The call of the planet for a sustainable electrification

Future challenges

Paris, September 2020

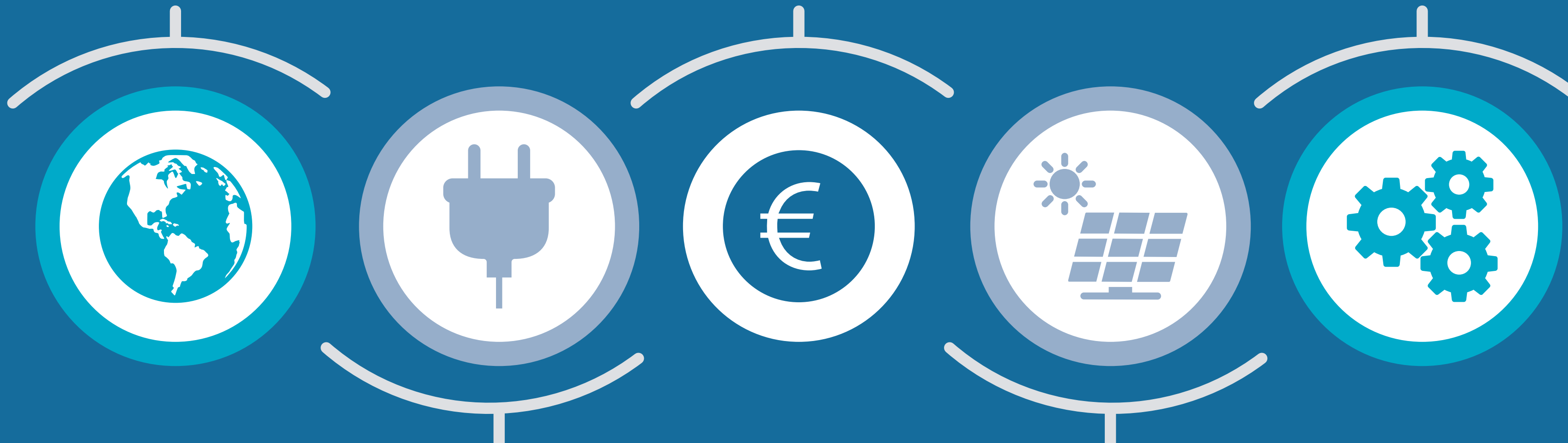
Growing demand for electricity requires major investments and the emergence of new economic models

Points to remember

100%
of the world's population must have **access to electricity from 2030 onwards** if the +2°C target is to be adhered to **(i.e. +1.8 billion inhabitants)**

EUR 23 Trillion
will be invested in new **means of electricity generation and grids between** now and 2040

New economic models
and new players are emerging, linked to the decentralisation and digitalisation of electricity systems



+20%
additional global demand for electricity between now and 2030 (2°C temperature target)

80%
of the additional electricity generation capacity deployed between 2018 and 2040 will be **renewable energies**

Source: IEA (World Energy Outlook 2019), Roland Berger

Electrification plays a key role in human development and in combating climate change, as its economic models are being disrupted

Driven by urbanisation and usage, electrification is playing a key role in human, social and economic development

> Driven by demographics and urbanisation, electrification is **instrumental to human development**

> Moreover, demand for electricity is bolstered by:
  – A **usage substitution effect** (industry, construction and transport)
  – The **continued expansion of** digital and fully electric usages

> To meet **growing demand for electricity** (+ 1.7% per year between now and 2040), there must be **substantial investment** in new means of generation and in grids, particularly in **Africa** and in **Asia**

Electrification has a key role to play in combating climate change, from its generation to its consumption

> Limiting global warning to 2°C means **reducing greenhouse gases by half** by 2050, compared with 2016 levels

> Electrification must contribute to a fall in CO_2 emissions at the level of:
  – **Generation,** through the deployment of new **renewable** capacities to replace carbon-based sources
  – **Grids** and **storage,** thanks to **sectorial coupling,** making energy flows interoperable and making the most efficient use of surplus generation
  – **Reduced consumption** through improved **energy efficiency**

Looking beyond the established players, new economic models and players are emerging in the electricity ecosystem

> **Decentralisation** of electricity generation contributes to the emergence of **alternative models** to those of established players: generation and flexibility aggregators, peer-to-peer platforms, etc.

> In addition, in line with the trend already seen in many sectors, energy is gradually switching to an **'as-a-service'** model (payment for a service provided)

> Finally, numerous **digital start-ups** are providing technology-based **asset and energy management** services and setting themselves up as new intermediaries

Source: Roland Berger

This document, which organised around three themes, looks at findings on the benefits of sustainable electrification

Agenda

A

Expansion of electricity in energy systems and economies

Page 5

B

Contribution of electrification to combat **climate change**

Page 18

C

Contributions by electrification to the development of new **economic models**

Page 35

Source: Roland Berger

A. Expansion of electricity in energy systems and economies

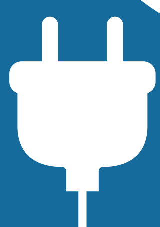
For a 2°C temperature target, demand for electricity will increase by 1.7% a year, accounting for 31% of total energy consumption in 2040

Key figures

+1.7%

per year between now and 2040

Average annual growth in global electricity production between 2019 and 2040



31%

in 2040

Electricity as a share of total energy consumption in 2040

No. 1

in 2040

Position of **electric vehicles** as sources of **additional demand** for electricity

Note: 2°C target corresponding to the average global temperature rise between 1850 and 2100, commonly accepted by the scientific community and enshrined in the 2016 Paris Agreement, beyond which the consequences of climate change for ecosystems (and ultimately for human activity) are deemed devastating.
Source: IEA (World Energy Outlook 2019 and World Energy Investment 2020), Roland Berger

Driven by urbanisation and usage, electrification is playing a key role in human, social and economic development

Expansion of electricity in energy systems and economies

Electricity plays a key role in human development, by providing access to education, information and communication technologies, and even by improving the productivity of certain economic activities

Beyond populations' **increasing access to electricity,** growth in demand is bolstered by:

> **A usage substitution effect** in industry, construction and transport (e.g. electric vehicles), linked to an increasingly stringent regulatory environment concerning local pollution

> **The growth of 100% electric digital tools and usages,** driven for example by the electricity consumed by data centres (despite their energy efficiency improvements)

Global demand for electricity is growing rapidly (x1.5 between now and 2040), primarily driven by emerging countries. To adhere to the 2°C[1)] target set in the 2016 Paris Agreement, the entire world population must have access to electricity by 2030, i.e. 1.7 billion persons more than in 2018

1) Average global temperature rise between 1850 and 2100 commonly accepted by the scientific community and enshrined in the 2016 Paris Agreement, beyond which the consequences of climate change for ecosystems (and ultimately for human activity) are deemed devastating.
Source: Roland Berger

Driven by urbanisation and usage, electrification is playing a key role in human, social and economic development

Expansion of electricity in energy systems and economies – Agenda

Source: Roland Berger

1.

Global electrification contributes directly and indirectly to 12 of the 17 United Nations Sustainable Development Goals

Link between electrification and Sustainable Development Goals

Source: United Nations Organization, Roland Berger

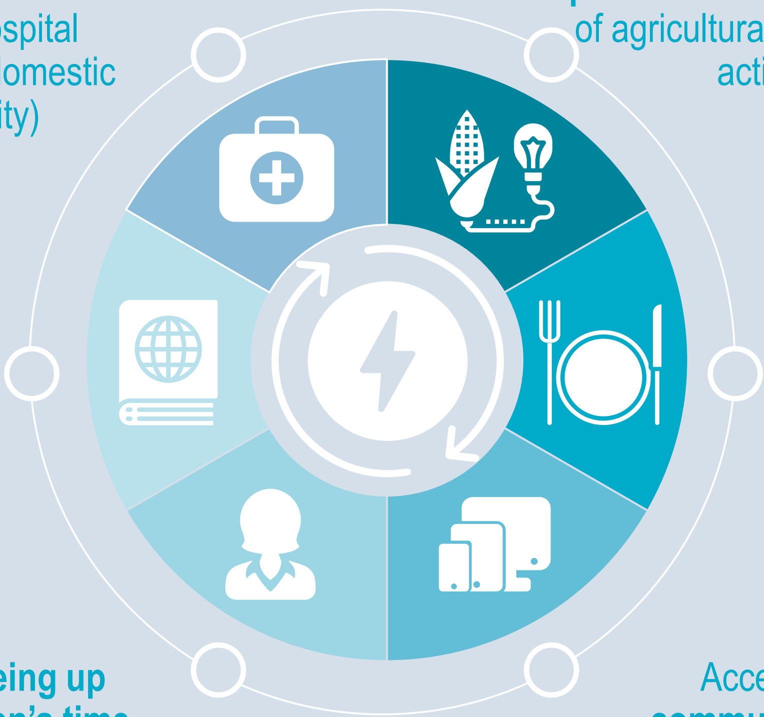
1.

