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Amrit Kaal: Path to Developed and Decarbonized India

Addendum: a focus on 2047 Net Zero

June 2023

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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.

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By aligning action with the 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 *"Amrit Kaal: Path to Developed and Decarbonized India"*, we introduced two scenarios for India's evolution of the energy system to 2070. A key part of the report is a unique and in-depth exploration of critical transformations in energy services (or practices) and consumption patterns, driven by both technological innovations rapidly spreading across a fast-developing Indian economy as well as ambitious policymaking. The first scenario, *2070 Net Zero*, built on government commitments of reaching energy independence by 2047 and net-zero emissions by 2070. The second scenario, *2047 Net Zero*, explored to what extent both targets could actually be reached by as early as 2047. In this addendum, we deep dive further on the latter, and explore associated policymaking implications.

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Introduction

This note is an addendum to the report *"Amrit Kaal: Path to Developed and Decarbonized India"*, released in January 2023[1].

A key originality of this report was an in-depth exploration of transformations in consumption patterns, driven by innovation and new technologies now available at scale, and their impact on future projections of India's energy system.

A key conclusion of this analysis was that of an emerging development paradigm which, instead of building on technologies from the 20th century, relied on modern technologies now available at scale, suggesting a rapid development path fundamentally different from what is often anticipated. The outcome would be more competitive development, but also greater energy independence and a more sustainable energy system. In other words, the way that the Indian economy would develop in the coming decades would not resemble that of mature economies, which face the different challenge of decommissioning their mature infrastructure and moving away from unsustainable consumption patterns.

We developed two scenarios to study such transformation. The first scenario, *2070 Net Zero*, followed the government ambition to reach energy independence by mid-century and a net-zero economy by 2070. In *2047 Net Zero*, we explored the feasibility of reaching both goals by mid-century.

In this note, we focus on *2047 Net Zero*, and dwell further on the findings from this scenario, and look as well at what it would take to enable such a scenario to materialize. The first chapter details key findings, while the second chapter compares this scenario to others in the literature, and the third chapter explores possible policymaking suggestions that could follow.

(1) Schneider Electric, 2023

1 What does *2047 Net Zero* mean for India's energy system?

Key drivers of net-zero

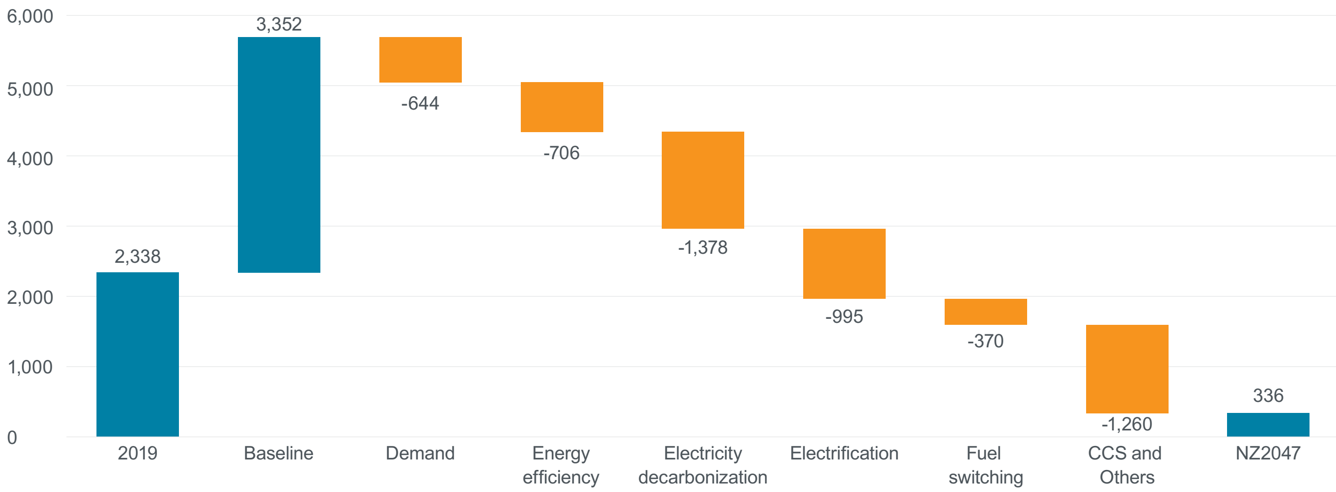
We explore first the evolution of emissions per key driver for the *2047 Net Zero* scenario.

- The baseline represents a continuation of current trends, a hypothetical scenario where economic activity would drive an emissions increase, without any change to the current energy system mix.
- We look at the evolution of emissions to 2047, and do not project them further here(2).
- We identify six key drivers of emission reductions(3):
  - Demand evolutions: this includes transformations from economic activity stemming from technological improvements and their impact on business models. This essentially revolves around circularity measures such as construction techniques evolution, new mobility patterns driven by new urban designs or the recourse to public transportation, and the rise of a sharing economy. This also includes rebound effects, when not explicitly excluded.
  - Energy efficiency: this includes all measures across sectors that contribute to improve the energy intensity of operations.
  - Decarbonization of electricity: this corresponds to the decarbonization of power generation, for all existing demand and all demand increases driven by activity (i.e., economic growth).
  - Electrification: this concerns the switch from traditional energies toward electrification. It is assumed here that this additional electricity demand is zero-carbon (as part of the overall decarbonization of the power system).
  - Fuel switching: in addition to electrification, all alternative fuel switches are here included (e.g., new fuels for aviation and maritime transport).
  - CCS and Others: this includes additional measures (notably on fugitive emissions, other energy transformations and process emission related changes as well as the deployment of Carbon Capture and Storage (CCS)).

India's emissions drop from 2,300MtCO_2/y today to 336MtCO_2/y by 2047, the rest being compensated by negative emission technologies that are assumed to ramp up from 2040 onward(4).

- About 30% comes from the decarbonization of the current power system with zero-carbon solutions.
- 25% comes from efforts to maximize the efficiency of the economy, through demand optimization (circularity, new mobility patterns, construction technique improvements) and energy efficiency (particularly on new constructions).
- 20% comes from electrification and other fuels switching (e.g., hydrogen, biogas, etc.).
- The remaining 25% includes efforts on fugitive emissions, other energy transformation sectors, and the deployment of CCS (including on power generation).

Figure 1 – India Waterfall, *2047 Net Zero* (MtCO_2/y)



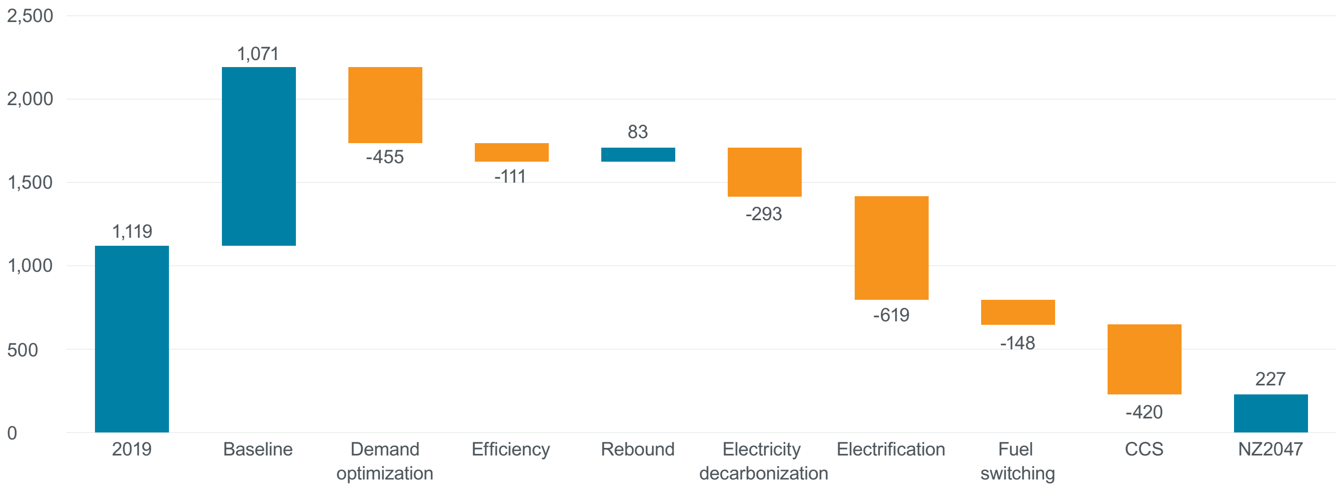
(2) In the main report, emissions are projected all the way to 2070.
(3) Emissions per sector also include associated emissions from electricity generation. For instance, the building sector emissions reported in this note include both direct emissions but also those related to electricity generation. As an important methodological note, the bulk of new capacities deployed in India in this scenario are zero-carbon. We thus consider all additional electricity demand to be zero-carbon, by design.
(4) See full report: Schneider Electric, 2023. Only CO_2 emissions are considered here.

Focus on industry

We observe a similar trend in industry, with a globally equivalent role for demand and energy optimization, electricity decarbonization, fuel switching and electrification, and CCS.

