World Economic Forum

In collaboration with Accenture

Shaping the Future of Energy and Materials
System Value Framework and Analysis Summary
October 2020

System Value of the clean energy transition

The System Value framework more holistically evaluates economic, environmental, social and technical outcomes of potential energy solutions across markets. The framework aims to **shift political and commercial focus beyond cost to include value**.

Using the System Value framework, the World Economic Forum, supported by Accenture, conducted analysis across several geographies as part of market evaluations **that examined recovery opportunities to accelerate economic growth and the clean energy transition**.

The flexible nature of the framework allows inclusion of both quantitative and qualitative analysis. The relevance of System Value dimensions may vary by geography and over time horizons.

Note: Above hexagons represent desired outcomes

Testing System Value with market solutions

Solutions were selected, in consultation with 25+ participating companies and 50+ global stakeholders, that deliver the **most impactful** outcomes per market **to accelerate economic growth and the clean energy transition** on a 2025 or 2030 horizon.
For further detail on each market, please see subsequent executive summary slides.

Brazil

87% Renewables
9% Variable

90+ Mt Cumulative CO_2 Emissions through 2025

- **Non-Hydro Renewables Expansion**
- **Digitalization of Transmission and Distribution**
- **Smart and Efficient Cities**

India

21% Renewables
10% Variable

550+ Mt Cumulative CO_2 Emissions through 2025

- **Renewable Energy Zones**
- **Distributed Solar**
- **Transmission Investment**
- **Efficiency Investment**
- **Coal Plant Closures**

China

29% Renewables
8% Variable

660+ Mt Cumulative CO_2 Emissions through 2025

- **Utility-Scale Wind and Solar**
- **Distributed Energy**
- **Internet of Energy**
- **Efficiency Investment**
- **Transport and Industrial Electrification**

South Africa

7% Renewables
5% Variable

- **Grid and Operational Upgrades**
- **Renewables Growth through FDI**
- **Repurpose of Coal Plants**
- **Distributed Solar**
- **Efficiency and Energy Management**

Europe

39% Renewables
16% Variable

*2,000+ Mt Cumulative CO_2 Emissions through 2030

- **Connected Cities and Electrification**
- **Renewables, Power Markets and Networks of the Future**
- **Hydrogen Economy**

*European analysis was conducted on a 2030 horizon to match Next Generation EU, with other markets focused on 2025.

United States

19% Renewables
11% Variable

520+ Mt Cumulative CO_2 Emissions through 2025

- **Renewables Expansion**
- **Transmission Investment**
- **Efficiency Investment**
- **Electrification and Demand Optimization**

Notes: (1) Above renewable and variable renewable figures refer to share of generation mix using 2019 data from BNEF and IEA. (2) Market solutions and resulting quantification are meant to be examined within context of the given market, rather than compared across markets. Certain System Value dimensions for some solutions were not able to be quantified. South Africa analysis scheduled to be released in November 2020. (3) CO_2 emission reduction represents reduction relative to base case. Mt = million (metric) tonnes.

Brazil recovery solutions

Solutions to deliver power sector modernization

Non-Hydro Renewables Expansion

Accelerate non-hydro renewables expansion (~7 GW wind and solar) through multiple initiatives such as fostering the liberalized market (ACL) with **innovative power purchase agreements (PPAs)**, **developing a new structured solution for the Energy Reallocation Mechanism (MRE)**, and **fossil thermo-plant substitution**.

34 Mt
Less CO_2 emissions from electricity generation through 2025

>132k
Direct and indirect jobs created from wind and solar through 2025

$2.8bn
Human health benefits from air quality improvements through 2025

Note: Above CO_2 and human health benefit figures represent cumulative, incremental savings in addition to 2025 base case projections.

Digitalization of Transmission and Distribution (T&D)

Address reliability and power quality issues through foundational **distribution network investments**, then digitize and modernize Brazil's grid through **smart grids**, **smart meters**, **internet of things (IoT)** and **distributed energy resources (DER)**.

14 Mt
Less CO_2 emissions from electricity generation through 2025

Up to 29k
Potential jobs created by grid digitalization initiatives

$1bn
Human health benefits from air quality improvements through 2025

Note: Above CO_2 and human health benefit figures represent cumulative, incremental savings in addition to 2025 base case projections. Estimated job potential based on US figures, adjusted for population.

Smart and Efficient Cities

Invest in smart cities via development of a **digital energy network**, enabling **energy efficiency and new business models** to support **distributed generation**, DERs and electric mobility, as well as public services such as **public lighting and vegetation management**.