Electricity plays a key role in human development, the objectives of which are still far from being achieved

Role of electricity in human development

Improvement in health (hospital equipment, domestic air quality)

Improvement in the productivity of agricultural and economic activities



Access to education (lighting, information technologies)

Food safety and security (refrigeration)

Freeing up women's time

Access to **communication technologies**

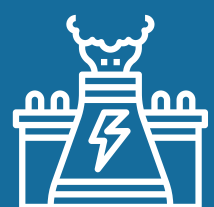
> Even before this unprecedented Covid-19 crisis, the world was not on track to meet key sustainable energy goals.[…] This means we must **redouble our efforts to bring affordable, reliable and clean energy to all –** especially in Sub-Saharan Africa, where the need is greatest – in order to build more prosperous and more resilient economies.
>
> **Dr Fatih Birol, Executive Director of the International Energy Agency, May 2020**

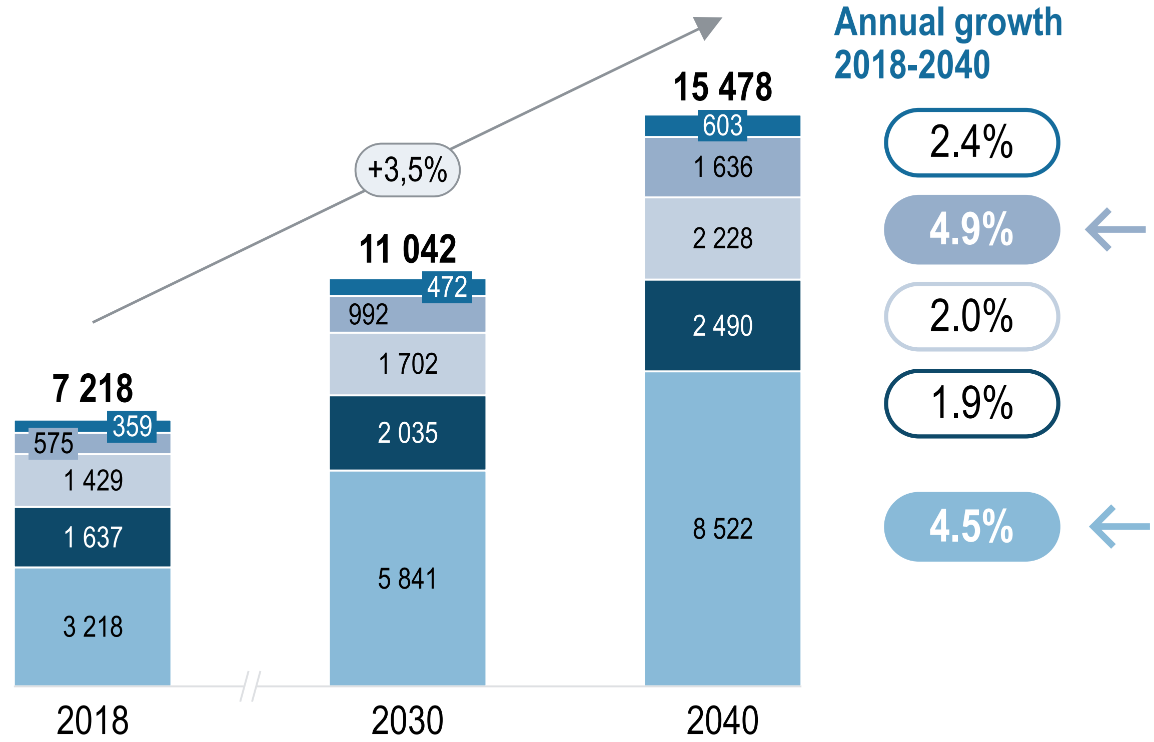
Source: International Renewable Energy Agency (IRENA), International Energy Agency (IEA) (World Energy Outlook 2019), Roland Berger

1.

Electrification is a prerequisite for meeting the 2°C temperature target: an additional 1.8 billion people must have electricity access by 2030

Change in electricity generation capacities [GW] – 2°C target





	2018		2030		2040	
Total electricity generation (TWh)	26,607	→	31,800	→	38,713	**1.7%**
Population with access to electricity % (millions of people)	**89%** (6,790)	→	**100%** (8,550)	→	**100%** (9,200)	

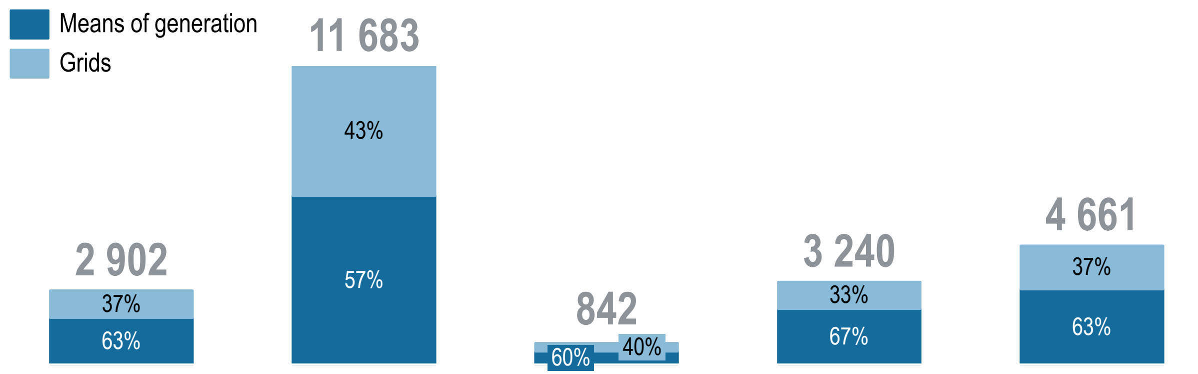
Asia & Pacific | Europe (including Russia) | North America | Africa and the Middle East | Latin America

Source: IEA (World Energy Outlook 2019), United Nations (Population Division – Medium variant estimate), Roland Berger

1.

Between now and 2040, ~EUR 23 000 billion will be invested in new capacities (generation + grids), with a particular push in Africa

Cumulative investment between 2019 and 2040 in electricity generation capacity [EUR billion][1] – 2°C target



	Africa and Middle East	Asia and Pacific	Latin America	North America	Europe (including Russia)
	x6 GDP of Nigeria	x0.9 GDP of China	x0.5 GDP of Brazil	x0.2 GDP of the USA	x0.4 GDP of Germany
Additional generation capacities 2019-2040[2] [GW]	+1,062	+5,303	+244	+798	+853
As a % of capacities in 2018	+185%	+165%	+68%	+56%	+52%
Main growth drivers	Development of new lines	Development of new lines	Development of new lines	Grid renewal	Grid renewal

1) Dollar to euro conversion rate: 0.89 2) Additional capacities – capacities withdrawn from the grid

Source: Oxford Economics, IEA (World Energy Outlook 2019), Roland Berger

2.

In addition, electricity is likely to benefit from a substitution effect in industry, construction and transport

Sectors' electrification – Rationale and applications

Switch in usages

- **A regulatory environment** favouring a switch of certain usages to electricity (e.g. taxing emissions, noise restrictions)
- Direct effect on the **reduction in local pollution** (emissions, noise, pollutants) in relation to heating technologies

Construction

- **Accelerated development of thermal control in buildings** (e.g. expansion of electric heating and more specifically of heat pumps)
- Sharp increase in **renovations** of **old buildings** (better insulation and energy efficiency)

Industry

- **Development of** better-performing electric motors (to the detriment of combustion engines) fuelled by batteries[1] or fuel cells (hydrogen)
- Electrification of **iron and steel-making processes: rapid development of electric arc furnaces** as an alternative to blast furnaces
- Electrification of **chemical processes: low-temperature chemical processes**

Transport

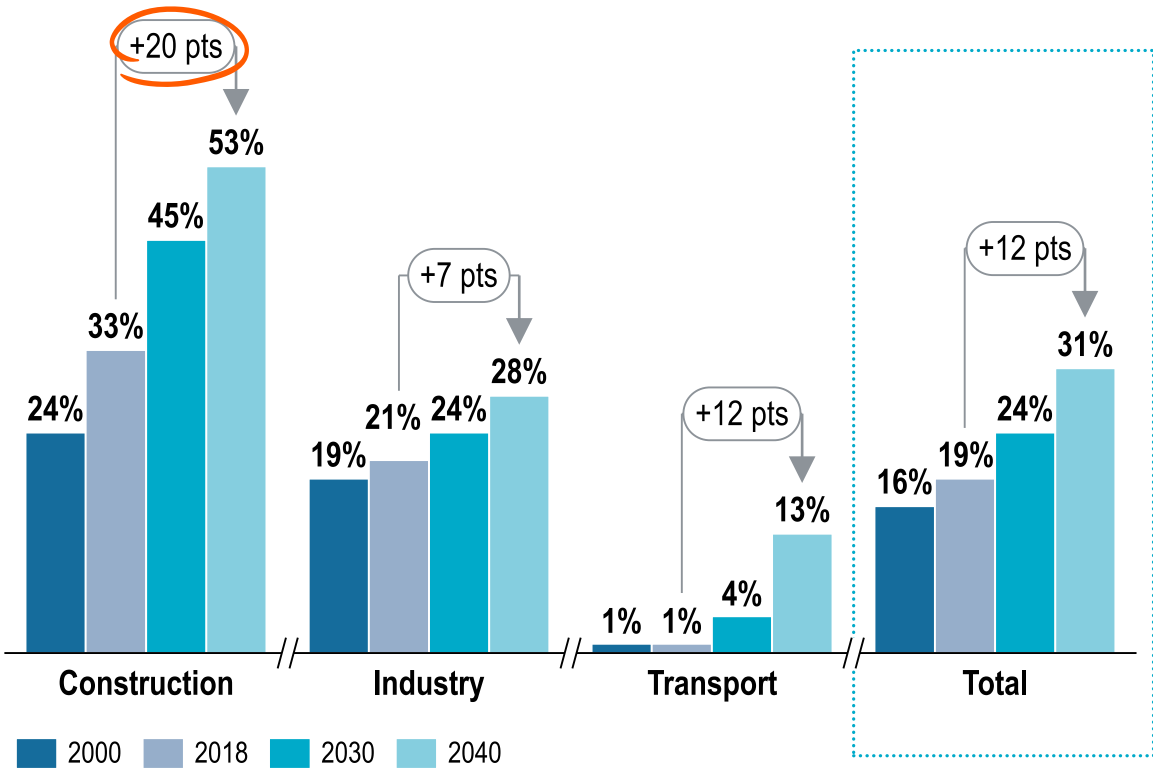
- **Development of electric land vehicles:** 1.9 billion electric vehicles by 2040, according to the IEA (2°C target)
- **Development of electric aircraft** is ongoing, for urban air taxis and for conventional airlines
- Development of **regional hydrails** (to replace diesel trains)

1) Provided the battery is charged by zero-carbon electricity
Source: IEA (World Energy Outlook 2019), Roland Berger

2.