- In this sector, demand optimization plays a much larger role than energy efficiency in optimizing overall energy demand. This has to do with a massive effort to limit the ramp up of resources demand (i.e., steel, cement) in construction and mobility, through both material efficiency measures (better designs, less waste) and changes in business models (e.g., greater recourse to public transport/mobility as a service, development of a sharing economy). Energy efficiency does play a role, but is limited by the relatively recent thus efficient industrial footprint in place.
- While hydrogen clearly plays a role in fuel switching (alongside other options such as biogas, for instance), it is dwarfed by the contribution of electrification, which is explained by the high share of manufacturing in the 2047 industrial footprint in India.

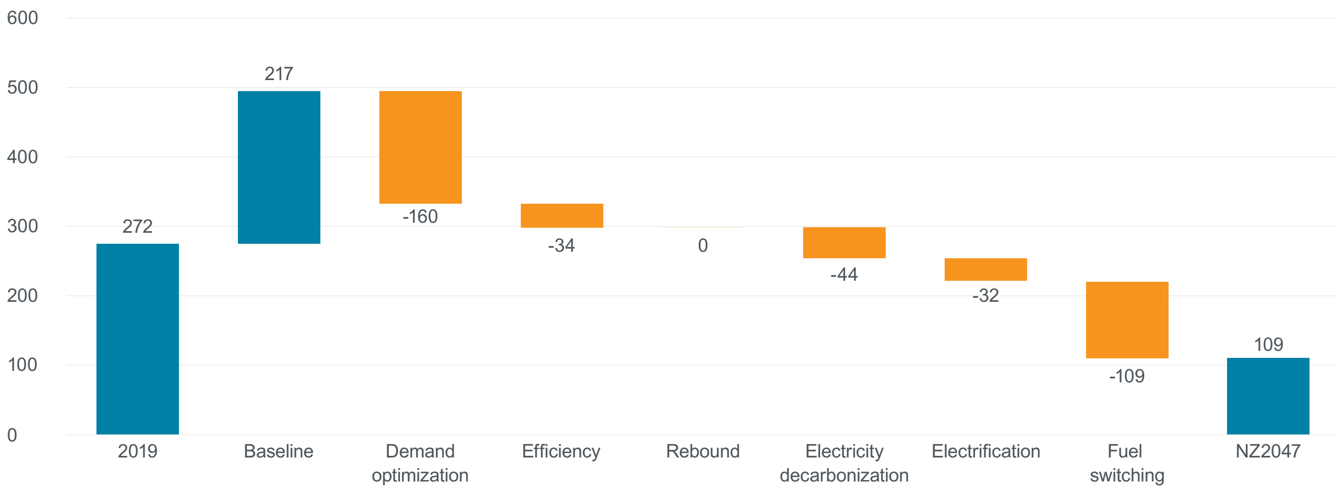
Figure 2 – Industry Waterfall, *2047 Net Zero* ($MtCO_2$/y)



We further focus on two industries. The decarbonization of steel is dominated by two key measures:

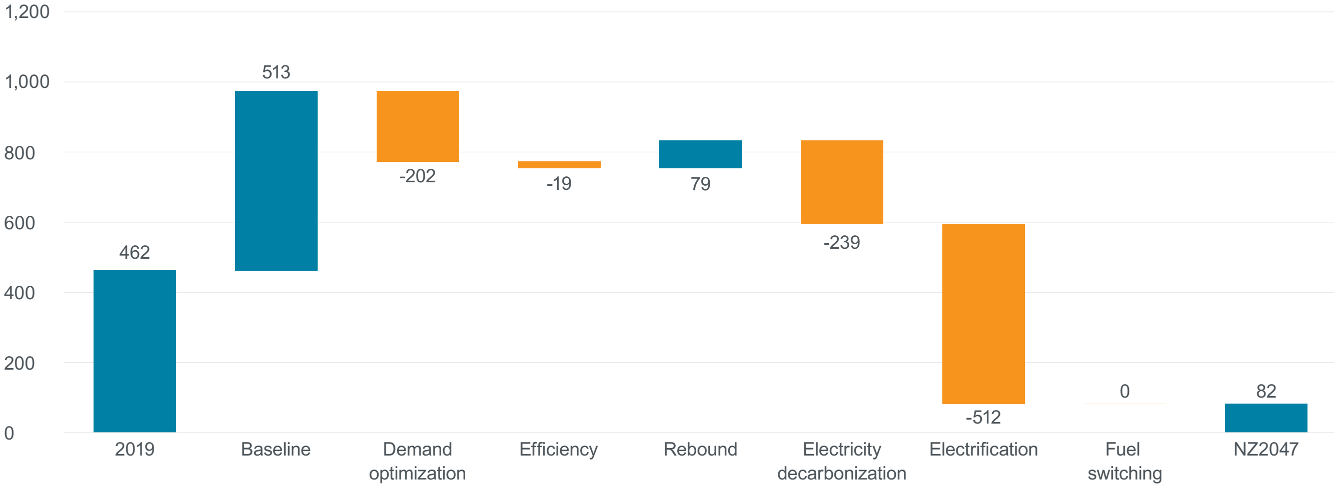
- Demand optimization, pertaining to significant improvements in construction techniques and a greater recourse to public transport/mobility-as-a-service solutions in cities. This also drives increased electrification of steel (the share of recycling reaches 25% by 2047, compared to 4% in 2019).
- Fuel switching represents the second largest contributor and implies a change in process from the traditional BF/BOF (Blast Furnace) coal-reliant process to H2-DRI (Direct Reduction of Iron Ore with Hydrogen).

Figure 3 – Steel Industry Waterfall (without process emissions), *2047 Net Zero* ($MtCO_2$/y)



A second important sector to cover in industry is manufacturing (Other Industry, which also includes the food and paper industries). The profile of decarbonization is here very different. While there are still important emissions saved from demand optimization (notably circularity and the reduction of the number of vehicles within cities and its impact on vehicle manufacturing), the bulk of decarbonization comes from both electrification of end-uses as well as the decarbonization of the power system.

Figure 4 – Other Industry Waterfall, *2047 Net Zero* ($MtCO_2$/y)

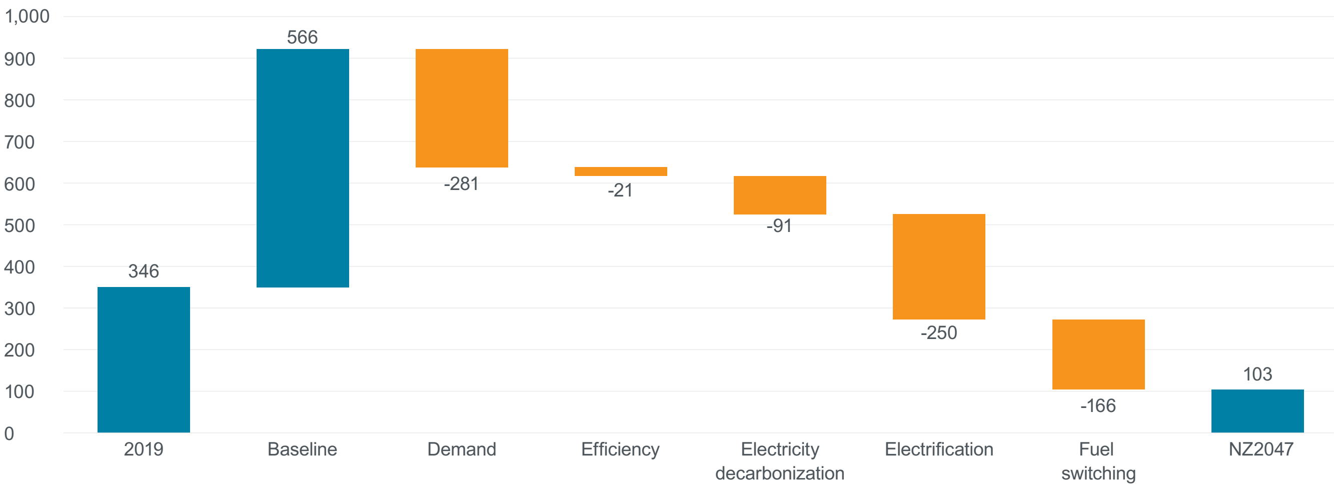


Focus on mobility

In mobility, demand optimization plays a critical role. This is related to the impact of ambitious urban planning and public transportation/mobility-as-a-service policies in cities, which help reduce the need for vehicles. As already discussed, this has not only an impact on mobility emissions, but also on their "embodied" emissions, i.e., those of the automotive sector (which are found in Other Industry above).

Electrification plays a significant role as well, essentially for road transportation, both private and commercial vehicles. Finally, fuel switching accounts for the rest, largely focused around the decarbonization of aviation and marine, through the development of alternative fuels (hydrogen-based fuels such as ammonia, and biofuels).

