to the product and construction phase**, with an impact of 250 kgCO_2e/m² for the structure (which represents 25% of the total CO_2 impact), and an impact of 140 kgCO_2e/m² for the skin (which has been a key point of attention during the commissioning phase, and which was supported by detailed Energy Modellings).
- Looking at the in use embodied carbon, we identify an interesting insight on the "services" layer. This layer is mainly composed of the active equipment providing the building services (heating, cooling, electrification, networks…), and corresponds to all the objects and equipment which are interconnected through electrification or digitization. **We highlight that 25% of the total CO_2 emissions on the Whole Life Cycle for 60 years is related to this services layer,** which corresponds to 250 kgCO_2e/m².
- The relative part of active equipment (i.e., HVAC, low current equipment, high current equipment, metering, network connectivity, BMS…) in the cumulated in use embodied carbon for IntenCity. **The percentage of this active equipment is reaching 15% to 18% of the total cumulated in use embodied carbon, while a standard low-electrified, low-digitized building would reach 4% to 7%.**
- This is resulting from the fact that IntenCity has been designed with a high level of active instrumentation, with the aim of maximizing the operational energy efficiency and limits, by hence, verses the operational carbon emissions. **We can estimate that the in use embodied carbon between a traditional low-electrified, low-digitized building versus an all-electric, all-digital building, increases by 2 to 3.** It is thus a key parameter to watch.

Towards smarter embodied carbon?

- Further, we can also identify the notion of "carbon ROI", meaning conscious choices – architectural and technical – of investing in smart embodied carbon, through active equipment versus passive equipment, such as for example the intensification of electrification, renewables, HVAC, and overall active instrumentation, **enabling significant long-term gains on carbon emissions in operations.**
- This confirms the high importance of balancing architectural choices and technical choices through Building Energy Modeling (BEM) and Building Information Modeling (BIM) in the design phase to dimension, control and limit the embodied in use carbon footprint of the active equipment. Therefore, **the BIM in design and construction influence on active equipment dimensioning is becoming strategic to limit the whole life carbon emissions of a building designed for the future.**

- Two typical examples[6] on IntenCity are:
  - #1 the **geothermal energy architecture**, modeled just as needed and adapted to the use of the site.
  - #2 the **1600 IoT Sensors** dispatched in the site enabling high-level of granularity in data collection for precise and effective energy efficiency actions.

'Digital design engineers' and 'Digital energy managers' are central in the building of the future carbon equation

- The subject of embodied carbon has historically been mainly the subject of construction builders and architects, rather than engineers. Since the realization of the potential of electrification and digital technology to massively decarbonize buildings, engineering challenges have intensified.
- Hence, **stepping up the digital competences in design and in operations becomes crucial**:
  - First, **'Digital design engineers' should be capable to master electrical and HVAC configuration softwares**, allowing precise simulation for tailored electrical/digital systems design to fully exploit the potential of energy and digital convergence in buildings. Simultaneously, 6D BIM software enables contractors, consultants, and other users to compare and adjust cost, schedules and carbon emissions in real time when selecting materials and suppliers. Most recent software offers the industry a 6D BIM solution that integrates embodied carbon accounting with cost estimating.
  - Second, **'Digital energy managers' should be trained to operate analytics and advisors at scale,** as one key technology to address whole life carbon is the use of advanced services and analytics, which offer robust predictability in maintenance to avoid inefficiencies impacting the carbon trajectory.

Preparing us for the shift of paradigm

- Thanks to the decarbonization of electrical grids, efficient heating, cooling and insulation systems and other initiatives, we are directionally on the correct path to reduce operational carbon to Net Zero.
- However, it's still way too slow and with a long way to go. In the future, the equation will flip, and embodied carbon will be the dominant polluter of the built world, and thus will require a detailed focus, especially on the hidden challenge of the embodied in use issue. In this new area, the active equipment will have a key responsibility in term of control and optimization of its own in use embodied emissions.