The proportion of electricity in the total energy consumption of these sectors should therefore continue and its growth accelerate

Share of electricity in total energy consumption by sector – 2°C target



> **Usage substitution,** making it possible to improve energy efficiency, for example:

– **'Smart buildings'** becoming more widespread, making it possible to reduce the total energy consumption of buildings by 10% by 2040

– Deployment of **digital solutions for truck operations and logistics,** making it possible to reduce freight energy consumption by 20-25% by 2040

> Increase in the share of **electrical technologies** in final energy consumption, despite strong **improvements in their efficiency**

Source: IEA (World Energy Outlook 2019), Roland Berger

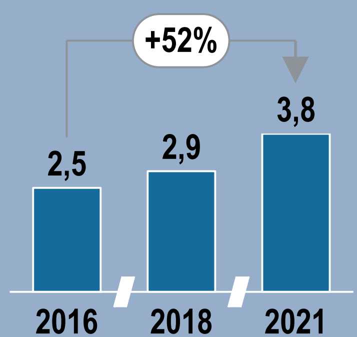
3.

100% electric digital uses are continuing their rapid expansion

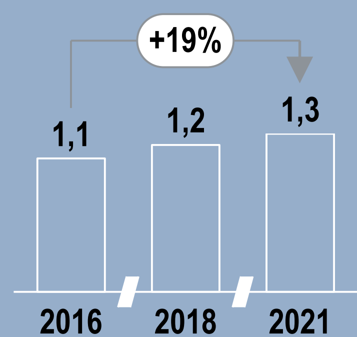
Growth in digital and data uses

The quantity of digital devices in circulation globally is growing rapidly...

Smartphone users [Billion users, Global]



Tablet users [Billion users, Global]



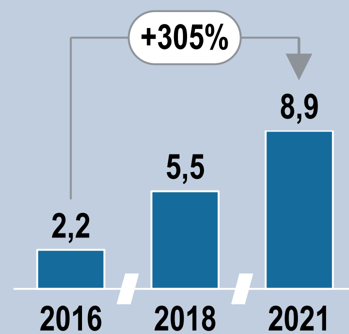
Increase in digital devices in circulation made possible by:

> Progress in miniaturisation and processing power

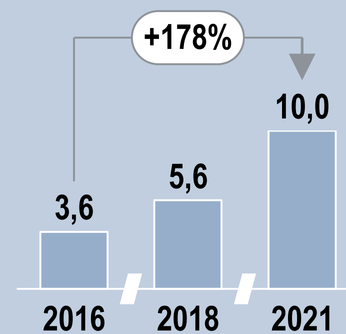
> An increase in middle-class incomes

… and high-speed broadband infrastructures, bolstering the growth of data generated beyond the increase in equipment

Data/smartphone traffic [GB/month, Global]



Data/tablet traffic [GB/month; Global]



The development and surge in new data-hungry digital usages made possible by the deployment of high-speed broadband infrastructure (4G, 5G, fibre optic) and geolocation technology: high-definition video streaming, video-conferencing tools, connected objects, cryptocurrencies, etc.

Widespread use of remote working on a larger scale (as a result of Covid-19), fostering an uptick in digital uses

Source: Usine Nouvelle, Ericsson (Mobility Report 2019), eMarketer, Roland Berger

3.

Electrical consumption by data centres is likely to continue to grow, despite improvements in their energy efficiency

Electricity consumption by data centres

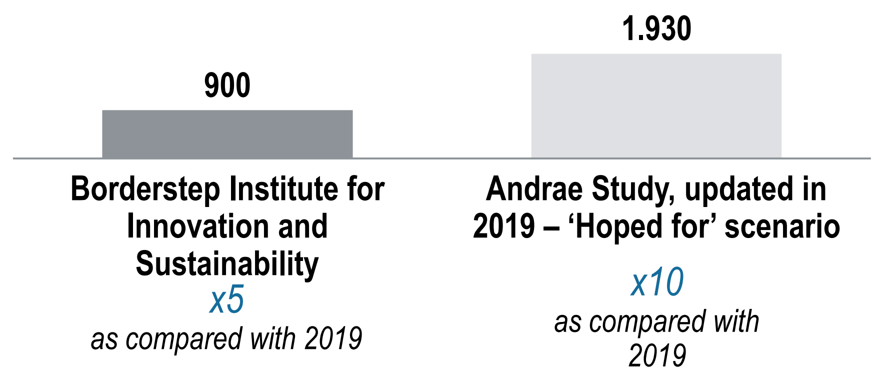
Recent situation

- **Cumulative data centre electricity consumption has been stable since 2015** and has not therefore had a significant impact on global electricity consumption, despite an increase in the number of data centres and data processed
- **Stability resulting from the increased energy efficiency of data centres,** made possible by the development of **'hyperscale' data centres** (on a large scale – 37% of data centres in 2019)

Historical energy consumption of data centres [TWh]

- **Convergence of bench-line studies and key players** regarding trends towards greater consumption by data centres: **energy efficiency gains will no longer be enough to offset the growth in data traffic in the coming years**
- **Divergence of** bench-line studies **on the speed of this growth**

Estimated data centre consumption in 2030 [TWh]



Future trends

Source: IEA (Tracking Buildings 2019), Borderstep Institute (Energy consumption of data centres worldwide), Roland Berger

Did you know?

The average outage time per customer in the USA was almost twice that of France in 2019, excluding exceptional events

Dubai – United Arab Emirates

~2 mins

France

~65 mins

USA

~115 mins

Senegal

~3 200 mins

Source: Enedis, US Energy Information Administration, Senelec, Roland Berger

B. Contribution of electrification to combat climate change

Electrification reduces CO_2 emissions, notably through the development of renewables

Contribution of electrification to combat climate change – Key figures

+2.3%
per year since 2000

Average annual rise in **CO_2 emissions** for a 3.2% annual rise in electricity demand

80%
by 2040

Share of renewable energy in additional generation capacities to be rolled out between now and 2040

No. 1
in 2040

Position of solar energy in total installed electricity capacity in 2040

1) Scenario based on public policy commitments in each region around the world
Source: World Bank, IEA (World Energy Outlook 2019), IRENA, United Nations, WHO, Roland Berger

Electrification will play a key role in combating climate change in terms of generation, grids and consumption

Contribution of electrification to **combat climate change**

For generation, **renewable energies should make it possible to significantly reduce the CO_2 emissions associated with electricity generation.** Between 2018 and 2040, renewable energies will therefore account for ~80% of additional generation capacity deployed for adherence to the 2°C target

'Sectorial coupling', leveraging different energy generation technologies, which is heavily reliant on electricity grid storage, will ultimately contribute to climate targets by bolstering the interoperability of all energy inputs, so that **more efficient use can be made of surplus or unavoidable generation**[1)] (renewable energy, heat, etc.)

For consumption, **electrification improves energy efficiency in several ways:** the greater intrinsic energy efficiency of electric motors as compared with combustion engines, deployment of sensors making it possible to manage and reduce electricity consumption, gradual reduction in electricity consumption in numerous day-to-day uses (computers, household devices, etc.)

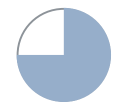
1) Unavoidable energy: quantity of energy lost since it is not recovered or re-purposed during the energy generation process, of which it is not the primary object

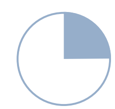
Source: Roland Berger

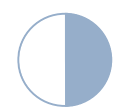
Electrification will play a key role in combating climate change, from its generation, the grid and its usage

Contribution of electrification to combat climate change – Agenda

Short-term contribution

1 **Production: growth of low-carbon production technologies**  *Page 22*

2 **Grid and storage: potential for sectorial coupling**  *Page 27*

3 **Usages: expected contribution of electricity to energy efficiency**  *Page 29*

Source: Roland Berger

1.

In 2015, 196 countries agreed to limit global warming to 2°C under the Paris Agreement by the year 2100

Paris Agreement

196 countries

Aims

To hold the increase[1)] in the global average temperature between now and 2100 to well below: **2°C**

To continue efforts to limit the increase[1)] in temperature to: **1.5°C**

Climate change – The Agreement acknowledges the existence of climate change and the importance of avoiding and minimising its effects

Ambitious – Every five years, countries will review their emissions reduction targets and will set more ambitious targets where possible

Finance – Rich countries will provide USD 100 billion to developing countries for measures to combat climate change between now and 2020

National contribution – A target was set for each country – The EU must reduce its greenhouse gas emissions by 40% by 2030.

Net zero by 2050 – Net global emissions must be reduced to zero in the second half of the 21st century

Renewable energies – **The Agreement calls for the development of renewable energy technologies to be accelerated and for the international exchange of technologies and know-how**

1) Average global temperature rise between 1850 and 2100 beyond which the consequences of climate change FOR ecosystems are deemed devastating.
Source: United Nations Organization, Roland Berger

1.