Figure 5 – Mobility Waterfall, *2047 Net Zero* ($MtCO_2$/y)



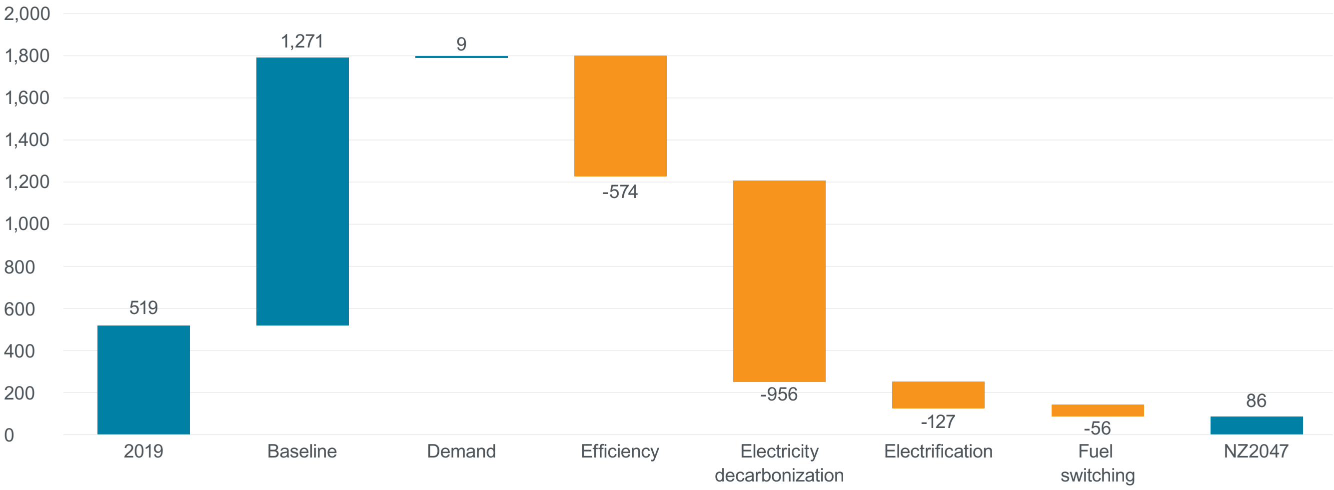
Focus on buildings

The buildings decarbonization profile is somewhat different as it is dominated by two main components:

- Energy efficiency plays a vital role here, and notably relates to stringent requirements on new constructions (which can also be achieved through a significant improvement in construction techniques), as these will form the bulk of the 2047 stock.
- Most of the increase in energy demand in buildings in India will come from electricity, driven by increased penetration of appliances and air conditioning. The decarbonization of electricity is thus fundamental and, as we will see further down, distributed energy resources could significantly help this to materialize.

Finally, electrification (and fuel switching) plays a more modest role. It essentially revolves around the conversion of traditional cooking systems to modern forms of energy, the main one being electricity.

Figure 6 – Building Waterfall, *2047 Net Zero* (MtCO_2/y)



Focus on power generation

Emissions from power generation today are around 1,000MtCO_2/y. In a baseline scenario (that is, if the same mix applies in 2047), those emissions would mount up to 3,000MtCO_2/y, or three times more. In practice, of course, this will not be the case. Our scenario estimates that the bulk of this new demand for electricity will be supplied by renewable energies(5). In 2047, emissions thus decline slightly to 799MtCO_2/y. We have assumed no forced retrofit of existing installations given the large increase in electricity demand which is likely to call for all available resources. In *2047 Net Zero*, almost all these emissions are abated through the deployment of CCS. The power system thus reaches carbon neutrality by mid-century.

(5) As discussed in the full report, Schneider Electric, 2023; and as further expanded upon in the next chapter.

Making it to net-zero

2047 Net Zero is an ambitious scenario which reaches both energy independence and carbon neutrality by mid-century. The analysis above demonstrates how each of the six drivers identified initially play out differently across sectors.

- 30% of the effort comes from the decarbonization of the power system, which reaches zero-carbon by mid-century. This is achieved through renewable energies, but also a recourse to CCS, as coal-fired power plants are decommissioned only at end of life. Another important finding is that the bulk of the increase in electricity demand will in fact materialize in buildings (nearly 60% if we account for mobility electrification, for which charging will primarily occur within building premises). In that regard, the development of distributed generation as an "enabler" of decarbonization and electrification represents another major opportunity, which is detailed further down.
- 25% comes from the optimization of energy demand throughout the economy. In buildings, this has mostly to do with more energy efficient constructions, and relies on the development of robust standards, but also improvements in construction techniques. In industry and mobility, however, this has mainly to do with a significant transformation of the industrial footprint toward a more resource-efficient one, i.e., one that is less dependent on steel and cement demand (and to a lower extent on chemical and manufactured products). Broadly speaking, this relates to ambitious circularity policies, notably in the domains of:
  - Urban mobility, with a dedicated effort to favor the recourse to modern public transportation/mobility-as-a-service solutions.
  - Construction, with the rapid adoption (by the early 2030s) of new construction techniques which rely more heavily on integrated design and execution, based on digital technologies, more resource-efficient design patterns, with significant material efficiency as a result(6).
  - We have also made assumptions on the development of more circular business models for manufactured products. While these measures also have a material impact, we have kept our assumptions relatively conservative at this point, hence the impact is less significant than for other drivers of change. This should be further analyzed in detail in future research.
- 20% of the effort comes from the electrification (direct or indirect) of the energy system. Two thirds of this comes from direct electrification, notably in mobility and manufacturing (and food and paper industries). Another third relies on indirect electrification of selected sectors, in particular the steel industry (direct reduction of iron) and "hard to abate" mobility such as aviation and marine (hydrogen-based fuels and biofuels).
- The last 25% come from the decarbonization of the energy supply, i.e., energy transformation facilities, fugitive emissions, but more importantly process emissions and the remaining fossil-based power generation in 2047, where CCS is deployed massively, for the sector to reach carbon neutrality by mid-century.

With all these measures, emissions would reduce from 2,300MtCO_2/y down to 336MtCO_2/y in absolute value (despite a growth in energy demand of nearly two times, and a growth in GDP of four times). In *2047 Net Zero*, these residual emissions are compensated by negative emissions, coming from Nature-Based Solutions (NBS) and Direct Air Capture (DAC) options, with the balance favoring NBS, with key uncertainties on the pace of development of DAC in the coming decades.

(6) In this exercise, we have not made any specific assumption on material substitution. This could thus further improve the situation and should be the object of further research. More in the full report: Schneider Electric, 2023.

Building out future-proof infrastructure

A transition of such magnitude will clearly require the rapid ramp-up of a decarbonized infrastructure. In *2047 Net Zero*, this infrastructure buildout will significantly differ from what has been observed in the past.

Circularity and efficiency

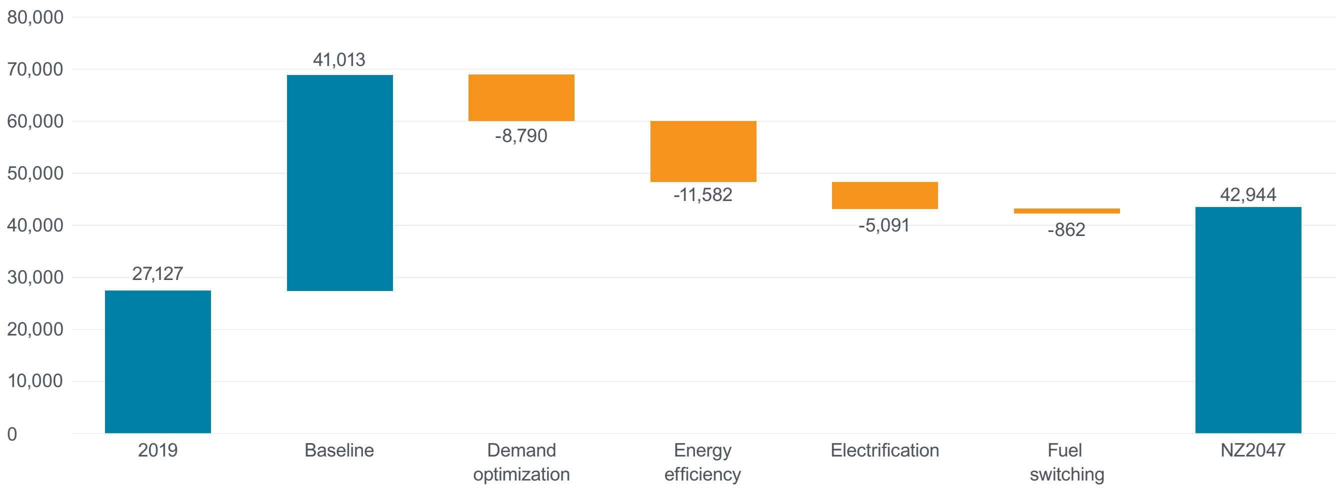
With an energy demand (for buildings, mobility, and industry) around 27,000PJ/y today, the continuation of current trends would lead to an increase in energy demand of roughly 2.5 times, i.e., building the massive underlying growth on the back of the existing energy system, with neither efficiency gains nor change of infrastructure setup factored in. In *2047 Net Zero*, the bulk of that growth in activity is in fact supplied with a new infrastructure, more efficient, electric and decarbonized.