3 Exploration #2: Decarbonization at district level

Purpose and methodology

In this second exploration, we compare 2 scenarios and perform the WBLCA analysis per year, per m² – on a life cycle of 60 years:

- Scenario 1: Retrofitting of 5 existing sites: we call this scenario **"Retrofitting GreenOValley"**.
  - Buildings involved are some of the former Schneider Electric Grenoble sites[(6)]:
    - Building #1: E1 (City center, railway station), built in the 70s.
    - Building #2: PLM (East of Grenoble, Meylan Innovallée), built in the 60s.
    - Building #3: 38ACG (West of Grenoble, Presqu'île), built in the 90s.
    - Building #4: S2 (City center), built in the 70s.
    - Building #5: HP4 (South of Grenoble), built in the 80s.

- Scenario 2: Erecting a new Building: we call this scenario **"Build IntenCity"**.

Note: this scenario is consistent with the one in Exploration #1.

Key insight #2

Building IntenCity right from scratch versus renovating old facilities is on par on a 60-year life emissions cycle

- In the local context of the Grenoble Metropole urban projects, the combined effects of sites mutualization and energy efficiency efforts are making IntenCity project as carbon intensive as a multi-facility renovation project.

Figure 5 – Cumulated carbon emissions for "Retrofitting GreenOValley" and "Build IntenCity" scenarios

Whole Life Cycle Assessment 60 years metric: $kgCO_2e/m^2$	Year	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	Total per site	Total cumulated
Scenario #1 Retrofitting GreenOValley Average of the 5 sites	Embodied Carbon	222	272	322	372	422	472	522	572	622	672	722	772	822	**1032**	**1032**
	Operational Carbon	18	34	50	66	82	98	114	130	146	162	178	194	210		
Building #1: E1 : Built in the 70s	Embodied Carbon	250	305	360	415	470	525	580	635	690	745	800	855	910	**1144**	
	Operational Carbon	18	36	54	72	90	108	126	144	162	180	198	216	234		
Building #2: PLM : Built in the 60s	Embodied Carbon	300	355	410	465	520	575	630	685	740	795	850	905	960	**1224**	
	Operational Carbon	24	44	64	84	104	124	144	164	184	204	224	244	264		
Building #3: 38ACG : Built in the 90s	Embodied Carbon	180	220	260	300	340	380	420	460	500	540	580	620	660	**820**	
	Operational Carbon	16	28	40	52	64	76	88	100	112	124	136	148	160		
Building #4: S2 : Built in the 70s	Embodied Carbon	200	255	310	365	420	475	530	585	640	695	750	805	860	**1070**	
	Operational Carbon	18	34	50	66	82	98	114	130	146	162	178	194	210		
Building #5: HP4 : Built in the 80s	Embodied Carbon	180	225	270	315	360	405	450	495	540	585	630	675	720	**904**	
	Operational Carbon	16	30	44	58	72	86	100	114	128	142	156	170	184		

Whole Life Cycle Assessment 60 years metric: $kgCO_2e/m^2$	Year	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	Total cumulated
Scenario #2: Build IntenCity	Embodied Carbon	623	653	683	713	743	773	803	833	863	893	923	953	983	**1028**
	Operational Carbon	4	7	11	14	18	21	25	28	32	35	39	42	45	

In the local context, and specifically for this project, building right from scratch emits as much as renovating sites

- Scenario 1: "Retrofitting GreenOValley"
  - Whole Life Cycle Carbon: 1032 kgCO_2e/m².
  - Embodied Carbon: 822 kgCO_2e/m², with the following breakdown:
    - Product and construction' (A1 – A5) embodied carbon: 222 kgCO_2e/m².
    - 'In use' (B1 – B5) embodied carbon* 600 kgCO_2e/m².
  - Operational Carbon: 210 kgCO_2e/m².
- Scenario 2: "Build IntenCity"
  - Whole Life Cycle Carbon: 1028 kgCO_2e/m².
  - Embodied Carbon: 983 kgCO_2e/m², with the following breakdown:
    - 'Product and construction' (A1 – A5) embodied carbon: 623 kgCO_2e/m².
    - 'In use' (B1 – B5) embodied carbon: 360 kgCO_2e/m².
  - Operational Carbon: 45 kgCO_2e/m².