The tonne-equivalent of CO_2 is used as a benchmark for climate policies

N.B.: 1Gt = 1 billion tonnes

Tonne-equivalent of CO_2...

... in volume

(more than one double-decker bus)

10 m[1)]

...in distance travelled

(transport)

1 return journey from Paris to NYC by plane (per passenger)

14,000 km by car in town

... in food equivalent

250 kilos of beef

1.2 tonnes of bread

... in monthly emissions by country[2)]

1.2 Americans

0.4 French people

0.1 Indians

...in electricity generation time

(for a plant operating at full capacity)

6 secs for a coal-fired plant[3)]

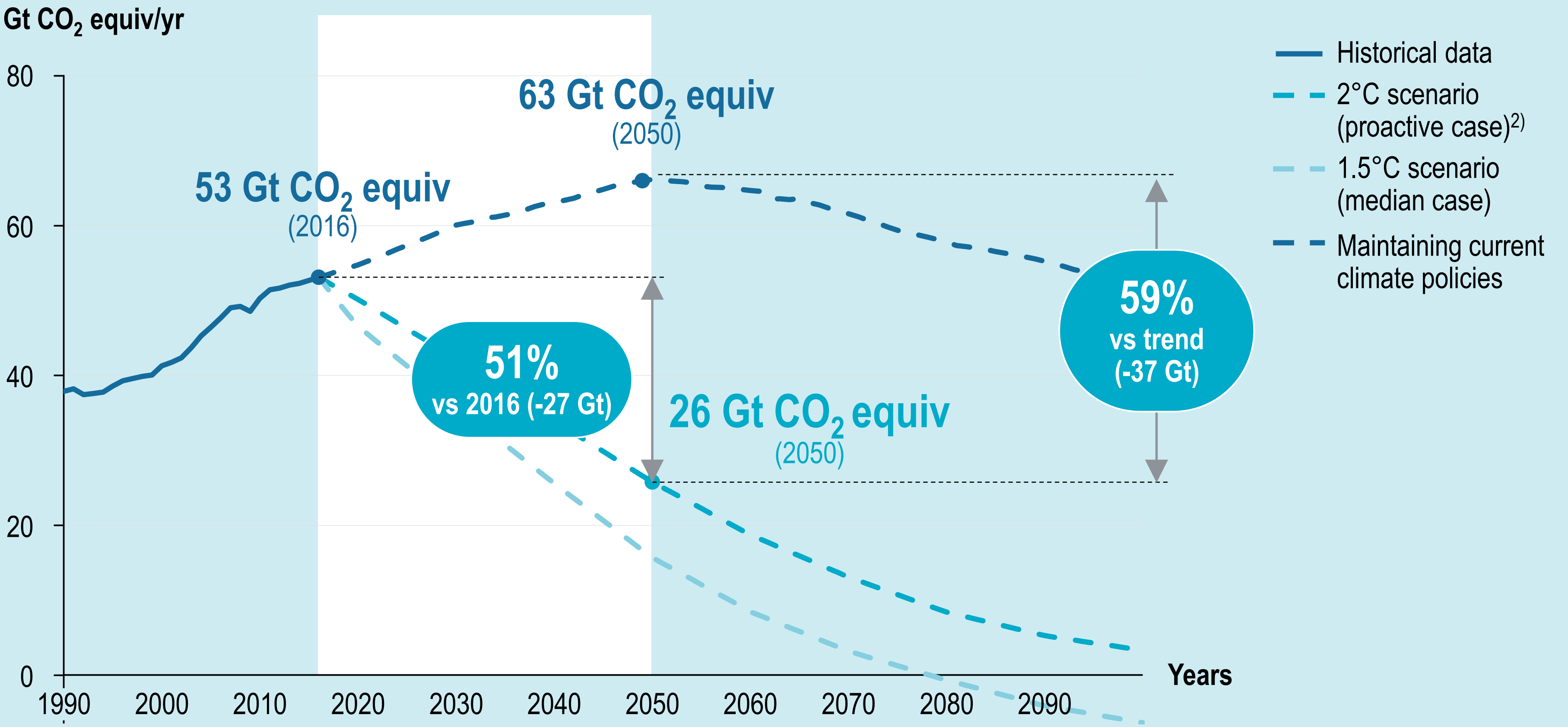
10 secs for a gas-fired plant[4)]

1) Bubble at atmospheric pressure and ambient temperature 2) Total CO_2 emissions of the country expressed as per inhabitant per month
3) Assumptions: electric power of 750 MW, 820 kg of CO_2 issued per MWh generated 4) Assumptions: 750 MW electrical power, 490 kg of CO_2 issued per MWh generated
Source: ConsoGlobe, United Nations Framework Convention on Climate Change (UNFCCC), EDF, Roland Berger

1.

Limiting global warning to 2°C means reducing greenhouse gases by half by 2050, compared with 2016 levels

Gross global greenhouse gas emissions of anthropogenic origin[1] [Gt CO_2 equivalent/year]



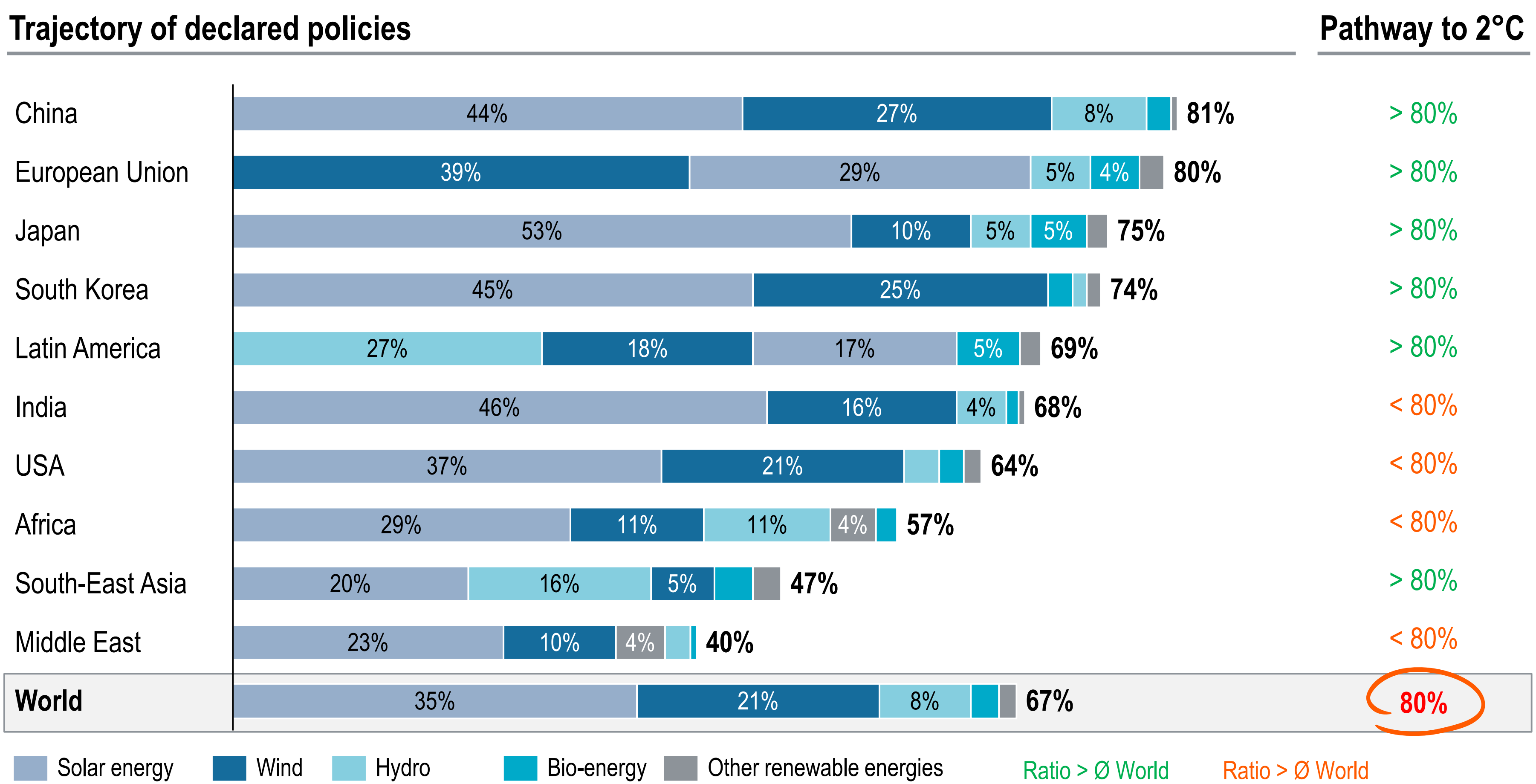
1) Historical data available up to and including 2014 (projected data for 2015-2020 re-processed 2) Intergovernmental Panel on Climate Change (IPCC) – Median scenario 2°C

Source: Electronic Data Gathering, Analysis, and Retrieval (EDGAR) database, Intergovernmental Panel on Climate Change, Roland Berger

1.

For the 2°C target, ~80% of additional generation capacities deployed between now and 2040 will be renewable energies

Share of renewables in additional generation capacities [2019-2040]



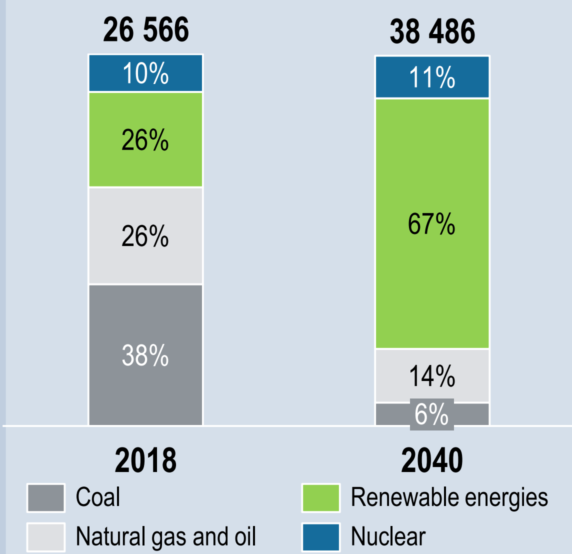
Source: IEA (World Energy Outlook 2019), Roland Berger

1.