Beyond emissions, which we reviewed in the previous chapter, this change of paradigm has a major impact on energy demand. In *2047 Net Zero*, final energy demand increases only by 1.5 times compared to current levels, through the development of an energy infrastructure which is therefore three times more efficient. Such a benefit strongly improves the cost of building out the necessary infrastructure to support the economy going forward, likely accelerating growth as well.

Energy efficiency measures represent 50% of this abatement. They mainly apply to buildings, both through the transformation of the existing stock, but more importantly through more stringent targets for new constructions. Another 30% is associated with demand optimization, or circularity, i.e., the transformation of current services into ones that require less input material (e.g., mobility service evolutions limiting the need for new vehicles, new construction techniques that reduce the need for steel and cement, the development of a sharing economy for parts of the economic activity, etc.). Finally, electrification accounts for 20% of the rest. In itself, electrification is also a vector of efficiency, notably in mobility.

These efforts, for the largest part, will apply to new constructions, facilities, and equipment. They thus do not represent an additional investment to realize, but rather a choice of infrastructure for the future, ensuring the economy is not locked into the use of fossil fuels for decades.

Figure 7 – Energy demand Waterfall, *2047 Net Zero* (PJ/y)



All-electric India

Massive supply infrastructure buildout

The rapid industrialization of the Indian economy leads to a sharp rise in electricity demand. Power generation increases from 1,700TWh/y today up to 10,000TWh by 2047, or a six times increase (Figure 8). As explored in the original report, and presented in Figure 9, electrification of the Indian economy concerns all sectors of activity. 50% of the increase occurs in buildings, driven by the significant penetration of modern appliances and air conditioning systems. Another 35% comes from industry, and essentially manufacturing activities which rely extensively on modern electric heating and motion equipment. Mobility only accounts for around 10% of the increase by 2047. This increase in electricity demand accounts for around 8,500TWh. Another 1,000TWh goes to hydrogen production with water electrolysis.

In *2047 Net Zero*, 98% of new generation is zero-carbon (2% goes to natural gas). 50% is solar, 25% wind, biomass power generation accounts for nearly 10% and nuclear and hydropower 5% of the increase each (Figure 10). As a consequence, all new electricity uses, whether in buildings, industry, or mobility, can be considered zero-carbon. The development of the Indian economy, relying on modern technologies and characterized by the penetration of modern appliances and equipment, is sustainable by design.

Figure 8 – Electricity generation, (TWh) – *2047 Net Zero*

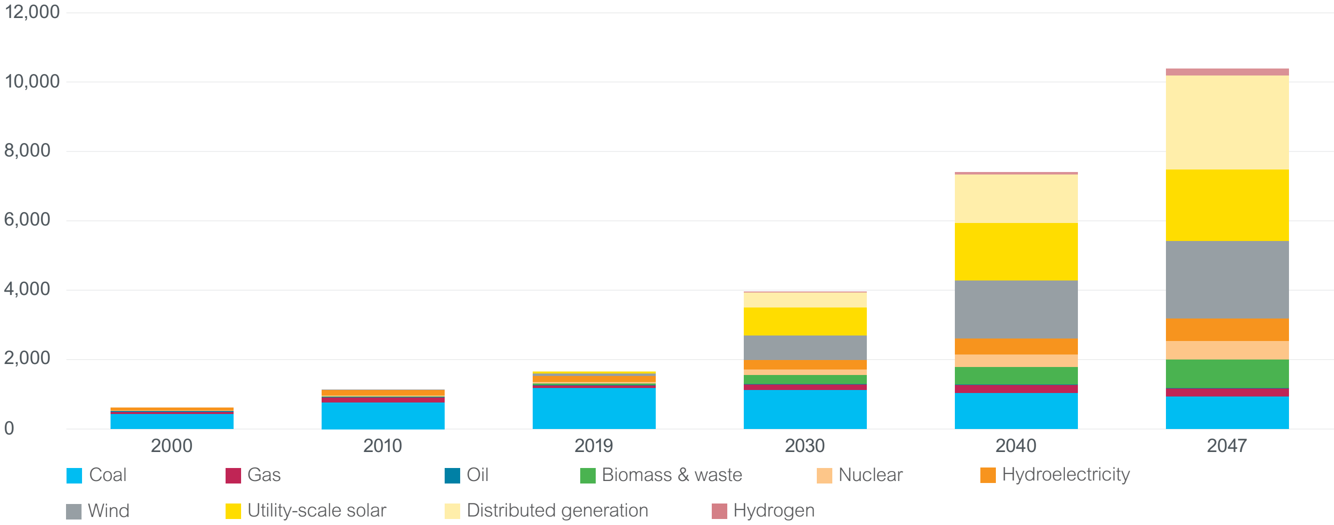


Figure 9 – Electricity demand, per sector (TWh) – *2047 Net Zero*

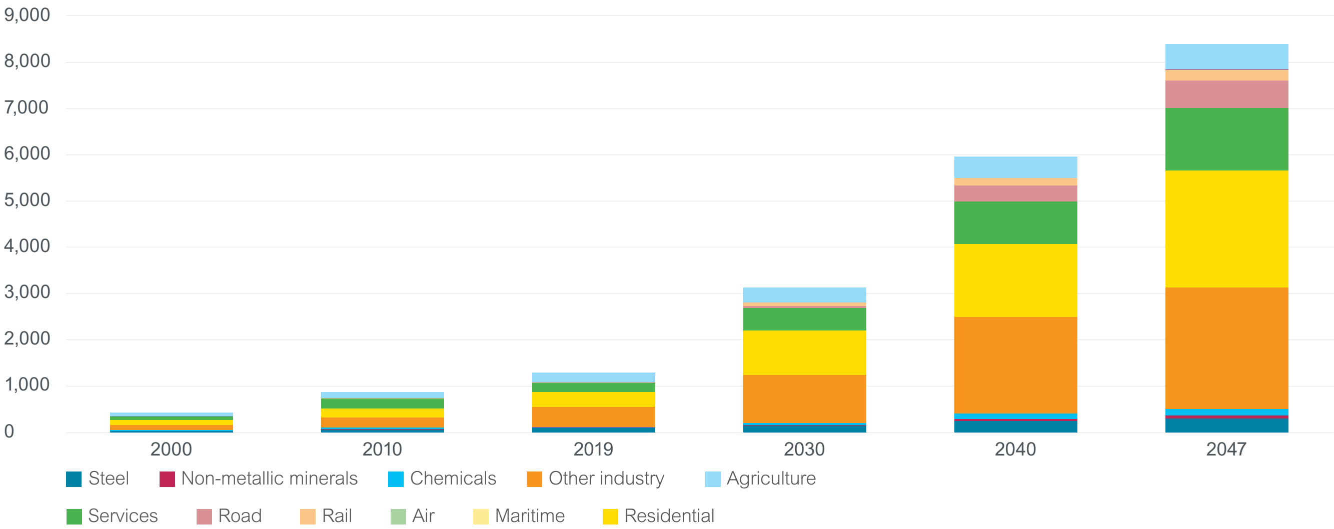
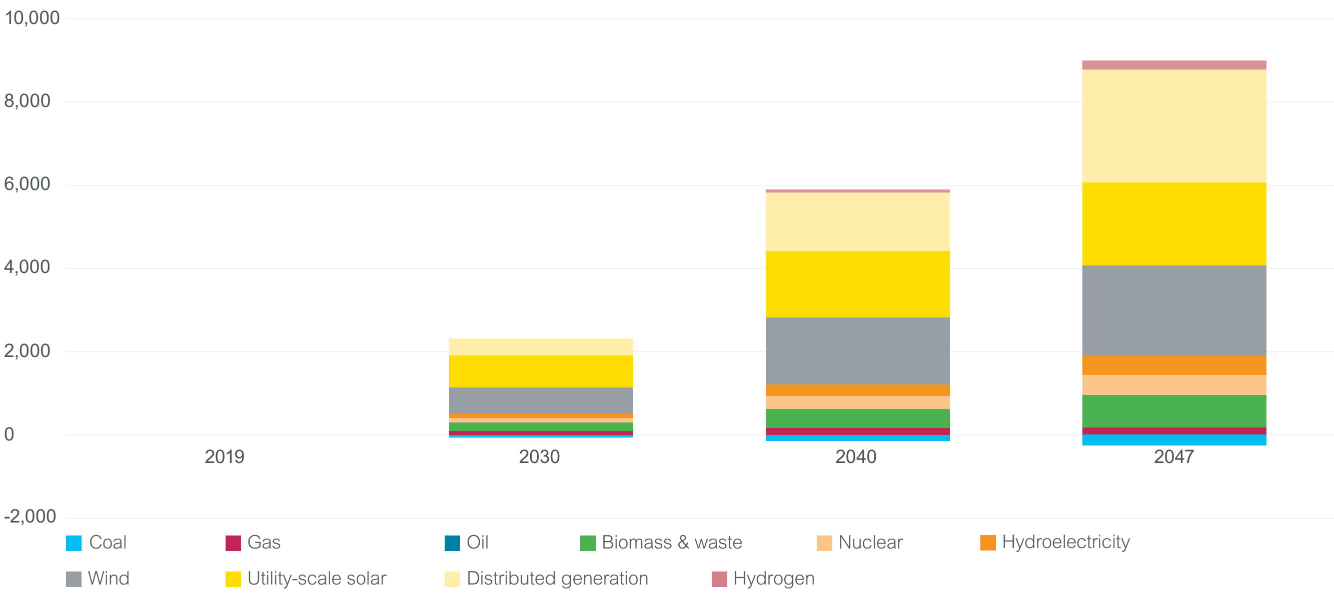