45 Mt
Less CO_2 emissions from electricity generation through 2025

1m
Potential jobs across smart buildings, appliances, efficient lighting

$3.4bn
Human health benefits from air quality improvements through 2025

Note: Above CO_2 and human health benefit figures represent cumulative, incremental savings in addition to 2025 base case projections. Estimated job potential based on US figures, adjusted for population.

China recovery solutions

Solutions to deliver peak emissions before 2030

Utility-scale Wind and Solar

New utility-scale solar and wind capacity growth (incremental +282 GW wind, +173 GW solar by 2025) **and cost competitiveness** are boosted by falling levelized cost of energy (LCOE) of variable renewables alongside **government mandated renewable share target**.

276 Mt
Less CO_2 emissions from electricity generation through 2025

1.3m
Total incremental jobs created through 2025

$14.1bn
Human health benefits from air quality improvements through 2025

Distributed Energy

Distributed energy is set to nearly triple over the next five years (incremental +138 GW distributed solar by 2025) as urbanization continues, costs fall, and subsidies support distributed and rooftop solar.

82 Mt
Less CO_2 emissions from electricity generation through 2025

1m
Total incremental jobs created through 2025

$4.2bn
Human health benefits from air quality improvements through 2025

Internet of Energy

Continuous digital transformation of the power grid promotes **smart grid** developments and eventually the construction of a new digital energy ecosystem – **the Internet of Energy**.

56 Mt
Less CO_2 emissions from electricity generation through 2025

$2.8bn
Human health benefits from air quality improvements through 2025

Efficiency Investment

Efficiency opportunities across the value chain such as **grid, buildings, and industrial energy efficiency** can reduce load, driven by government energy saving policies.

90 Mt
Less CO_2 emissions from electricity generation through 2025

$4.6bn
Human health benefits from air quality improvements through 2025

Transport and Industrial Electrification

For transport, accelerate the construction of **charging infrastructure** and ongoing **electric vehicle (EV) purchasing subsidies**. For industry, continue to transform and **electrify manufacturing processes**.

160 Mt
Less cross-sector CO_2 emissions through 2025

1.8m
Total incremental jobs created through 2025

$8.2bn
Human health benefits from air quality improvements through 2025

Note: Above CO_2 and human health benefit figures represent cumulative, incremental savings through 2025 compared to 2025 baseline.

Europe recovery solutions

Solutions to deliver the 2030 ambition

Connected Cities and Electrification

To continue decarbonizing Europe's cities, increase efficiency of power use and distributed energy resources, leverage **digitalization** and **demand optimization** for greater **smart flexibility**, and accelerate **electrification** through transition to **e-mobility** and **decarbonized heating systems.**

263 Mt
Less CO_2 emissions from electricity generation and heating in 2030

680k
One-year jobs created through 2030 (EVs and efficiency)

€36bn
Human health benefits from air quality improvements in 2030

Costs
€34bn
Incremental EU efficiency and EV charger investment through 2030

Note: Above CO_2 and human health benefit figures represent incremental savings in addition to 2030 base case projections.

Renewables, Power Markets and Networks of the Future

Transform grids, networks and power markets to support increased variable renewable and distributed resources, enabling a grid with **55%-60% share of wind and solar by 2030 and >70% renewables.**

By 2030, variable renewables will power a larger share of transport, heating and industrial applications, which currently are not electrified.

117 Mt
Less CO_2 emissions from electricity generation in 2030

€43bn
Human health benefits from air quality improvements in 2030

Costs
€152bn
Projected capital expenditure in electricity transmission in EU28 to 2030

Note: Above CO_2 and human health benefit figures represent incremental savings in addition to 2030 base case projections.

Hydrogen Economy

Build a **green hydrogen** market and infrastructure to enable cost-effective bulk hydrogen transport, storage of renewable energy and **decarbonization of Europe's 3,000 industrial clusters** (representing 54 million jobs).

529 Mt
Less CO_2 emissions from industry in 2050

Up to 900k
Estimated jobs from blue and green hydrogen in 2050

Costs
€16-31bn
Investment in new infrastructure per year up to 2050

Note: Emissions reduction from bringing industrial emissions to zero by 2050.

India recovery solutions

Solutions to accelerate renewables investment

Renewable Energy Zones

Accelerate utility-scale wind and solar (incremental +9 GW wind, +12 GW solar by 2025) through developing **renewable energy zones** that would take a **proactive approach to transmission** planning, thereby **lowering the project risks for developers**.

Distributed Solar

Speed growth of the Indian distributed solar sector (incremental +6 GW solar by 2025) through **establishment of public-private partnerships** and **KPI-based incentives for states**.

