



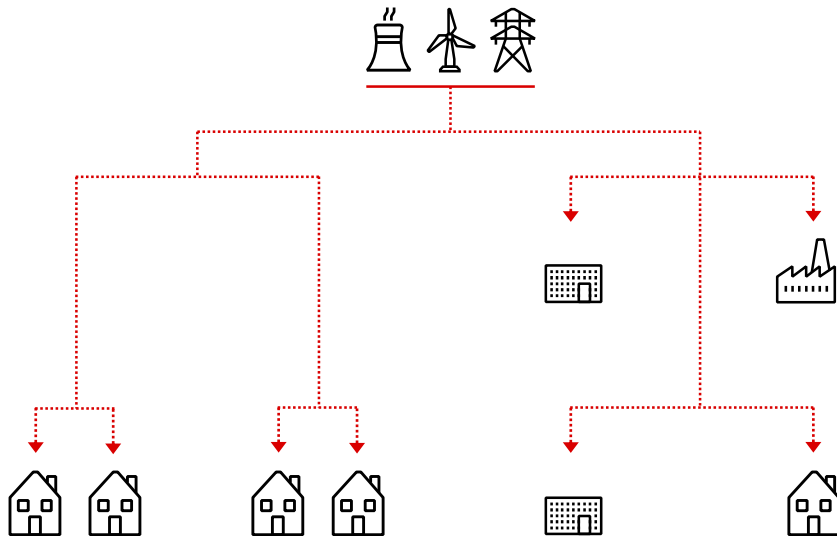
Energy Storage for micro- and mini-grids in urban and rural Africa

Maxine Ghavi, Group SVP, Program Director Microgrid, ABB

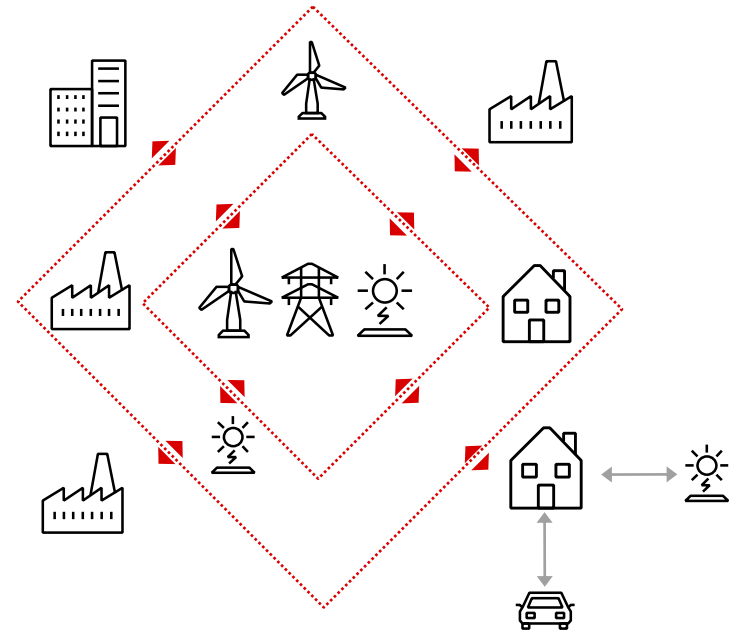
Energy and grid transformation

Transition from a centralized to a distributed grid

Traditional grid



New grid

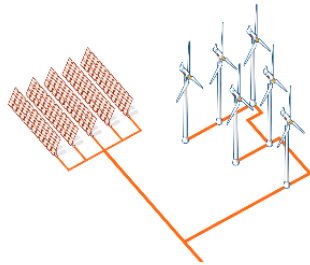


New developments are accelerating the transition

Energy and grid transformation

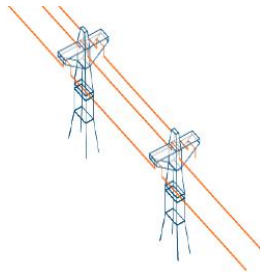
Global trend – Big shift in the electrical value chain