Figure 10 – Additional electricity generation, (TWh) – *2047 Net Zero*

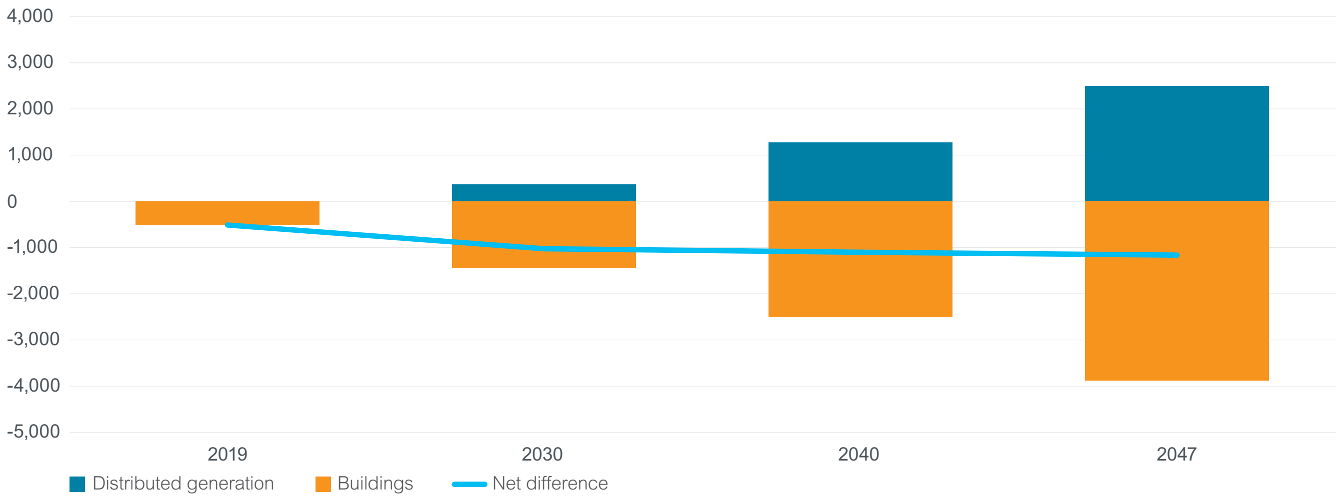


The rise of decentralized infrastructure

Solar energy accounts for 50% of additional generation by 2047. It increases from around 55TWh/y today up to 4,700TWh/y by then. This potential is largely realized by the actual development of distributed generation (rooftop solar) over buildings, which amounts to 2,700TWh/y by 2047, or nearly 60% of the total increase.

This growing penetration of distributed generation on buildings' rooftops can be compared to the rise of electricity demand in buildings which, as discussed above, represents 50% of the total increase in electricity demand by 2047 (and 60% if including mobility charging). Figure 11 shows that this increase in distributed generation largely compensates for the rise in demand. By 2047, the additional demand to be supplied by the grid infrastructure only increases by around 1,000TWh, out of a total increase in electricity demand of 3,900TWh. The penetration of distributed generation is thus a massive enabler of the development of modern building energy uses and supports to a great extent the important developments that need to materialize on the grid.

Figure 11 – Electricity demand in buildings, (TWh) – *2047 Net Zero*



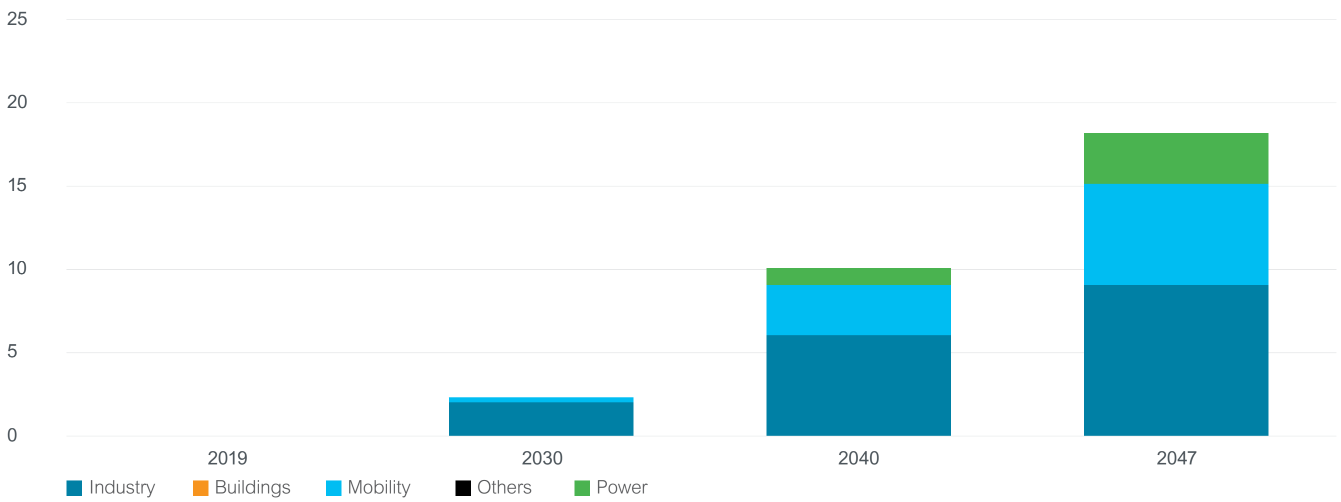
Hydrogen

Hydrogen will play a material role in the overall Indian trajectory to net-zero. Our analysis suggests a rise in demand up to 19Mt/y by 2047 (additional growth). This growth will essentially relate to industrial activities: steel manufacturing in industry, alternative fuels production for transport in petrochemical facilities (e.g., synthetic fuels, ammonia), and a smaller contribution within the power system as a balancing solution.

A key finding is thus that the production and use of hydrogen will be highly concentrated around key industrial sectors of activity.

We consider these 19Mt/y to be entirely supplied by water electrolysis. This will require around 1,000TWh additional power generation capacity to be deployed on the power grid.

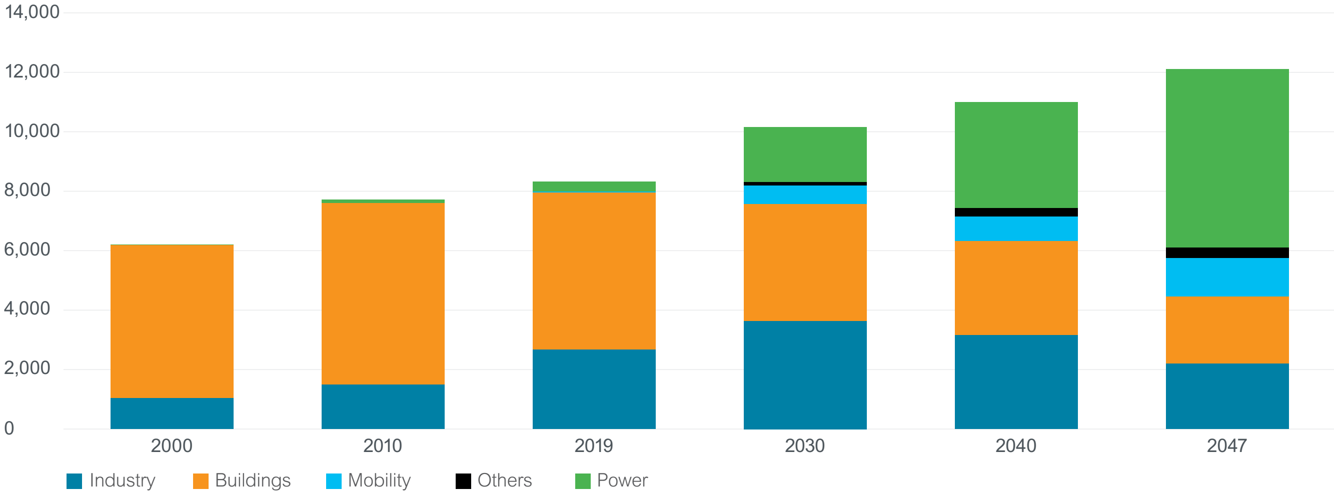
Figure 12 – Hydrogen demand, (Mt/y) – *2047 Net Zero*



Biomass

In *2047 Net Zero*, the demand for biomass will increase by around 50%, up to 12,000PJ/y by mid-century. While the bulk of biomass use revolves today around buildings (cooking), such uses will significantly reduce over time, and, for buildings, be substituted by more sustainable solutions. Yet, the bulk of the rise in demand will stem from new uses, a recourse to biofuels in aviation, and more importantly the development of biomass power generation, as another zero-carbon option to complement wind and solar in the power system. However, it remains an open question as to whether this increase can actually be met in a sustainable manner. For power in particular, alternative options could also emerge over time.