CO_2 emissions should therefore fall by 8.6 Gt in 2040, compared with an emissions trend with a comparable generation mix

Estimate of CO_2 emissions avoided in 2040 – 2°C target

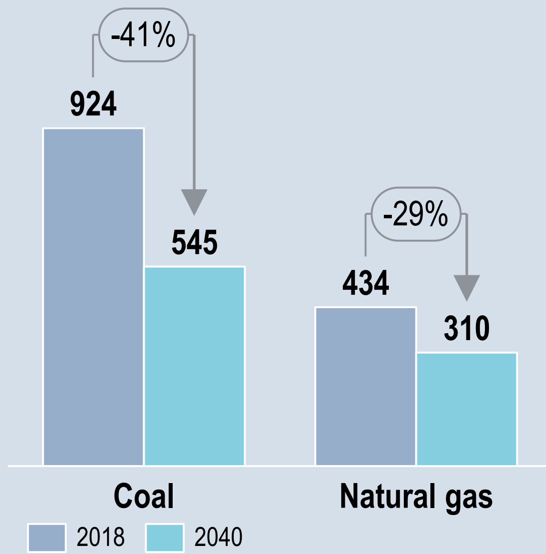
Electricity generation by source [TWh]



Growth in renewable energy generation resulting directly from an increase in installed capacities

+

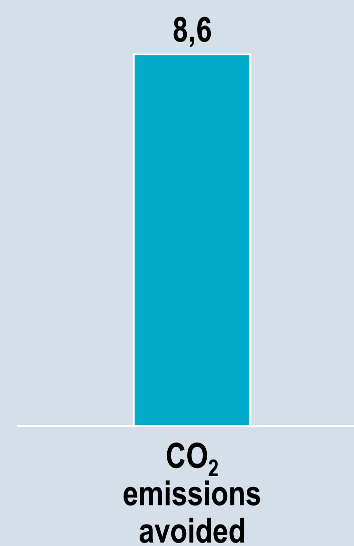
Direct emissions of CO_2 by source [gCO_2 / kWh]



Anticipated reduction in CO_2 emissions from generation sources thanks to technological progress

=

CO_2 emissions avoided in 2040 vs comparable mix trend [Gt]



Avoided emissions associated with electricity generation, compared with an emissions trend with a comparable generation mix

Source: IEA (World Energy Outlook 2019), Roland Berger

2.

By making energy flows interoperable, sectoral coupling will make it possible to make the most efficient use of surplus production

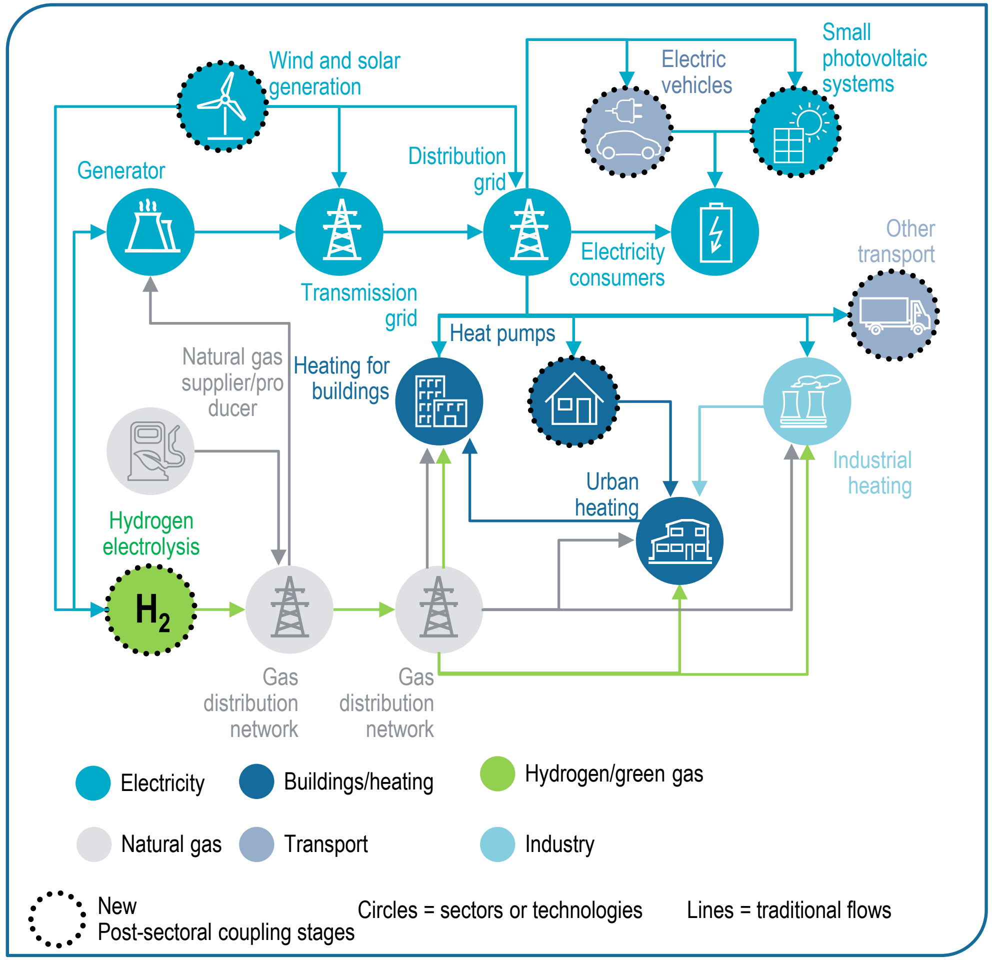
Sectoral coupling – Overview of the concept

> **Principle: efficiency by combining different energy flows** that had previously been separate, on complex sites

> **Source of value: recovery of unavoidable energy that was previously lost**

> **Technical means: energy storage** in the form of electricity (battery), heat or hydrogen (synthesis through electricity)

> **Outlook: development, through technological progress,** of digital (real-time/algorithmic management), renewables and storage (fall in costs)



Source: Bloomberg New Energy Finance (NEF), Roland Berger

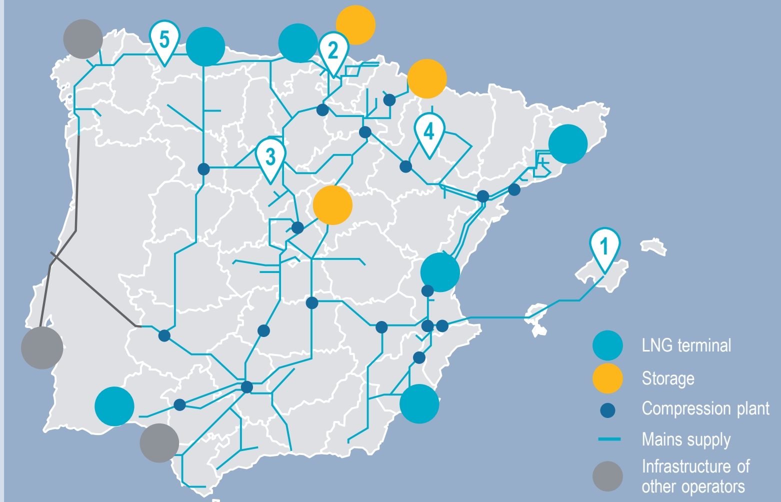
2.

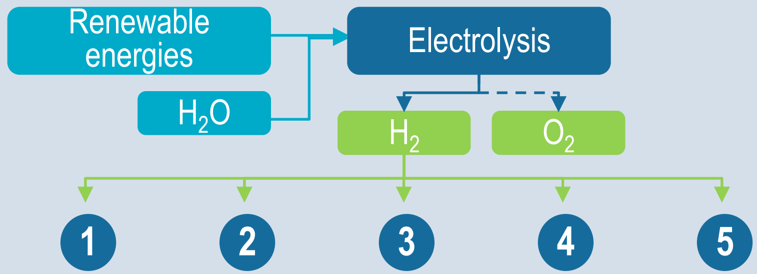
By way of example, the Green Spider project aims to interconnect electricity, hydrogen and natural gas on a large scale in Spain

Case study – Enagas Green Spider Project

Enagas Green Spider Project

- > **Generation of green hydrogen** in Spain, through electrolysis supplied by renewable means of generation
- > Creation of **5 industrial hubs** that convert hydrogen produced by different means
- > Development of a **grid for exporting** to the rest of Europe
- > **Key figures**: 1 GW of renewable - 0.5 GW of electrolysis - EUR 2 billion in investment





Hubs →	Balearic Islands	Basque Country	Castile and León	Aragon	Asturias
Hydrogen plants	✓				
Gas networks	✓		✓	✓	
Refineries/ industry		✓			
Trains			✓		
Underground storage			✓		
Ports					✓
LNG terminals[2)]					✓

1) LOHC = Liquid Organic Hydrogen Carrier 2) LNG = Liquefied Natural Gas
Source: Enagas (Hydrogen for Climate Action – Green Spider project), Roland Berger

3.