We can observe that the total CO_2 emissions varies depending on the building profile.

Buildings dimensions, age, structural integrity, local environment, and key factors impacting the capacity of making an efficient renovation, both by cutting the operational emissions and by limiting the in use embodied carbon ramp up overtime*.

Learnings #2

Both scenarios are on par from a carbon footprint standpoint on a whole life cycle, but for quite different reasons

- First, the **operational carbon on the renovation scenario is 4 times higher than operational carbon of the build scenario,** as:
  - The level of energy efficiency of a renovated building is lower than that of a new building.
  - The design optimization is more constrained in a renovation, which does not allow to maximize technology integration, due to existing site constraints (dimensions, age, structural integrity, local environment…).
  - The dimensioning of renewable production sources, and especially on-site solar, is more constrained.
- Second, we observe that **the total embodied carbon of the new build scenario is higher than the renovation scenario,** which is logic as the quantity of carbon emitted for the product and construction stages are by essence higher than a renovation. However, the dynamics of the in use embodied carbon are different, and show a higher yearly increase for the renovation scenario, which is mainly due to:
  - The fact that in renovation, a part of the project will not be renovated, and thus keeps its intrinsic and initial carbon emission characteristics, which have – by far – a very negative carbon impact, as the material and equipment design and deployed decades ago were not designed with sustainability requirements: for instance unsustainable steel sections, with around 40 years of life-cycle, carries on average 12,100 kgCO_2e/m^3[(7)], or old façades accounting for up to 30%[(7)] of a building's embodied carbon are typical 'hard to renovate' embodied carbon elements.
  - Moreover, if we take a very old facility (for instance PLM site, built in the 60s), the negative impact is even higher, as the older the materials and equipment, the worse the carbon impact.
  - The fact that a renovation might face some constraints in term of modern material selection, and thus neither leverage the very last technology optimizations,
  - Lastly, from a pure Facility Management standpoint, it is basically much more challenging to optimize the maintenance of the equipment of five remote buildings versus an integrated one with consistent and standardized on-site equipment.

Upfront embodied carbon: can we go even further?

- The initial embodied carbon 'investment' taken for the new built is compensated by the lower ramp up of embodied emissions, thanks to low-carbon design and construction and by the **near to zero ramp up of operational emissions, which have been cut off by the investments on decarbonization technologies.**
- While asking ourselves what would have happened if we had optimized even more the design and the construction of IntenCity, we could estimate that a greater focus on low-carbon materials alongside the use of energy modellings - leveraging modern software and analytics – could have helped reduce by 20% initial embodied emissions, with a footprint (A1 – A3) of 450 kgCO_2e/m², thus optimize the new build scenario whole carbon impact by 5% to 10% overall.

No dogmatism on renovation vs. new build.

- As a learning, **we highlighted that any building decision should be based on whole life-cycle analysis,** as the best approach may indeed differ from one situation to another and is highly dependent on the local context.
- This clearly raises the question of the validity of the renovation of old buildings, whose physical integrity considerably limits the impacts of decarbonizing technologies, and for which the performance may never correspond to a reconstruction.
- Moreover, as the design and construction processes continue to improve, as low-carbon materials are becoming increasingly dominant, there may be a growing rationale for new construction (and demolition) which emerges.
- Multi-site mutualization also proves important, and a redesign of urban footprints also presents major opportunities for building decarbonization as well as overall user footprint optimization.

*The modelling takes into account the future decarbonation of the grid.
Methodological considerations are described in the Appendix section – Methodology.

4 Exploration #3: Decarbonization at user level

Purpose and methodology

We evaluate the average carbon footprint per user, beyond building premises, considering the influence of the district, thus facilitating comparisons between projects and in relation to local or national objectives.