Generation mix



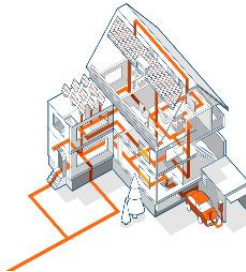
Renewable share: ~40% of capacity by 2035
Greater volatility, less predictability
More feed-in nodes

Power transmission and distribution



Increasing complexity
Control/ information flow is key value driver
Transmission: Longer distances, higher voltages

Micro-/ Nano-grids



On-and off-grid
Control/ automation on “local” level
Energy storage is key

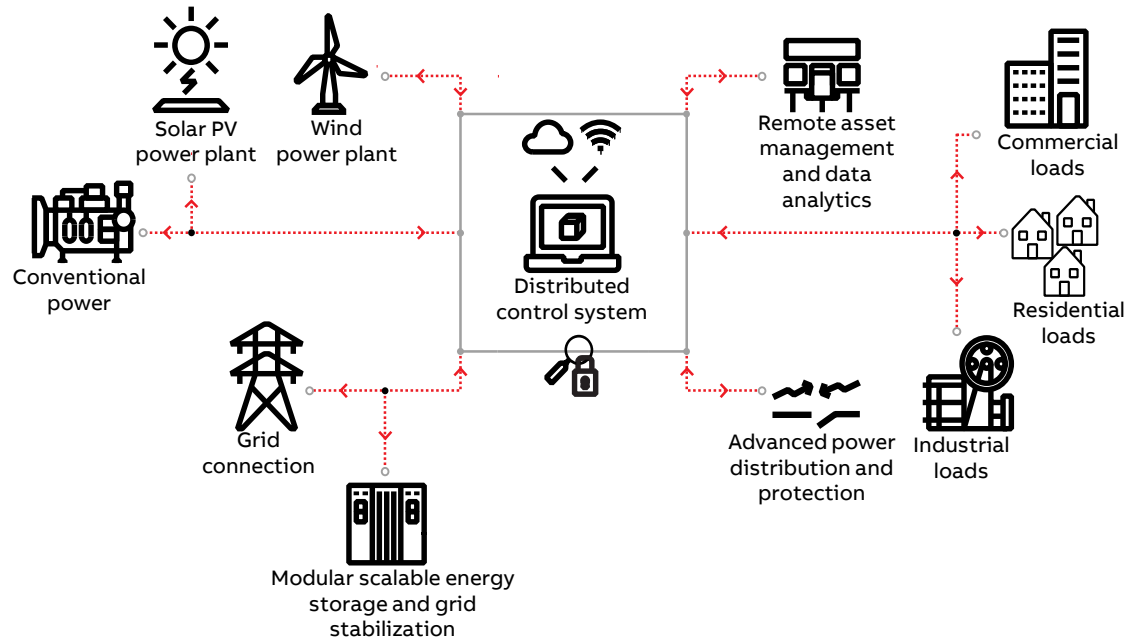
Microgrid

Generation at the point of consumption and always available

Microgrid definition

Distributed energy resources and loads that can be operated in a controlled, coordinated way either connected to the main power grid or in “islanded”* mode.

Microgrids are low or medium voltage grids without power transmission capabilities and are typically not geographically spread out.