Electrification makes it possible to progressively and significantly improve the energy efficiency of numerous usages

Link between electricity and improved energy efficiency

Increased efficiency of electric motors as compared with combustion engines (transport, industry)

Page 30

> **Greater intrinsic** efficiency of the electric motor as compared with a combustion engine, together with **less local pollution**, leading to **progressive substitution** in **transport** (electric vehicles) and **industry**

> Possibility of equipping electric motors with **variable speed drives,** making it possible to adjust speed as needed in real time, to significantly reduce the associated energy consumption

Development of smart sensors and meters to optimise consumption

Page 31

> Development of **smart sensors/meters**:

- Providing a detailed and **real-time picture** of the **consumption** of a **building** (industrial, commercial, residential) or even of a specific **piece** of equipment
- Making it possible to **adjust and optimise electricity consumption** based on the data received
- Facilitating the switch between grid and **own consumption**

Continuous improvement of the energy efficiency of electricity usage

Page 32

> **Fall in average electricity consumption** of domestic electrical appliances, thanks to:

- Technological progress and improved performance
- Consumers who are more aware of their environmental impact
- Thermal renovation of old buildings

Source: Roland Berger

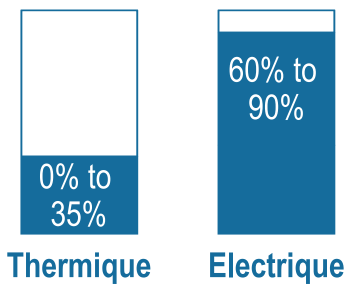
3.

More energy efficient than their combustion equivalents, there are now more electric motors in industry and transport

Case study – Electric motor

Transport

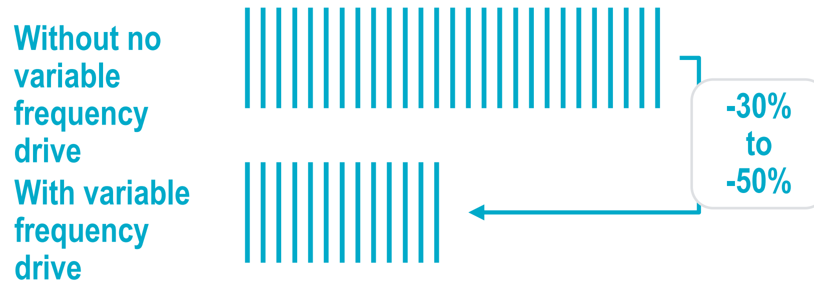
Typical energy efficiency of an engine



- **Electric** vehicles, accounting for **~10% of electricity consumption** in Europe by 2050 (as compared with just % in 2019)
- **Energy efficiency** of electric motors, higher overall than for combustion engines (which run on fossil fuels)
- **The ultimate impact** of electric motors on the fall in greenhouse gas emissions will greatly depend on the **electricity generation method**

Industry

Energy consumption of an electric motor



- Since **energy** is a **major item of expenditure in industry,** it is increasingly using electric motors **since they are intrinsically more efficient** than their combustion equivalents for numerous applications. This leads to a consequent reduction in local pollution.
- **Electric motors** can be equipped with **variable speed drives,** making it possible to adjust the speed as needed in real time (as opposed to running in nominal mode at a constant speed), to **significantly reduce the** associated energy consumption

Source: European Environment Agency, A&H Conseil, press review, Roland Berger

3.

Through the use of smart objects and data processing, electrification can also improve energy efficiency

The example of electricity sensors and meters – Main advantages

NON-EXHAUSTIVE

Measurement of electricity consumption in **real time, segmented by usage**

Individuals

- **Greater sense of responsibility and awareness among consumers**: better direct control of consumption, making it possible to achieve energy savings over time
- **Billing** based on actual consumption

Industry

- **Virtually instant readjustment** (for example, based on the price of electricity)
- **Targeting of energy savings** over time (for example, operating smart industrial facilities at their maximum efficiency, alerts about consumption by certain equipment)

Tertiary sector

- Facilitation of **self-generated energy consumption**: switch in real time from own consumption of renewable energy to exchanges with the national grid when supply is intermittent

Finally, less need for new power plants:
better management of electricity consumption, making it possible to limit greenhouse gas emissions

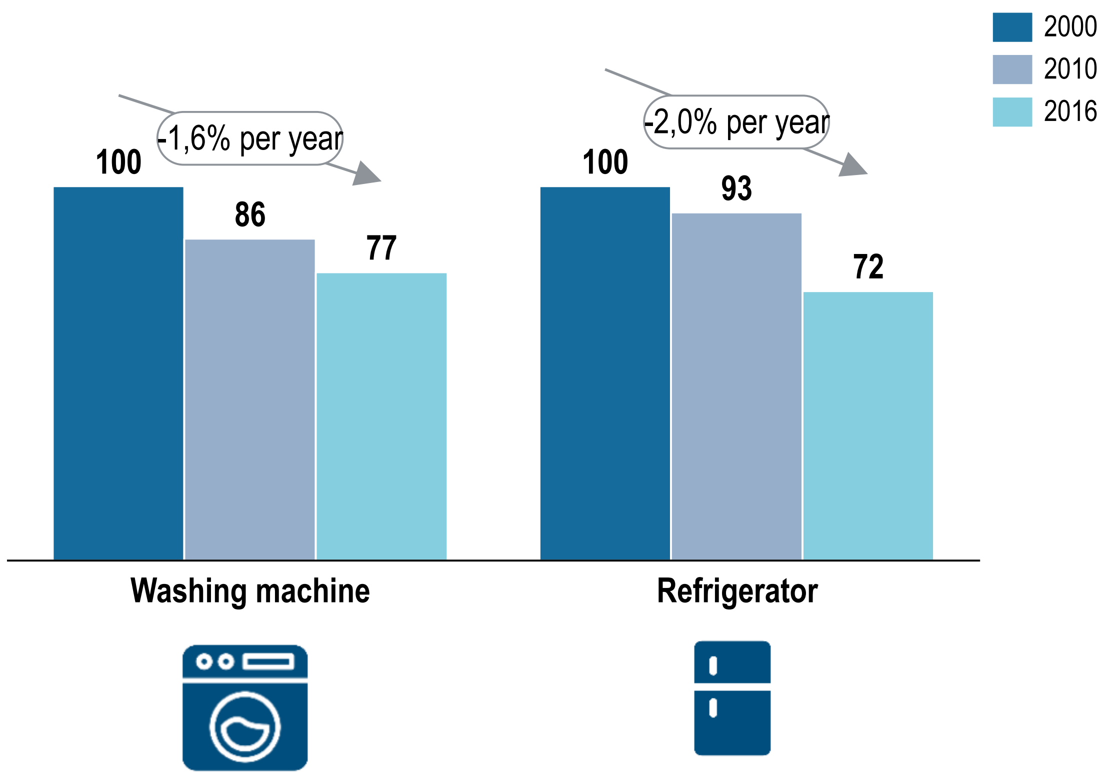
Source: Smart Energy GB (Smart Energy Outlook), Roland Berger

3.

Finally, the energy efficiency of electricity usage is being continuously improved

Case study – Electricity usage

Average electricity consumption of domestic appliances
[Baseline 100 in 2000; Europe]



> **Main factors contributing to a fall in the average energy consumption** of household electrical appliances

- **Technological progress:** new appliances intrinsically more efficient and less energy-intensive
- **More responsible** user **behaviour**
- **Thermal renovation of housing:** better insulation, reducing electricity consumption associated with heating or air conditioning

> **Gradual expansion of the housing stock,** contributing to an increase in consumption that does not undermine energy efficiency gains

Source: European Environment Agency (Progress on Energy Efficiency in Europe), Roland Berger

If economic deceleration becomes necessary, electrification will be all the more essential

Impact of a scenario of deliberate economic deceleration on electrification

Electricity remains **essential to human development**

The entire global population must have **access to electricity from 2030 onwards,** to ensure adherence to the +2°C target

Examples of impact on **human development:**

> Better access to **education**

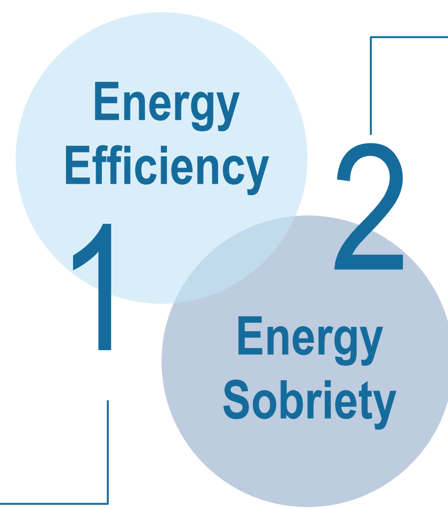
> Further expansion of the **healthcare system**

2 conditions are necessary, but are not sufficient in themselves (more far-reaching lifestyle changes are required), **for achieving a scenario of deliberate economic deceleration**

Technical condition

Continuous improvement of **usage efficiency** across all sectors (construction, industry, transport)

Substitution effect: switch from highly polluting usages to electricity



Behavioural condition

Promotion of certain **alternative sectors** (low-impact transport)