The objective is to determine if the combined effects of IntenCity project direct impacts ('hard levers') and pro-active initiatives at site management level ('soft levers') are impacting positively the decarbonization journey of a Schneider Electric employee working on the Grenoble's metropolitan area.

Key hypothesis #1: French annual carbon footprint represents 11.5 tons of CO_2 equivalent[(8)].

- It emerges that 40% of the impacts of the French, or 4.5 tCO_2e/year, are determined directly at the district scale, representing the user-carbon spend in all buildings, such as offices, schools, stores, restaurants, hospitals, etc.
- We have considered that the Schneider Electric employee at IntenCity (the user) is following this national reference.

Key hypothesis #2: IntenCity impact area is around 2.3 tons of CO_2 (20% of the total user carbon footprint)[(8)].

- We design our model on IntenCity specifically, by eliminating user carbon footprints from districts on which Schneider Electric does not have direct user-impact during a working day, as IntenCity is primarily the working office of the employees.
- We integrate the effect of home office to precisely evaluate the effective user physical presence on site.

Key hypothesis #3: The carbon savings at user level are generated by a combination of hard and soft levers[(9)].

- Providing technical solutions (hard levers) to decarbonize at user level is a first action, which needs to be completed with ad-hoc policies (mobility, waste, goods, transports) on soft levers.
- Engaging the user as a central stakeholder of decarbonization is a shift of paradigm, as the user is incentivized or constrained to adapt his behaviors to the climate deviation, what addresses his values, cultures, and habits.
- Consequently, for each hard lever of the model, we identify additional soft levers that help further drive down reductions, in relation as well to the local ecosystem.

Figure 6 – Average French user carbon footprint breakdown
Metric: tCO_2e/cap/y

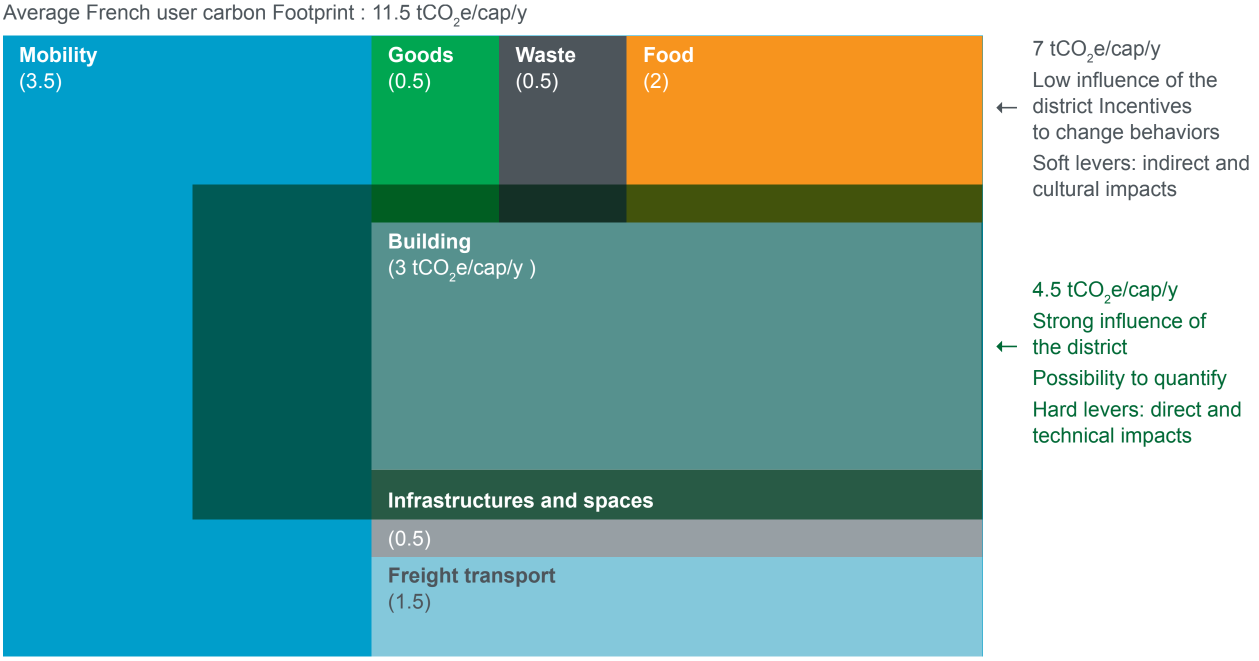


Figure 7 – IntenCity carbon impacts on the user carbon footprint versus previous sites