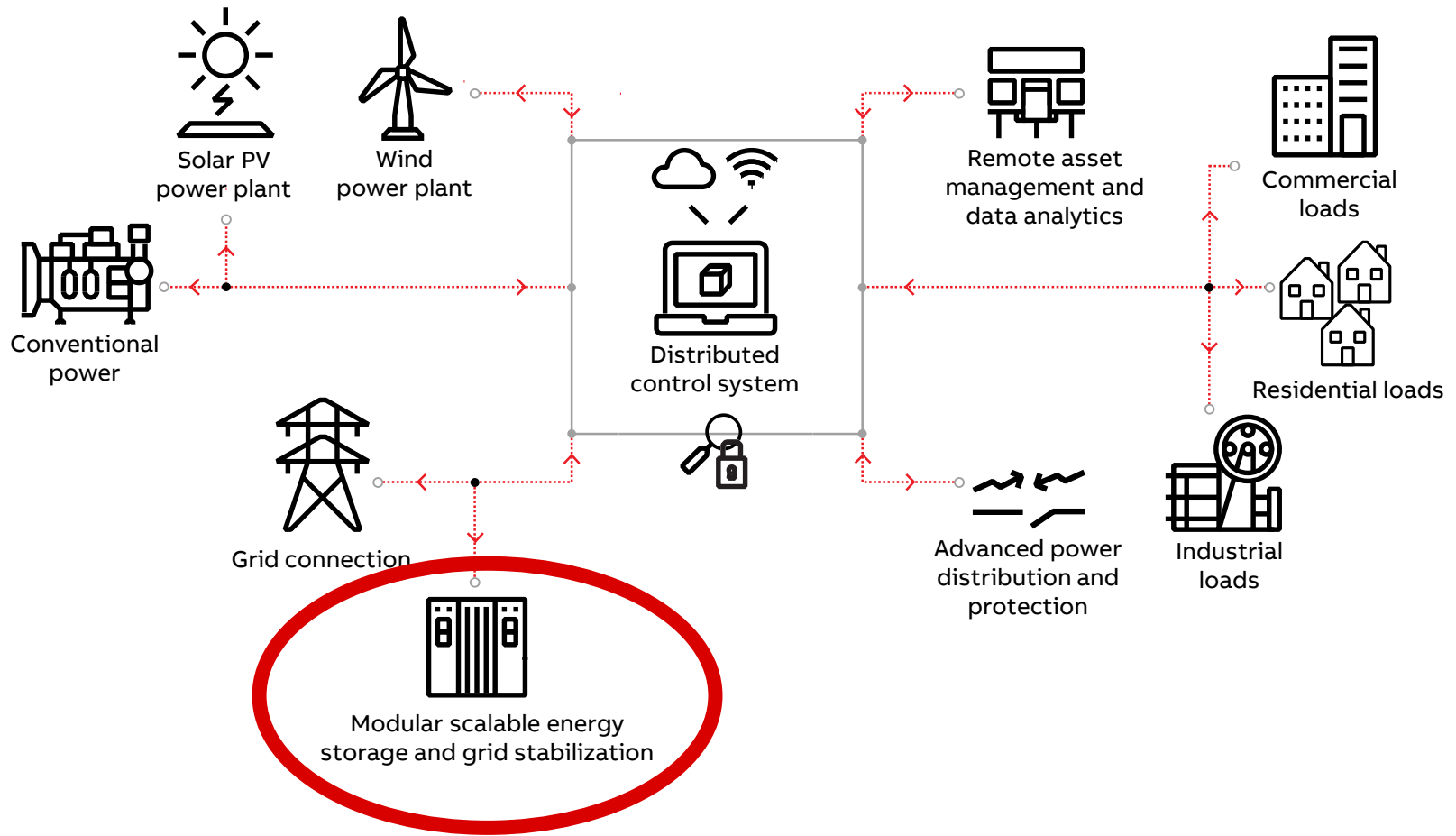
Microgrid segments and main drivers

Covering a diverse range of applications

		Main drivers					
		Social	Economic	Environmental	Operational		
Segments	Typical customers	Access to electricity	Fuel & cost savings	Reduce CO2 footprint	Fuel independence	Uninterrupted supply	
<div style="display: flex; flex-direction: column; align-items: center; justify-content: center;"> <div style="background-color: #800000; color: white; padding: 5px; margin-bottom: 10px;">Off-grid</div> <div style="background-color: #f08080; color: white; padding: 5px; margin-bottom: 10px;">Weak grid</div> <div style="background-color: #a9a9a9; color: white; padding: 5px;">Grid-connected</div> </div>	Island utilities	(Local) utility, IPP*	✓	✓	✓	(✓)	
	Remote communities	(Local) utility, IPP, Governmental development institution, development bank	✓	✓		✓	
	Industrial and commercial	Mining company, IPP, Oil & Gas company, Datacenter, Hotels & resorts, Food & Beverage		✓	(✓)	✓	✓
	Defense	Governmental defense institution		(✓)	(✓)	✓	✓
	Urban communities	(Local) utility, IPP			(✓)		✓
	Institutions and campuses	Private education institution, IPP, Government education institution		(✓)			(✓)