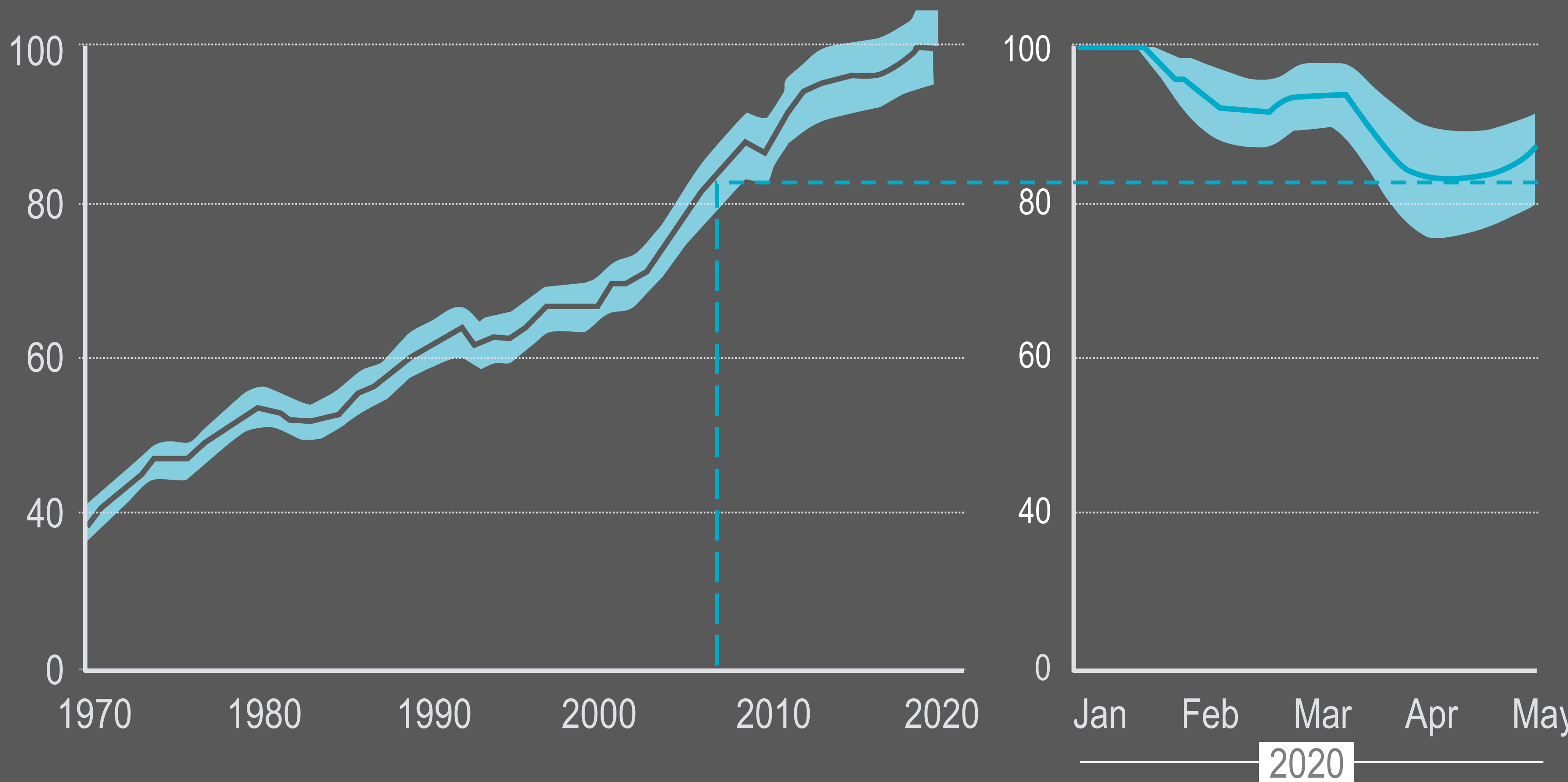
Promotion of **new behaviours** (remote working) and acceptance of a reduction in **comfort level** (air conditioning)

Source: Roland Berger

Did you know?

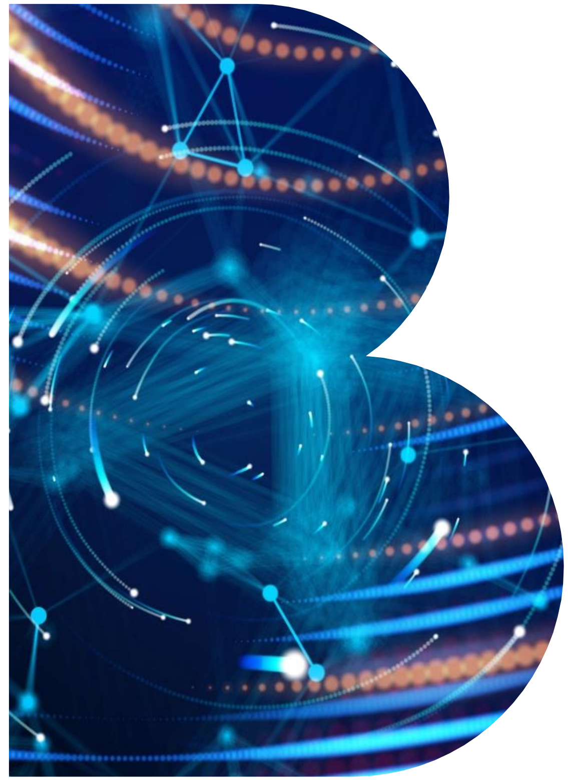
While the fall in global fossil fuel-based CO_2 emissions during the Covid-19 pandemic was impressive, it was merely equal to the average level in 2010

Daily average fossil-fuel-based CO_2 emissions [Mt CO/day]



Source: The Global Carbon Project, Roland Berger

C. Contribution by electrification to the development of new economic models



Looking beyond the established players, new economic models and players are emerging in the electricity ecosystem

Impact of electrification on economic models – Summary

Decentralised models

Emergence of **new players** with business models associated with the decentralisation of energy

Energy As a Service models

Emergence of new energy models and sales methods associated with usage rather than the asset itself

New intermediaries

Emergence of numerous digital technology-based start-ups, setting themselves up as new intermediaries

Source: Roland Berger

Looking beyond the established players, new economic models and players are emerging in the electricity ecosystem

Contributions by electrification to the development of **new economic models**

The **decentralisation of electricity generation** has contributed to the emergence of new players alongside the established players: generation and flexibility aggregators, energy brokers, *peer-to-peer* platforms that connect producers with consumers

In line with the trend already seen in many sectors, **energy is gradually switching to an 'as-a-service' model,** repositioning players in the value chain: e.g. increasing flexibility of uses, payment for services provided, and no longer for the infrastructure

Numerous **digital start-ups** are providing technology-based asset and energy management **services and** setting themselves up as **new intermediaries**

Source: Roland Berger

These models are mainly associated with the decentralisation of generation and the development of new services

Impact of electrification on economic models – Agenda

Source: Roland Berger

1.

The decentralisation of energy generation has contributed to the emergence of alternative models to those of established players

Economic models and activities associated with energy decentralisation

NON-EXHAUSTIVE

(Flexibility) aggregators

- > **Intermediaries** facilitating access to the **capacity market** for 'small players' (including consumers): aggregation and **capitalisation on the flexibility** of these players, paid on the basis of the availability of their **load management response**
- > **Solution enabling customers to reject the load management response** as they choose (risk assumed by the aggregators)

(Generation) aggregators & developers

- > Aggregators of supply (capacities) and demand (needs) through the **creation of virtual power plants** (VPPs) that can be managed remotely and in real time
- > Solution replacing **power purchase obligation agreements and** enabling small producers to access the **electricity market**

Energy brokers

- > Marketplaces **that ensure supply matches demand** between the commodity price agreements and the main suppliers
- > Peer-to-peer marketplaces for **flexibility services**

'Peer-to-peer' matching players

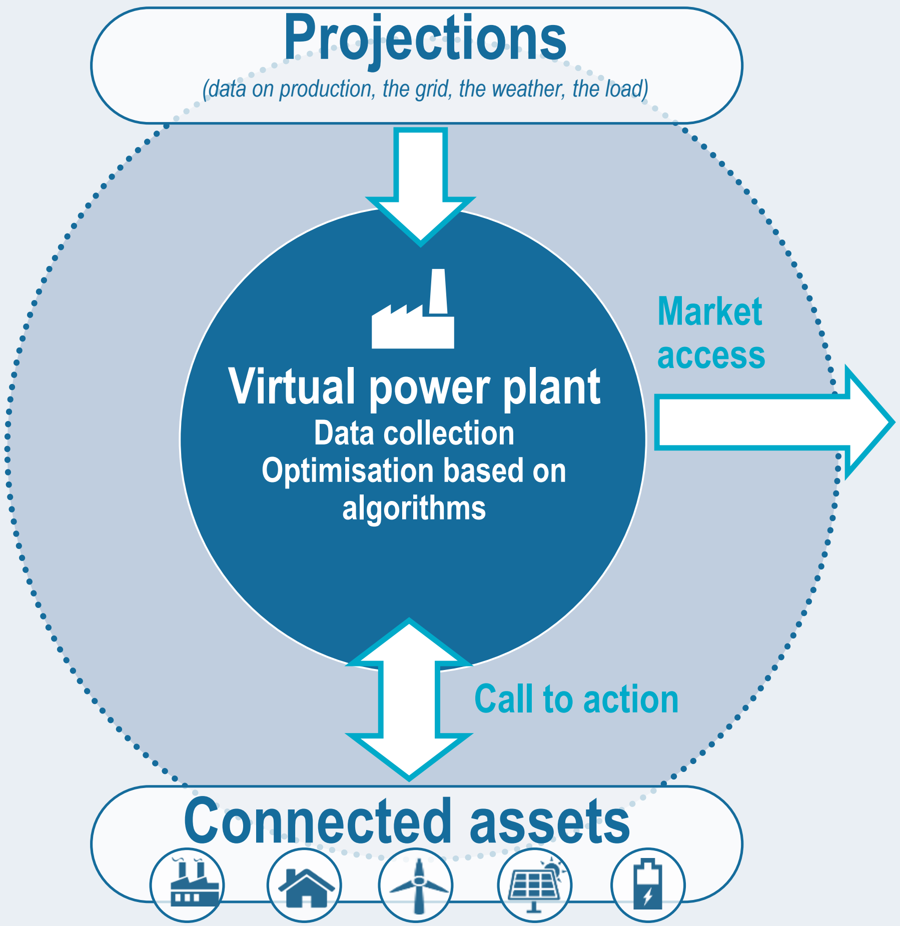
- > **Direct matching of consumers with producers** (disintermediation)
- > A solution aimed primarily at providing **green and own production energies** and to making the pricing policy transparent and easy to understand
- > 100% digital **subscription pathway**

Source: press review, Roland Berger

1.