Intencity – Decarbonization at user level in kg of CO_2 per capita per year ($kgCO_2e/cap/y$)				**Schneider Electric as a building and urban developer** Hard levers (direct & technical) of user decarbonization					
Scope of user emissions		User average user carbon footprint **Total** ($kgCO_2e/cap/y$)	User of Schneider Electric site **District scope (baseline)** ($kgCO_2e/cap/y$)	Construction	Operations and End-Uses	District externalities	**Schneider Electric as an user** Soft levers of user decarbonization	**Estimated Carbon savings in operations IntenCity vs. previous old site** ($kgCO_2e/cap/y$)	**Calculation main factors** (key parameters)
Mobility	Long distance	**500**	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Buillding-related mobility – Personal	**2,000**							
	Buillding-related mobility – Pro	**1,000**	1,000		Electrical vehicle infrastructures	Intersites mobilities	Mobility policy: contribution to modal shift infrastructure, carpooling, home-office, electric and soft mobility, carsharing, participation in public transportation passes	-500	Intersites mobility reduction : 250 $kgCO_2e/cap/y$ EV and soft mobilities: 250 $kgCO_2e/cap/y$
Buildings	All building uses (Healthcare, Retail, Restaurants, Offices, Education…)	**3,000**	625	Site mutualization Net-Zero Building Optimized user-built area Solar panels by design	Energy efficiency (heating, lighting, spaces) Renewable energy Electrification at end use	Green Grid energy contract EcoWatt plan (HVAC cut if red alert) Site mutualization and integration	Sufficiency plans at site level: instructions for users for lighting and heat management, digital sobriety, limitation of stair usages… Modern Home Office policy	-616	Operational carbon IntenCity = 1,4% op. carbon old site Integration of Home Office (-30% on site)
	At home – Residential		N/A	N/A	N/A	N/A	N/A	N/A	N/A
Others	Waste	**500**	100		High level of waste management standard (LEED)	Integration of Grenoble Metropole Waste Management plan	Sharing of goods, responsible purchasing, waste management, enhanced waste sorting, repair workshop	-30	30% of waste management improvement vs. old sites
	Food	**2,000**	400	–	Smoke optimization system according to the menu	–	EcoWatt Orange and Red: Suppression of grills and fryers	-40	10% of optimization vs. old sites
	Goods	**500**	100	–	Limitation of individual comfort goods (coffee makers, fridge, radiators)	–	Disconnecting chargers, reducing the number of screens, switching to PC and mobile batteries	-20	20% of optimization vs. old sitest
	Infrastructure & spaces	**500**	100	–	Energy flexilbility and microgrid (not operational)	–	To be investigated	N/A	N/A
	Freight transport	**1,500**	N/A	N/A	N/A	N/A	N/A	N/A	N/A
TOTAL		**11,500**	**2,325**					**-1,206**	

Key insight #3

IntenCity provides 10% of carbon savings over the average Schneider Electric employee carbon footprint per year

The combined effects of buildings and low carbon urban projects are impacting positively the decarbonization journey of an employee working on the Grenoble's metropolitan area.

Let's have a look at the carbon savings in operations per user (in kgCO_2e/cap/y), due to the construction of IntenCity vs. a former site.