Microgrid

Generation at the point of consumption and always available

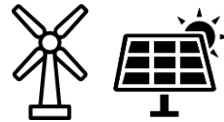


Energy storage provides multiple benefits for microgrids

Operational goals

- Access to electricity
- Maximize reliability
- Uninterrupted supply
- Reduce environmental impact
- Maximize renewable energy contribution
- Fuel & cost savings
- Fuel independence
- Provide grid services

Renewable power



Microgrid control system



Energy storage and grid stabilization



Power system functions – “8S”

1. Stabilizing
2. Spinning reserve
3. STATCOM (static synchronous compensator)
4. Seamless transition between islanded and grid-connected states
5. Standalone operation
6. Smoothing
7. Shaving
8. Shifting

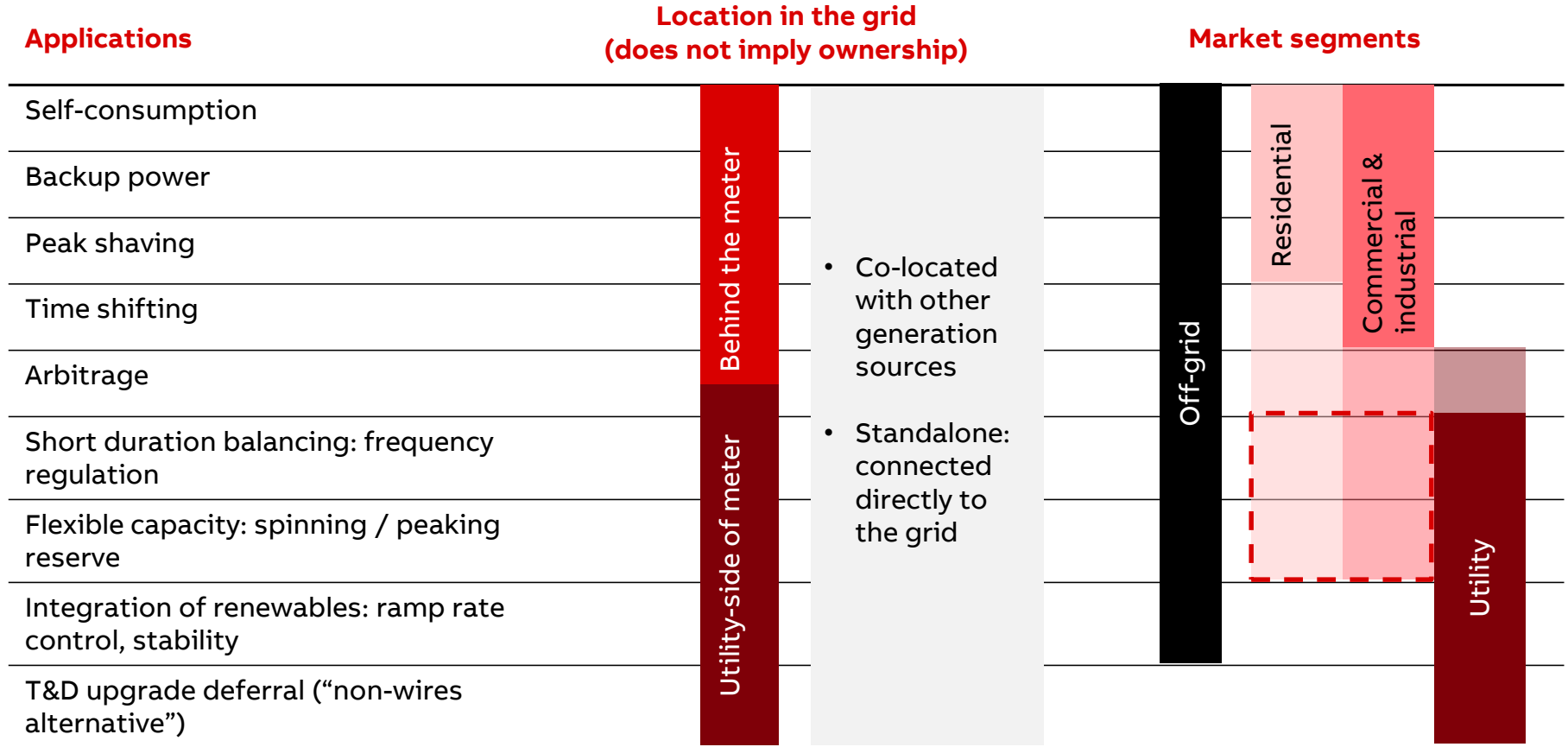
8S applications

Response times and energy and power requirements

	Application	Time frame	Energy requirement	Power requirement
S1	Standalone	milliseconds	low	high
S2	Seamless transition	milliseconds/seconds	low	high
S3	Stabilize (V & f support)	seconds	low	high
S4	Statcom (power quality)	seconds	zero	high
S5	Spinning reserve	seconds/minutes	medium	high
S6	Smoothing	minutes	medium	medium
S7	Shaping (Peak lopping/shaving)	minutes/hours	medium	low
S8	Shifting (load leveling)	hours	high	low