Figure 13 – Biomass demand, (PJ/y) – *2047 Net Zero*

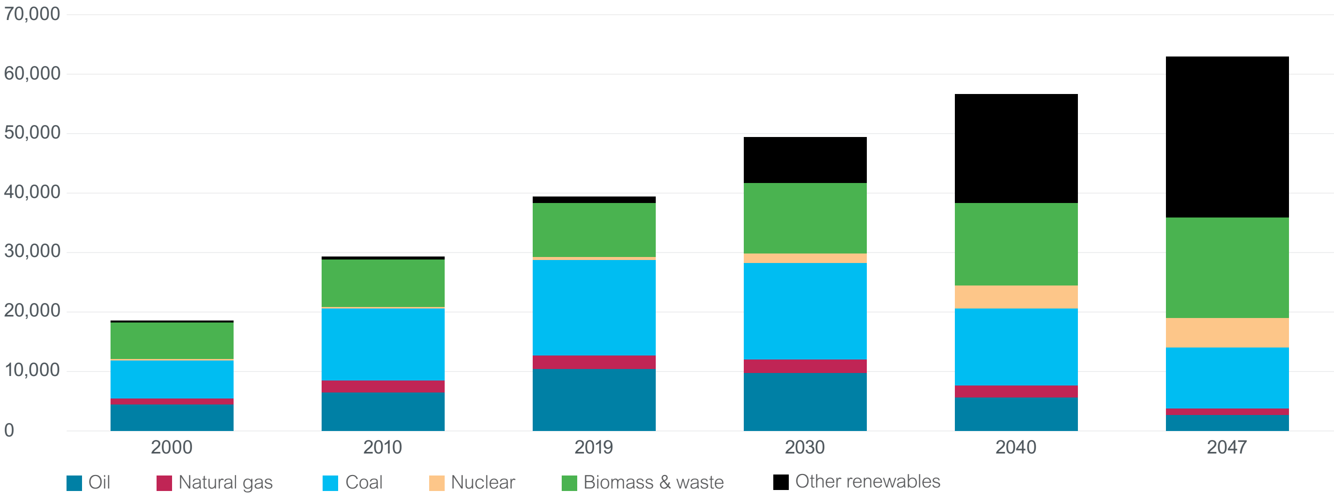


Energy independence

This new infrastructure buildout, driven by demand-side evolutions, will necessarily transform energy supply, and affect energy dependencies. In *2047 Net Zero*, the supply of oil and natural gas declines by 70% from today's levels in 2047, in absolute value. This is mostly due to a continued reliance on oil products, mostly in mobility due to the incomplete electrification of passenger vehicles, aviation, and shipping.

Overall, the supply of oil and natural gas drops from 30% down to 6% of total energy supply – near energy independence.

Figure 14 – Energy supply, (PJ/y) – *2047 Net Zero*



Key uncertainties

As explained in the main report, scenarios are thought experiments, not predictions. They are built to test assumptions and analyze their impact on aggregated systems, such as energy. This exercise does not depart from others in this regard. We briefly summarize here some of the uncertainties discussed in the main report, as they relate to the above discussion.

1. A deeper focus is needed on the construction industry

One of the major game changers of our scenario is the significant improvement in construction techniques which, as a result, supports a less resource-intensive development of the building stock, with critical consequences for material production industries, notably steel. In a true net-zero scenario, such evolution will prove crucial.

2. More research on specific consumption pattern evolutions could bring new insights

Air conditioning penetration will significantly impact the future of the Indian energy system. The extent and pace of its development must thus be analyzed carefully, alongside alternative options and technology developments that could further challenge our assumptions in this report.

Another significant transformation of consumption patterns by mid-century will be the evolution of mobility services in urban centers. In 2047 Net Zero, we favor the rapid development of alternative models to individual private transformation in rapidly urbanizing areas alongside a rapid transition to electric vehicles. Both hypotheses assume significant support from policy in the short run.

The development of circular models in industry also plays an important role in the development of a modern industrial footprint. This will rely on more closed-loop business models, a greater recourse to recycling, and the emergence of green supply chains and "designed-for-circularity" products. With limited development thus far at global level, this also represents an important assumption which will require strong policy support for it to materialize.

3. What role for biomass in the future energy system?

As alluded to above, our modeling effort suggests an important increase in biomass supply by mid-century. Moreover, biomass supply will switch from traditional resources to sustainable ones. Despite the clear outcome of our model, this assumption could be revisited, notably in light of critical dependability issues, arbitrages between agriculture and bioenergy production, and the effects of climate change on agricultural yields. Should such issues materialize, this could transform our projections for certain uses of biomass, notably power generation, where other alternatives may emerge as a result.

4. More research is needed on the role for and the type of negative emissions

As was already discussed, residual emissions in *2047 Net Zero* are around 336MtCO_2/y. The extent to which these will be compensated for by negative emissions, such as Direct Air Capture (DAC) or Nature-Based Solutions (NBS), will define the ultimate landing by mid-century.

5. We are far from having seen it all

Any prospective effort on the development of new technologies, while essential to an informed debate on the energy system evolutions, cannot be considered exhaustive. More research is thus needed to further refine the landscape of innovations, and their potential to unfold. Notably, there are a few elements that we have deliberately left unattended at this stage, around specific decarbonization technologies in hard to abate industrial sectors, that could play a more critical role going forward. These include alternative process technologies in steel (e.g., electrowinning), cement (e.g., low-clinker), and chemicals (e.g., new material designs, leading to material substitutions across a vast array of industries).

In addition, we have not considered here any second order effects from the massive buildout of a strong power backbone, and the consequences that it could have on adjacent technology developments in other sectors. As an example, we have not considered how the combination of access to a plentiful electricity resource alongside new forms of energy storage (e.g., high temperature heat storage) could transform existing industrial facilities. In a sector like cement, for instance, relying on such an infrastructure could, in theory, help remove fossil fuel consumption entirely. As such developments are at prototype stage however (low Technology Readiness Level – TRL), they were not integrated into our analysis at this stage[7].

(7) Such innovations could also significantly challenge, among other things, the emerging role of gas toward mid-century in certain sectors, such as building and cement, for instance. They could also challenge the need for hydrogen as a balancing solution for the power system, at least in part.

2 How does *2047 Net Zero* compare to similar scenarios?

In this chapter, we compare *2047 Net Zero* to the Teri and Shell Net Zero Emissions scenario (NZE) and to the International Energy Agency Sustainable Development Scenario (SDS)(8).

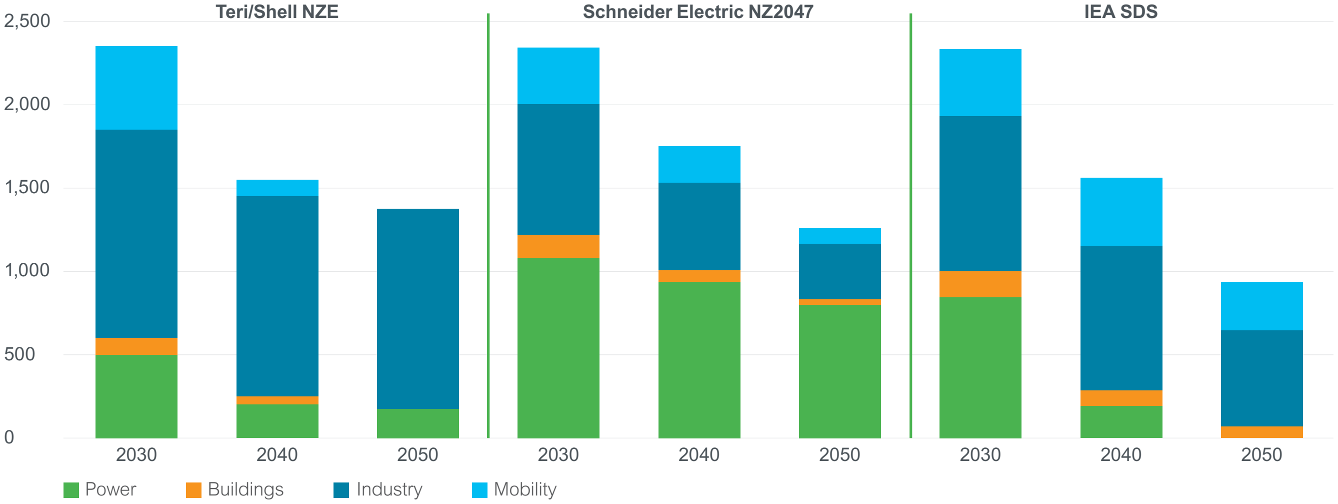
Emissions: power and industry are key uncertainties

At an aggregated level, emissions in these three scenarios are remarkably consistent for 2030 and fall to levels around 1,000MtCO_2/y by 2047 (for buildings, mobility, industry and power only, *prior to CCS*). In a net-zero world, these emissions would thus have to be compensated for by a similar amount of CCS solutions or other negative emission solutions, such as Direct Air Capture or Nature-Based Solutions.