- The blue column is covering the scope addressable directly (through 'hard' and 'soft' levers) by Schneider Electric on its own site. We took it as the baseline of measurement: the values indicated are the estimated values of a Schneider Electric user working on a former Schneider Electric site, before IntenCity construction.
- The red column is the estimated carbon savings generated by the construction of IntenCity, after the transfer of the employees from previous old sites to the new building. Hence, it allows us to dimension, per scope of user emissions, the direct and technical impacts of IntenCity ('hard levers'), plus the 'soft' initiatives taken by the site management.

IntenCity has a positive impact at the user footprint level

- Modeling allows us to assess that a Schneider Electric employee (the user) working on IntenCity in 2022, versus an employee working at the former Schneider Electric sites, optimizes its own average annual carbon footprint:
  - by about 50% of carbon savings in operations at IntenCity level, corresponding to the effective scope of a user at work.
  - by about 25% of carbon savings in operations at the district's levels, corresponding to the scope of the user in districts.
  - **by about 10% of carbon savings in operations at the total user carbon footprint level**.

Learnings #3

We can highlight 3 main levers to decarbonize user footprint

- **Lever 1: Working in the IntenCity building vs. a former site: providing a net-carbon saving of 616 kgCO_2e/cap/y.**
  - A bundle of hard and soft actions, such as: low-carbon building, optimized user-built area, local renewable energy production, fatal energy recovery, granular energy monitoring, site mutualization, user sobriety behaviors.
  - **The highest impact comes from IntenCity energy efficiency level versus previous sites, as IntenCity is emitting 60 times less carbon in operations per year versus a previous site, which brings a considerable positive impact at the user level,** considering the important concentration of Schneider Electric employees in the 1500-users capacity of IntenCity.
  - Worth to note also that integration of workplace policies, such as home office for instance, help to limit actual consumption of IntenCity building as specific zones are set in "energy rest" mode, thereby limiting the carbon impact per user.
  - Overall, **these savings address up to 5% of the total user carbon footprint per year.**

- **Lever 2: Clean mobility is bringing an additional amount of carbon savings of 500 kgCO_2e/cap/y, thanks to:**
  - A massive optimization of the intersites mobility, as half of those are eliminated with one integrated site.
  - A pro-active policy for Electrical Vehicles, soft mobilities, carsharing, public transportation, on which Schneider Electric is supporting the Metropole.
  - Overall, **these savings address up to 4% of the total user carbon footprint per year.**

- **Lever 3: Waste, food, and goods are the three remaining carbon savings contributors, where soft levers are predominant with a combined carbon saving in operation of 90kgCO_2e/cap/y.**

- Best practices are already in place at country and site level to limit the carbon emissions on these dimensions.
  - The **EcoWatt program with the suppression of grills and fryers in case of orange or red alert over the French electrical grid,** responsible food initiatives (local circuits, vegetarian meals…).
  - **Incentives toward numeric sufficiency** (disconnecting chargers, reducing the number of screens, switching PV and mobile batteries…).
- More generally, we see that working on 'soft' levers can have a direct and immediate impact of the user decarbonization, without heavy investments, but with a high sensitivity to the local culture and its specific capacity to adapt to change.

Enhanced services for the user

- Positive externalities are much more important in the scenario 'new build', as combining mutualization of sites and modern efficiency technologies generate more extra-benefits at user level, through efficient mobilities (by limiting intersites mobility, by enabling one integrated mobility policy), food and restauration, waste management, laboratories mutualization, resources and competences interactivity, site data management and focused advanced services, advanced comfort, and resilience.
- Moreover, IntenCity new build is offering easier access for the user to the surrounding environment, becoming a positive and transformative brick of the district, boosting healthier lifestyles, whereas five renovations would have shown more limited potential.
- Overall, investing on integrated services in one place offers the site management the possibility to enrich its level of user services overtime, by providing adapted services, facilitating a smart combination of well-being at work and productivity for the company.