Application and segment mapping

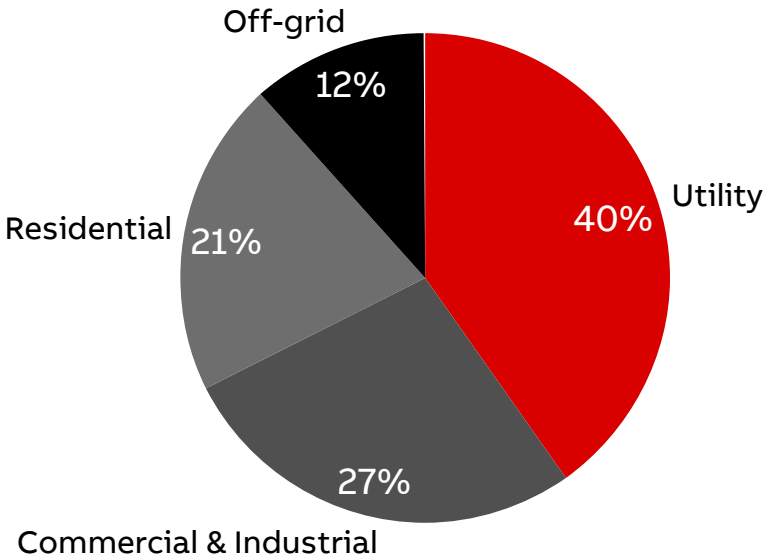
Grid-connected and off-grid



Application forecast by segment

Grid-connected applications capture up to 90% of market revenue

\$39 Bn cumulative 2017-25

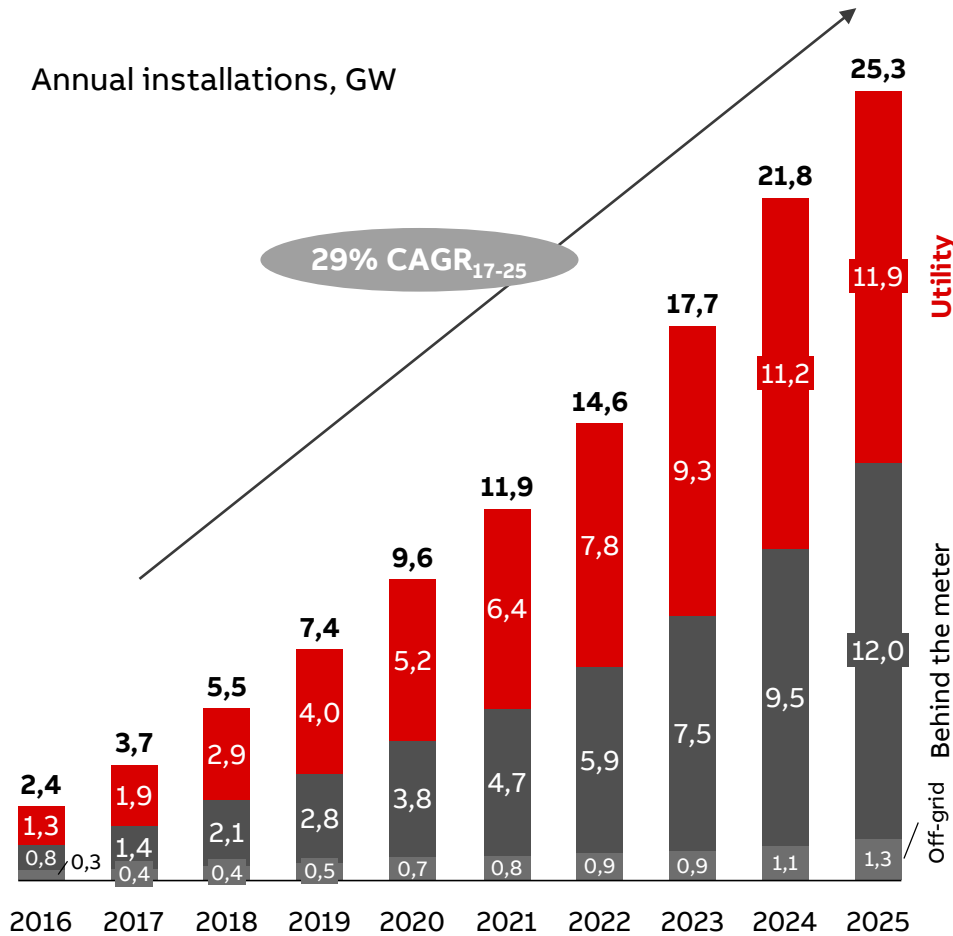


	Main applications	Key markets
Utility	<ul style="list-style-type: none"> - Ancillary services - Peaking capacity - RE integration - T&D support and upgrade deferral 	USA, AU Europe (DE, IT, UK) India Middle East
C&I	<ul style="list-style-type: none"> - Increasing solar self-consumption - Backup power - Peak shaving & ToU charges 	USA, AU, India Europe (DE, IT, UK) Sub-Saharan Africa
Residential	<ul style="list-style-type: none"> - Increasing solar self-consumption - Backup power 	USA, AU Europe (DE, IT, UK) India
Off-grid	<ul style="list-style-type: none"> - Electrification - Backup power - Grid stability 	Sub-Saharan Africa India South-East Asia

Value spread across segments in both emerging and developed markets

Long-term growth forecast

Double-digit volume growth drives cost competitiveness



Utility-scale deployments dominate in the short term.

- Energy storage becoming increasingly important as network operators seek to integrate rising levels of variable renewable generating capacity

Behind-the-meter gains major traction by 2025 as payback for end-user systems becomes economically attractive.

- PV + storage systems for self consumption, backup power, power quality and peak shaving an attractive value proposition for C&I customers