Transmission Investment

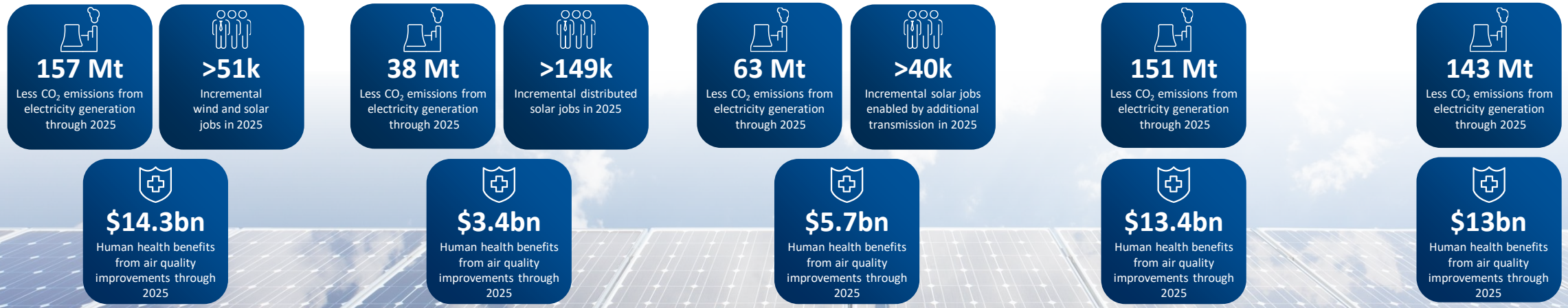
Invest in vital transmission infrastructure through **privatization efforts, renewable energy zones** and **acceleration of existing opportunities such as green energy corridors**.

Efficiency Investment

Bolster efficiency through **improvements to air conditioning, agricultural pumps, industrial efficiency and building standards**, while increasing focus on reducing transmission and distribution losses.

Coal Plant Closures

Accelerating coal plant retirement for sites that are considered financially and operationally "stressed" would lead to 41% incremental increase over current planned closures by 2025.



Note: Above CO_2 and human health benefit figures represent cumulative, incremental savings in addition to 2025 base case projections.

United States recovery solutions

Solutions to improve resiliency

Renewables Expansion

Proposed **multi-year extensions of the investment tax credit (ITC) and production tax credit (PTC)** could increase **solar** capacity by 25% (+33 GW) and **onshore wind** by 14% (+22 GW) over 2025 base case projections, with additional ITC, process and infrastructure support able to expand the nascent **offshore wind** industry (+11 GW).

300 Mt
Less CO_2 emissions from electricity generation through 2025

250k
Incremental jobs created in 2025

$34bn
Human health benefits from air quality improvements through 2025

Costs

$25-29bn
Present value cost to government of ITC/PTC extension through 2025

Transmission Investment

Potential to increase renewable deployment, wind capacity by 11% (+18 GW) and solar by 2% (+3 GW) in 2025, through **transmission expansion, interconnection and reinforcement**.

121 Mt
Less CO_2 emissions from electricity generation through 2025

60-110k
Incremental jobs created in 2025

$14bn
Human health benefits from air quality improvements through 2025

Efficiency Investment

Replicating the investment level of the 2009 US Recovery Act, the US could achieve efficiency gains through implementing **smart buildings and energy infrastructure**, keeping energy costs low for consumers.

103 Mt
Less CO_2 emissions from electricity generation through 2025

550k
One-year jobs created through 2025

$12bn
Human health benefits from air quality improvements through 2025

Costs

$20bn
Potential investment through recovery stimulus

Electrification and Demand Optimization

Greater support for **battery storage systems, road transport electrification and electric heat pumps** can boost system flexibility and reliability while cutting emissions.