5 Exploration #4: Decarbonizing is more affordable than we think

Purpose and methodology

- In July 2022, the Schneider Electric™ Sustainability Research Institute[10] published a quantitative study exploring the impacts of decarbonization investments on carbon emissions, energy efficiency and financial value. While traditional existing studies focus on one element of the transition (e.g., energy efficiency, electrification, onsite solar, etc.), we have in this study combined the performance of various decarbonization options together, looking for the intrinsic benefits associated to their combination.
- Intencity is a good case study to confirm results from simulations.

Key insight #4

The total cost of investment (TCI) of technology to reach Net-Zero operational emissions is around 2% of the cost of the building

- We focus on the implementation of active energy efficiency (enabled by digital controls), the smart electrification of heating, and the implementation of onsite solar (and storage). These three bricks are already implemented on IntenCity.

- Consequently, we apply our general model to the specific case on IntenCity, exploiting real datas from two years of operations, and explore the results and compare them to our model[a]

- We took in consideration the following elements in the Total Cost of Investment evaluation:
  - **Category A of BMS with Energy Monitoring model and its instrumentation** (Power Meters, IoT, Sensors, Valves and Actuators),
  - **2485 Solar Systems of 385W each** (including panels, inverters, and acquisition boxes),
  - **Heat Pumps**, without piping.

- **The TCI of IntenCity building is 1,7%**, while the general modelling shows a **TCI profile for this archetype between 1,5% and 2,2%.**

- Worth to also note that:
  - IntenCity still overperforms the study archetype on electricity demand, energy spend and CO_2 emissions.
  - The building is basically a best-in-class in design versus the general model, typically with higher level of insulation.
  - On the TCI side, the small extra cost of IntenCity is due to premium quality of the equipment in place, especially on the heat electrification (which includes geothermal, fatal energy recovery) and thermal storage.

- In the current context of the fossil fuel crisis in Europe, **it is worth to note that these coordinated investments in electrification and digitization will be quickly amortized and allow both to limit energy consumption**, but also to massively decarbonize while allowing the creation of long-term value through full connectivity and access to more than 60,000 granular data points from the site.

(a) The office building archetype used in the Schneider Electric model is 45,000m² – 10 floors building, hence not directly comparable.

6 Perspectives for the building market

Wrap up of IntenCity lessons learned

The blueprint for net-zero building exists now

- IntenCity is a **practical example of real decarbonization in operations**, its alignment with the World Economic Forum 'Building Value Framework'[11] helps to clarify what has been practically implemented and offers potential sharing to a broad audience. The results are tangible: **IntenCity has a cumulated carbon footprint 5 time less than an average European building on a 60-year life cycle, thanks to the combination of on-site solar distributed generation, active energy efficiency and electrification at end use.**

- Worth to note that **Design is crucial**, the collaboration throughout the project life cycle, using digital tools (such as BIM Energy modelling) to model the building's behaviors is essential. The architectural and engineering choices, as well as the methods of collaboration between technical domains, during the design and construction phases are indicative of the quality of the value created and transferred throughout the project. Practically, **electrical, and digital engineering is crucial, to avoid oversizing or undersizing active equipment in the building. In the Buildings of the Future, Building Energy Modeling and Building Information Modeling are central to balance conscious choices in design phase to effectively decarbonize operations.** Moreover, modern design is further enhanced by advanced services and analytics in operation, preventing from deviations.

- Being **impactful is the result of clearly determined investments for real decarbonation**. This requires a conscious assessment of equipment needs to maximize long-term impact, making the most of their potential through software and services.

Continuous commissioning is the new form of continuous design

- It is worth to know that **all the technical domains (14 in total) of IntenCity have been commissioned**. This is basically seldom happening in the building industry. This comprehensive commissioning has allowed to transform the design objectives into operational objectives, supported by the IntenCity performance contract with the Energy Manager, and has provided a clear and factual energy efficiency trajectory to the site management.

- **Data Management is central**. An energy model has been created that integrates about 60.000 variables. It can simulate, for example, all the thermal and performance characteristics of the building, the course of the sun, solar masks, and solar gains. Local weather data were used to feed the model. **This Building Energy Model has been updated based on key project milestones to verify that the design and execution of the work is following objectives.**

- This requires new competences, **moving from traditional 'facility' management to 'digital energy' management in operations**.