An aggregator manages and makes the most efficient use of decentralised capacities on the energy markets using high-performance information systems

Case study – Aggregator: 'virtual power plant' value chain



Concept of the virtual power plant (VPP)

Portfolio of power generation assets used by an assets manager to **pool and optimise market access** for decentralised players, sometimes with small-scale storage

Operating generation units grouped together as a **single resource**

Optimisation of the virtual power plant by adding it to **the grid**

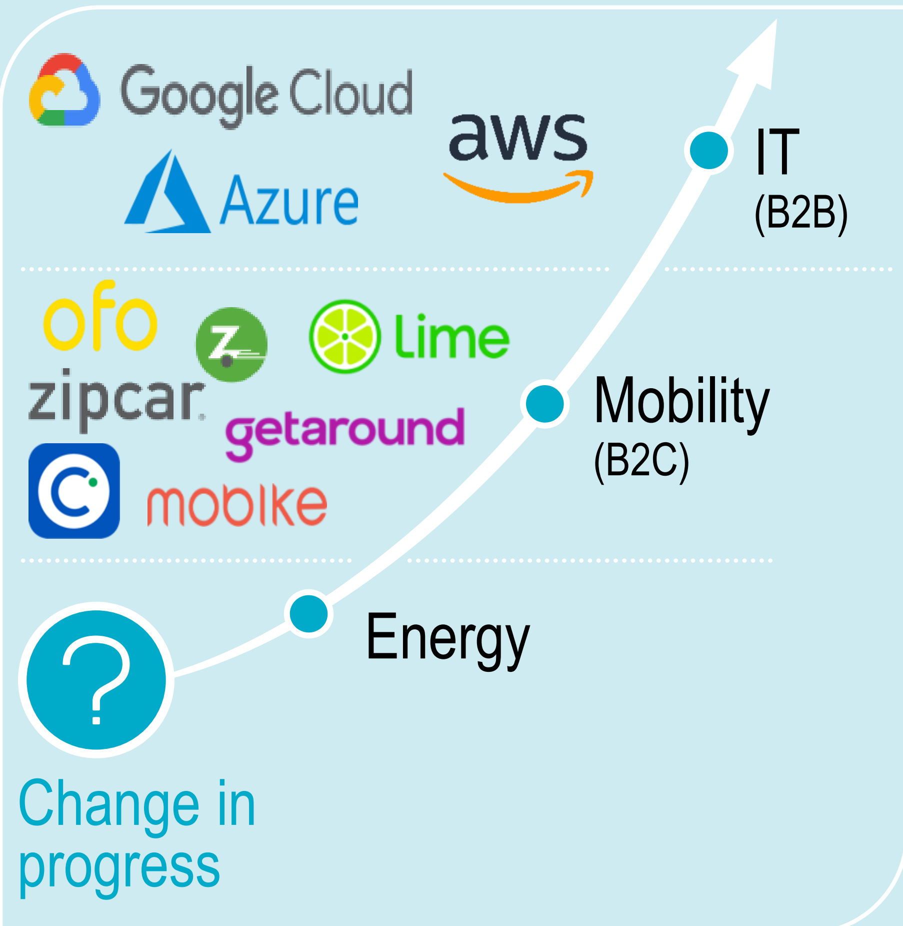
Association with the **concept of the 'Internet of Energy'**:
a grid equipped with numerous **information technologies** making it possible to **control remotely and in real time** the means of generation (for example, based on the weather, changes in electricity prices, etc.)

Source: press review, Roland Berger

2.

In line with the trend already seen in many sectors, energy is gradually switching to an *'as-a-service'* model

Energy as a Service (EaaS) – Explanation of the concept



The 5 distinctive features of *Energy as a Service*

- **New offering**: grouping together multiple services with a guaranteed minimum level, concentration of the supply on the customer experience
- **Infrastructure financed by the services** (and no longer by the commodity): billing customers based on the quantity of services used
- **Flexible contracts**: change in the types of B2B contracts (not aligned with the life cycle of the infrastructure – 10, 20, 40 years)
- **Broad customer base**: offsetting the shorter contract term with a broader customer base to ensure sufficient income
- **More direct market**: standardisation of direct sales using digitalisation, in contrast to the historical model (wholesale sales + B2B retail sales - bypassing intermediaries)

Source: Roland Berger

Several *'as-a-service'* models are possible and can be combined – Players who capture increased value are evolving

Economic models and activities linked to energy services

Major drivers of the *'as-a-service' model*

Societal
> Capitalising on the sharing economy
> Decline in the perceived value of ownership (Millennials)

Corporate
> Concentration on core business and outsourcing other functions
> Balancing and budgeting of expenditure (from CAPEX to OPEX)
> Pooling of risks linked to the assets and reduction in balance sheet size

Technological
> Facilitation of sharing through digital technologies

	Ownership (purchase)	**Financing** *(leasing)*	**Subscription** *(pay-per-use)*	**Platform** *(pooling)*
Definition	Provision of a financing solution for the customer's asset	Leasing of an asset for a defined period	Asset made available to a single customer on request, fixed and/or variable remuneration	Asset made available to several customers on request, fixed and/or variable remuneration
Ownership of the asset	Customer	Customer	Provider	Provider
Risk	> Default	> Intercontract > Costs linked to usage	> Utilisation rate > Costs linked to usage	> Utilisation rate > Availability of the assets in the event of simultaneous usage > Costs linked to usage
Return	Low	Average	High	High

With the *'as-a-service' model*, the value-added is progressively captured by the suppliers of technological equipment and services (including platforms)**, and no longer by the established commodity providers**

Source: Roland Berger

3.

Digital start-ups, as new intermediaries, provide technological services (sensors, data, software)

Economic models associated with *'smart buildings'* and *'smart grids'*

NON-EXHAUSTIVE

Categories	Proposed solutions	Start-ups
Planning of grid investments	> **Software solutions** facilitating the work of **grid planners** > Examples: digital twinning, investment planning solution	ADAPTRICITY, COSMOTECH, SENSEWAVES, TOPPLAN
Grid management	> Data-based solutions enabling **predictive maintenance, evaluation** of grid performance and energy losses, as well as **real-time monitoring and historical analysis** of load and congestion (dynamic management) > Examples: real-time overview of grid status, assistance in exploiting smart meter data	neelogy, Odit-e, intesens THE CONNECTED MAINTENANCE, Greenbird
Monitoring cable status	> Monitoring cable status and **fault detection** through **signal and wave-based** technologies > Examples: close monitoring of cable status across the grid, reduction in the risks of cable faults	wirescan DIGITAL, WiNMS
Management of energy consumption data	> Use of **data from existing sensors/owners** to be able to offer **software solutions that optimise energy consumption** (primarily used in buildings) > Examples: optimisation of energy consumption in buildings using Internet of Things (IoT) devices (connected objects) made available from a data hub to the data analysis service	DCbrain, Deepki, opinum, smappee, energisme

Source: Energy Utility Week, Crunchbase, corporate websites, Roland Berger

Did you know?

The Smart City concept is nothing new, but very few towns and cities have yet managed to put it into practical effect over a given area

Cities around the world that have declared their **Smart City ambitions** — **~250**

Cities that have drawn up **plans** demonstrating a **global strategic approach** — **15**

Cities that have achieved an **advanced stage of implementation** — **8**

To be deemed effective, the strategic plan must be founded on **3 focus areas**

> **Lines of action** (e.g. changes in mobility, e-services)
> **Planning** (e.g. dedicated budget and personnel, measurable targets)
> **Infrastructure and policies** (e.g. legislation and regulations, high-speed broadband)

To assess the implementation of the Smart City concept, **4 factors** are examined

> Appointment of **project managers**
> Quantity of **lines of action** actually covered
> **Progress** of the project as a whole
> Establishment of a **monitoring framework**

Source: Roland Berger Smart City Strategy Index

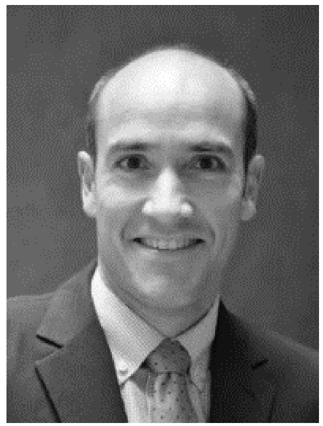
Roland Berger

The authors of this study will gladly respond to your questions, comments or suggestions.

Authors

Emmanuel Fages
Partner

emmanuel.fages@rolandberger.com
+33 1 53 67 03 90



Baptiste Maisonnier
Principal

baptiste.maisonnier@rolandberger.com
+33 1 53 67 09 45

Dimitri Fournier
Project Manager

dimitri.fournier@rolandberger.com
+33 1 70 39 41 36

Source: Roland Berger

Roland
Berger
THINK:ACT