5-9 Mt
Less cross-sector CO_2 emissions through 2025

22-25k
Incremental jobs created in 2025

$2bn
Human health benefits from air quality improvements through 2025

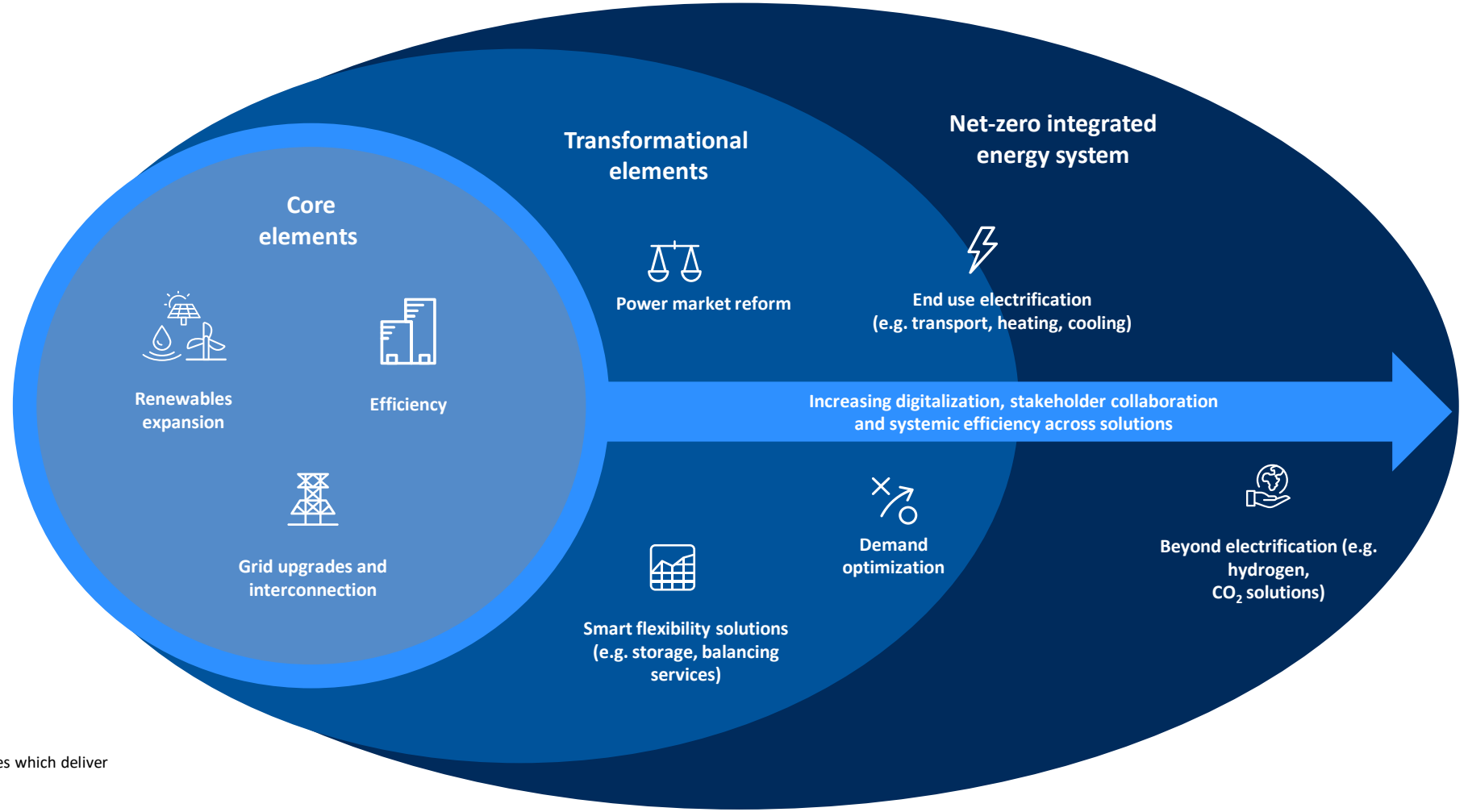
Note: Above CO_2 and human health benefit figures represent cumulative, incremental savings in addition to 2025 base case projections.

Path to maximize System Value

Markets are moving from addressing core elements of the electricity sector transition…

…through "pivot points" where generation mix hits 20-30% annual variable renewables (>50% instantaneous) and transformational elements enable…

…acceleration to a net-zero integrated energy system with a strong focus on systemic efficiency



Note: Icons represent solution types which deliver System Value outcomes

Key insights along the path

Path summary

The expansion of renewables, grid upgrades and interconnections, and efficiency are core elements – these solutions remain essential throughout the path to an integrated energy system.

As markets transition to 20-30% annual variable renewables (>50% instantaneous) in the electricity generation mix, policy must take an integrated approach, instead of viewing supply and demand in isolation.

Getting to net zero in transport, industry and heating **requires an integrated energy system, supported by strategic linking of energy sectors, systemic efficiency and high levels of clean electrification**.

Systemic efficiency is more than just reducing load and losses, it is optimizing synergies between (and within) supply and demand, leveraging digital technologies and avoiding additional capacity investments.

Additional insights

Net-zero industrial consumption needs significant green generation and grid buildout, combined with CO_2 solutions. Renewables alone would need to more than double to meet the energy need of industrials (electrification, green hydrogen) in a net-zero system.

Energy security is no longer solely about oil and gas imports/exports, with cyber and natural disaster events increasing. Renewables, interconnections, increased diversity of sources, storage, aggregators and supply chains will contribute more to energy security.

Hydropower and natural gas can be accelerators for variable renewables by providing grid flexibility services and seasonal storage.

With the right policies in place, technology and financing will not be the barriers hindering net-zero goals. Greater stakeholder collaboration can improve administrative and regulatory processes such as permitting (e.g. offshore wind).