The way these emissions are split per sector however varies significantly from one scenario to another.

- Power generation: both Teri/Shell NZE and the IEA SDS scenarios foresee a rapid decline in emissions for the sector, particularly Teri/Shell which sees this happening by 2030. In contrast, *2047 Net Zero* is much more conservative, arguing that, given the expected six-fold increase in electricity demand by 2047, existing capacities will not be retired and will continue to operate for long in the century, until finally reaching end of life and/or being decommissioned when solid economics and an available supply chain can compensate for this loss in supply. This is prior to CCS development.
- Industry: both *2047 Net Zero* and the IEA SDS foresee a sharp decline in industrial emissions by mid-century, with a more pronounced acceleration for *2047 Net Zero* by 2030. As discussed in the original report, this is mainly based on the assumption that manufacturing (Other Industry) will essentially build on the back of a new electric backbone, rather than perpetuating the recourse to coal, biomass, or other fossil fuels such as oil and natural gas. Teri/Shell NZE is more conservative and projects a very limited decline of such emissions by mid-century, but these essentially revolve around the mining sector(9).
- Mobility: the projections of the IEA SDS are very conservative with a limited decarbonization of the sector overall (yet, with significantly increased stock), while both *2047 Net Zero* and Teri/Shell are more optimistic on the rate of decarbonization. While the bulk of these emissions revolve around road transport (private cars, trucks), emissions from aviation and shipping are also non-negligible.
- Buildings: scenarios follow similar patterns to mobility, the key topic at hand being the rate of electrification of cooking, with different assumptions across scenarios, though overall a similar trend toward modernization.

Figure 15 – Comparing scenarios: emissions, (MtCO_2/Y)



(8) Teri/Shell, 2021, India: transforming to a net-zero emissions energy system
©OECD/IEA, 2021, World Energy Outlook
Note that both Teri/Shell and the International Energy Agency report figures for 2050, while *2047 Net Zero* reports them for 2047. We have considered in what follows that these levels correspond to the same year, a minor approximation to match results.

(9) It is worth noting as well that we observed some key differences between the three scenario 2019 levels. While both Schneider Electric and the IEA scenarios share globally similar levels, Teri/Shell shows some differences in 2019 baselines, notably around the share of industry emissions (around 30% larger), the share of biomass in final demand (three times lower), and a twice higher penetration of electricity in service buildings. A deeper analysis of 2019 levels and their scope is thus an important topic for further alignment.

Final energy demand: similar trends toward electrification, but different paces

In terms of total final energy demand, both Teri/Shell and Schneider Electric show very similar figures for 2050, while the IEA SDS is more ambitious in terms of efficiency gains on energy demand (Figure 16).

The share of electricity demand is highest in *2047 Net Zero*, largely driven by the significant increase in buildings (appliances, and more importantly air conditioning), and in manufacturing. The share of electricity in buildings is however smaller for Schneider Electric than it is for Teri/Shell NZE, and relatively similar to that of the IEA SDS, but, and this is the key difference, it is also much higher in industry, which is what yields the difference between the scenarios. Ultimately, the share of electricity reaches around 60% in Schneider Electric, as opposed to 40-50% in other scenarios, compared to around 16% in 2019.

The share of coal is the second major order of business. It drops significantly in the *2047 Net Zero* and IEA SDS scenarios (from 2019 levels at around 20%, down to 6% and 13% respectively), but stabilizes at a much higher level in Teri/Shell NZE. Once again, this is mainly related to the fate of coal in industry[10].

Oil demand drops across all scenarios, albeit at a very low pace for the IEA SDS (because of slow electric vehicles pick up), and with near phase-out of oil demand in Teri/Shell NZE by 2040. Both the IEA SDS and Teri/Shell NZE assume a transitionary role for natural gas in the energy system until 2040, before natural gas is displaced again by mid-century.

Arguably, the key question arising from this review of final energy demand revolves around the future energy mix of industry in India: one that continues to rely heavily on coal, but that transitions in part to natural gas, or to electricity. Schneider Electric *2047 Net Zero* is more ambitious on electrification because of the large share of manufacturing in India's future industrial footprint. This is a key question for further research.

Figure 16 – Comparing scenarios: energy demand, across scenarios (PJ/y)

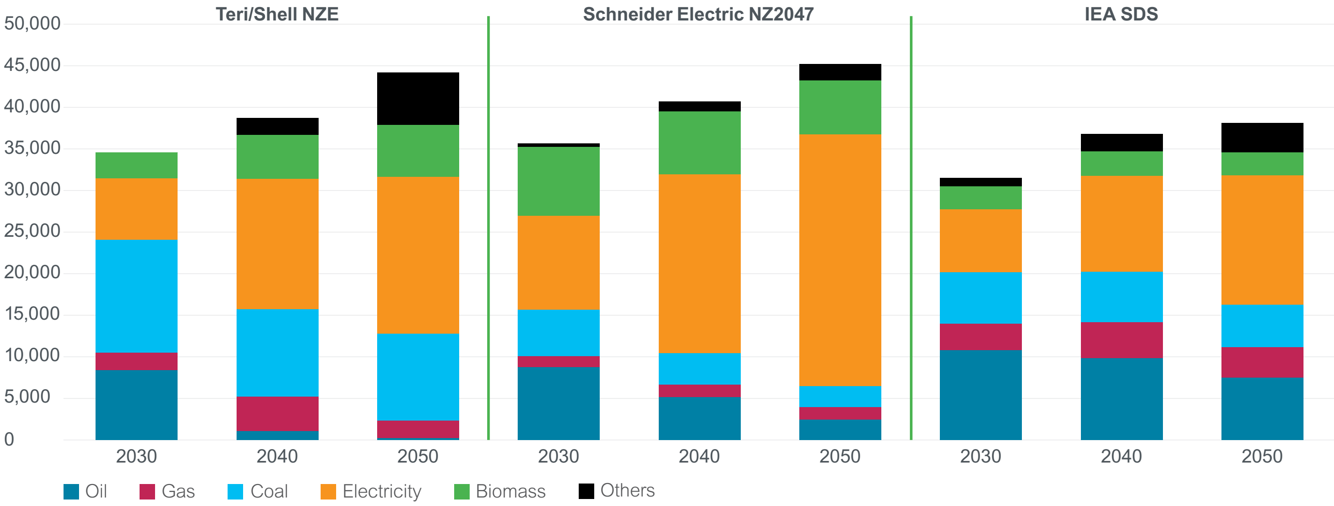
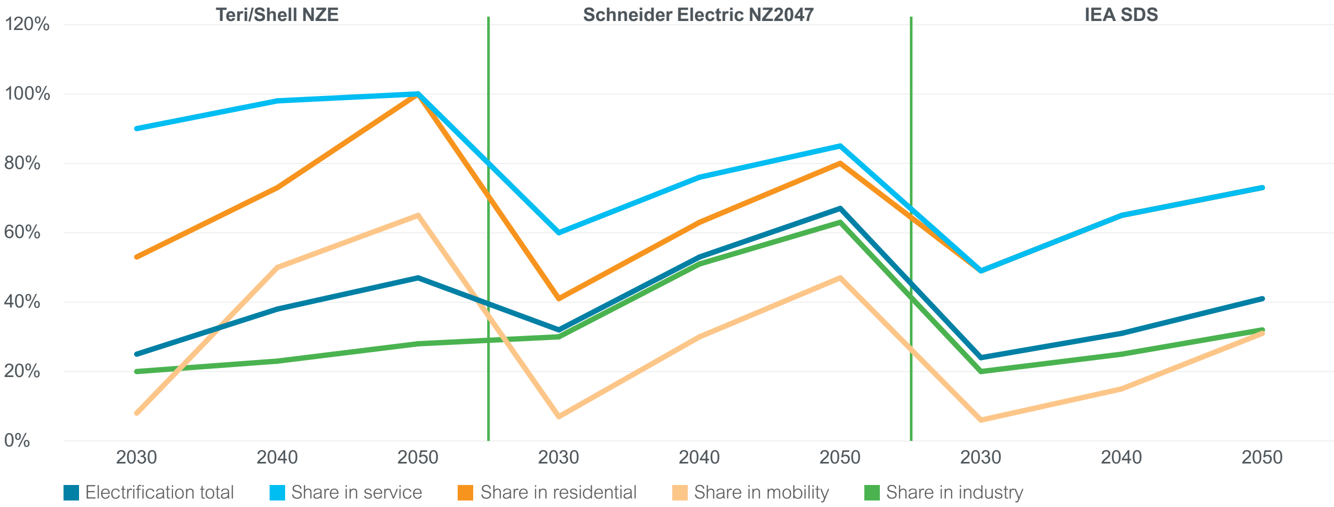


Figure 17 – Comparing scenarios: electrification rates, across scenarios



(10)And possibly, again, to scope differences between scenarios. See footnote 9.