Renovation versus New build

- A key finding of the IntenCity use case is also that the full life-cycle emissions of the new building construction were equal, if not less, than the renovation of existing buildings.

- This conclusion is definitely not applicable in every case, **it clearly raises the question of the validity of the renovation of particularly old buildings**, whose physical integrity considerably limits the impacts of decarbonizing technologies, and for which the performance may never correspond to a reconstruction. There should therefore be no dogmatism on the subject.

- Moreover, as the design and construction processes continue to improve, as low-carbon materials are becoming increasingly dominant, there may be a growing rationale for new construction (and demolition) which emerges. Multi-site mutualization also proves important, and a redesign of urban footprints also presents **opportunities for building decarbonization as well as overall user footprint optimization**.

7 Appendixes

Terminology

Carbon dioxide equivalent emissions (CO_2e) represents an equal GHG emissions quantum. It is commonly use since it is the major component of GHG emissions (burning of fossil fuels, waste, biological materials, emissions from chemical reactions).

Embodied carbon refers to a quantity of CO_2e associated with the materials used to construct and maintain the building throughout its lifespan (material extraction, manufacture, construction, demolition, and end of life).

Operational carbon refers to the emissions associated with the heating, cooling, and energy use of the building.

Whole Building Life Cycle Assessment (WBLCA) is a method to quantify both embodied and operational carbon emissions of an asset over its life cycle.

BEM – Building Energy Modeling

BIM – Building Information Modeling

CO_2e – Carbon dioxide equivalent

EPD – Environmental Product Declaration

EUI – Energy use intensity

HVAC – Heating Ventilation and Air Conditioning

Kg – Kilogramw

kWh – Kilowatt hour

WBLCA – Whole Building Life cycle carbon assessment

m^2 – Meters squared

t – Ton

WorldGBC – World Business Council for Sustainable

WGBC – World Green Building Council

/cap – per capita

/y – per year

Methodology

WBLCA methodology
- Reference methodology is based on the WBCSD Building System Carbon Framework, (2020)[3]

WBLCA general assumptions

General
- Civil Engineering domains sources from an external audit performed during the LEED Design & Construction certification project.
- Technical Engineering lots (electrical, plumbing, heat…) are sourced from Schneider Electric internal datas.

Transportation scenarios
- 50km – Locally manufactured
- 300km – Nationally manufactured
- 1,500km – European manufactured

Element lifespan
- Structural frame and foundations – 60 years
- Roof coverings – 30 years
- Partitions – 30 years
- Finishes – 30/20/10 years
- Façade elements – 35/30 years
- FF&E – 10 years
- Services – 20 years

Building life
- 60 years

Carbon factors data sources
- Environmental Product Declarations (EPD) from manufacturers

Building elements categories
- Substructure
- Superstructure: Frame + Upper floors + Roofs + Stairs and ramps
- Skin: External walls + Windows and external doors
- Internal walls and partitions: Internal walls and partitions + Internal doors
- Internal finishes: Wall finishes + Floor finishes + Ceiling finishes
- FF&E: Fittings, furnishings, and equipment
- Building services

Assumptions on the renovation scenario
- Assumption of embodied in use average for Commercial Building = 6 kgCO_2e/m^2/y, without Construction (A4 – A5) + End of life (C)
- Integrating Construction (A4 – A5) + End of life (C) brings an additional carbon weight of +15% vs the embodied in use across the life cycle.
- Integrating an expansion coefficient of 15% to due to Facility Management inefficiencies due to the multi-site management of 5 sites, with different properties.
- Hence, for the renovation scenario, hypothesis taken for the in use embodied carbon are:
  - 8 kgCO_2e/m^2/y for the traditional scenarios (classical renovation of 80s & 90s buildings)
  - 11 kgCO_2e/m^2/y for the extreme scenarios (buildings from 60s & 70s)

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