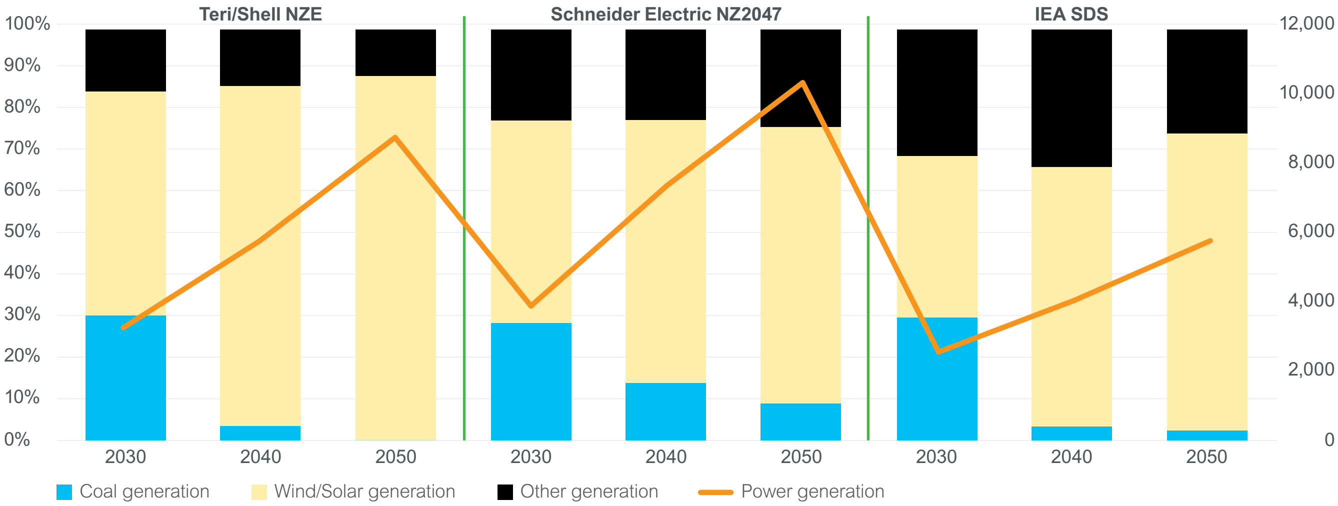
Power generation: the fate of existing coal is in question

Power generation projections are more consistent across all three scenarios reviewed. Overall power generation increases up to 9-10,000TWh in both Teri/Shell NZE and *2047 Net Zero*, with a lower ramp up to 6,000TWh in IEA SDS (still representing a four times increase compared to 2019).

From a mix perspective, all scenarios converge on a major role for renewable energies in the future power mix. This is particularly true for Teri/Shell NZE, with a rate of penetration near 90% by mid-century. Both the IEA SDS and Schneider Electric are more conservative, with a rate of penetration of 70%, giving way to complementary options such as nuclear, biomass power, and others.

A key question, however, is that of the fate of coal fired power plants. All scenarios agree on limited progress on this front by 2030. Yet, both Teri/Shell NZE and IEA SDS anticipate a near full decommissioning by 2040, while Schneider Electric estimates that a share of the fleet will be kept in operation until after mid-century, given the significant pressure on building out the power infrastructure. This is another important argument for debate. Could renewable energies become so affordable, and for coal-fired power plants to be decommissioned before they reach end of life?

Figure 18 – Comparing scenarios: power generation mix, across scenarios (TWh)



3 What would it take to reach net-zero by 2047?

Building the economy on 21st century technologies

The above deep dive into *2047 Net Zero* helps to understand what it would actually take to reach the goals of energy independence and net-zero by mid-century. A key finding of the above analysis is that such a pathway essentially has to do with **building the economy of India on the backbone of modern technologies**, now available at scale:

- Developing assets, products and services that have best-available efficiency levels and that are built for a more circular economy (notably for construction and mobility), notably by leveraging digital technologies.
- Building an all-electric India, with a strong focus on rapidly switching new mobility and industry (manufacturing) assets to modern and electrified systems, rather than relying on past-their-prime solutions and infrastructure.

Another key finding is that most of this development will actually follow the rapid urbanization of the country, a transition which is already on its way (construction of new buildings, mobility services, and manufacturing will all materialize in or close to urban centers). In other words, most of this development will also have to do with ***the way* urbanization actually materializes**.

What these findings suggest is, first, the **regional aspect of the transformation** at play: a development which primarily occurs at the city or regional level, and which may also significantly differ for India relative to other countries' energy systems, with different endowments and issues at hand. Second, and more importantly, these findings also suggest that a significant opportunity exists for India to develop a radically different model for its economy (and living standards) than the ones experienced by its counterparts in mature economies, a model that could serve **as a blueprint for economic development** in the 21st century.

Last, the sheer size of India's economic development in the coming decades also provides grounds for optimism. If a large share of that economic activity has "yet to be built", such **an accelerated transition might be more feasible than we think**, particularly in a world where the 21st century technological toolbox is now available at scale.

An ambitious policy framework for *2047 Net Zero*

For such a feat to materialize, however, will require an ambitious policy framework to favor a rapid switch toward new technologies now available. We suggest here a few policy directions that could support this turnaround. This is obviously not an exhaustive list.

Building on best-available technologies

A key policy instrument of India for efficiency is the PAT scheme (Perform, Achieve & Trade), mainly targeted today at energy intensive segments (steel, cement, etc.). Yet, optimal energy efficiency needs to be a target for all economic activities, with a benefit in terms of emissions short term, but also for it to play a major role in accelerating the development of a sustainable infrastructure to support growing economic activity.

A key ambition could thus be to foster energy efficient practices for non-PAT segments and end-users, especially MSMEs (Micro Small & Medium Enterprises), for which the initial challenge is often the lack of monitoring and benchmarking of energy use. To achieve such an ambition could revolve around the creation of an energy data bank and performance benchmark as a first step.

Additionally, industries and commercial buildings could be encouraged to rapidly adopt energy management standards such as ISO 50001. This could be fostered by incentives and rebates to those who would have successfully adhered to ISO 50001 guidelines for three or more years.

Another direction of travel could be to introduce a revenue-neutral "feebate" scheme across sectors to have facilities or products with higher energy intensity pay a fee (calculated based on both their energy intensity and absolute volume of energy consumed), while firms with lower energy intensity would receive a rebate (based on a similar calculation). The benchmark or pivot point should be carefully designed by government after conducting a comprehensive analysis for each sector, system, appliance, or equipment considered. Such a policy could be designed to be revenue-neutral.

Such policy support could also be further implemented into codes and standards. For instance, under the ECBC (Energy Conservation Building Code) or the upcoming Energy Conservation and Sustainability Building Code (ECSBC), incentives (financial or in terms of Floor Area Ratio (FAR)) can already be provided for buildings that are compliant with Super ECBC or ECSBC clauses.

Finally, new institutional arrangements could be developed, consisting of end-users, technology providers, and financial institutions, to accelerate the implementation of pilot or proof-of-concept projects in key areas where solutions are yet to be operationalized, such as, for example, advanced demand-side management solutions (DSM), analytics and digitization projects in industries and buildings, or specific technologies applicable to MSMEs.

Toward a circular economy

Another ambitious policy goal would revolve around fostering the rise of a more circular economy in India. This would require a coherent policy framework to encourage the systematic use of circular economy principles with a focus on environmental impact and lifecycle analysis for all types of assets. This could, among other things, build on:

- Extended Producer Responsibility (EPR) schemes for waste recycling/refurbishing/reuse, which could be extended to all major sectors and products.
- Increasing awareness around embodied carbon with adoption of policies to stimulate demand for low and zero-carbon assets.
- Introducing design and material standards focused on circularity for all major sectors and products.
- Increasing public (and private) investment to develop alternative materials, low-emissions equipment, solutions and technologies and the scale up of relevant supply chains.

Developing an all-electric India

A key topic of *2047 Net Zero* will be the rapid electrification of India's economy, and this will also concern sectors and equipment for which 20th century fossil fuel technologies continue to dominate. To avoid locking the economy into fossil fuels for decades would require a significant ambition toward electrification of the economy. This could build on:

- A significant policy focus around electrified mobility development, as well as electrified heating systems, for both buildings and industries (notably, in the latter, for low-grade steam and hot water processes).
- The development of market enabling policies and a coherent regulatory framework to accelerate the penetration of renewable electricity, alongside distributed generation (in buildings notably), smart grids and microgrids.
- In particular, a strong focus should be placed on developing the significant potential of rooftop solar in the country's energy mix. This could be done through a favorable policy mix, combining financial incentives and subsidies, demand aggregation mechanisms, education programs, and awareness campaigns.

R&D and innovation

Finally, several sectors and applications still require additional investment into finetuning and scaling up some of the solutions that will have to play out by mid-century. It is another opportunity for India to develop a strong R&D global hub. This could be facilitated by incentive-based policies and a mix of public and private funding. An example presented in this report, among others, could focus on Carbon Capture and Storage solutions, and possibly on Carbon Capture, Utilization and Storage, alongside hydrogen development, to manufacture future-proof fuels.

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