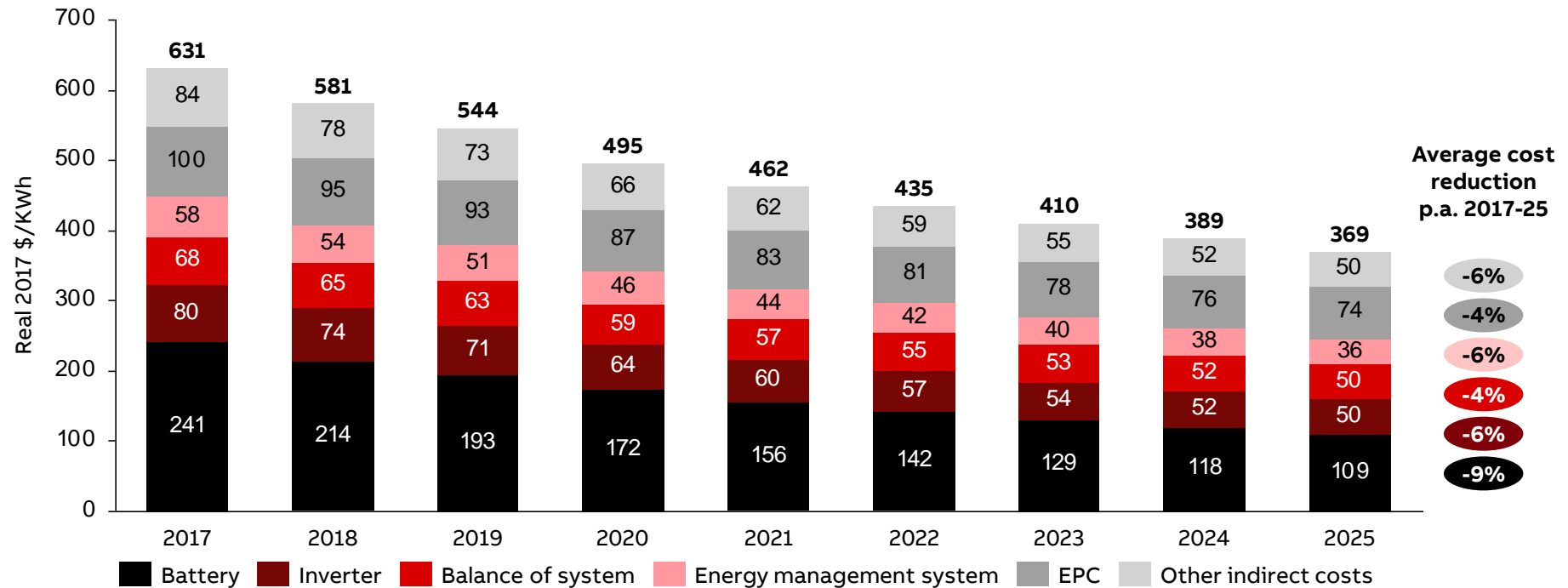
Village electrification and C&I installations drive growth in off-grid segment

- Delivering reliable, affordable and clean electricity for universal access to power

Energy storage cost reduction forecast

20% cost reduction along value chain in 2017-20

CAPEX for a fully-installed energy storage system (1MW/1MWh)





References

ABB in microgrid

Global references



ABB in microgrid: selected global references

Chugach, Alaska, US

(Wind, Diesel, Storage, Flywheel)



Microgrid system consists of:

- Wind (11 x 1.6 MW)
- PowerStore Flywheel (1 x 1 MW)
- PowerStore Battery (1 x 2 MW)
- Diesel (1 x 17.6 MW, 1 x 9 MW, 1 x 3.6 MW, 1 x 0.76 MW)

Customer benefits:

- Reduce wind ramp rate violations
- Reduce Area Control Error (ACE) violations
- Allow for additional wind capacity to be constructed

AusNet Services, AU

(Storage, Diesel, Grid)



Microgrid system consists of:

- PowerStore-Battery
- Transformer and diesel generator
- Microgrid Plus Control System

Customer benefits:

- Manage peak demand – Active and reactive power during high demand
- Transition to island operation without supply interruption
- Delay of power line investments

Marble Bar, AU

(Solar, Diesel, Flywheel)



Microgrid system consists of:

- Diesel (4 x 320kW)
- Solar PV plant (1 x 300kW)
- PowerStore-flywheel (1 x 500kW)
- Microgrid Plus System

Customer benefits:

- Reliable and stable power supply
- Minimize diesel consumption and CO2 emissions
- 60% of the day time electricity demand generated by the PV plant

ABB in microgrid: selected Africa references

Robben Island, ZA

(Solar, Diesel, Storage)



Microgrid system consists of:

- 500 kW / 837 kWh PowerStore Battery
- Microgrid Plus Control System
- 667 kWp Solar PV plant
- Diesel generators (1 x 500 kVA)

Customer benefits:

- Lower fuel costs and carbon emissions by 75 %
- Wireless network enables remote monitoring from Cape Town and eliminates need to maintain a workforce on the island

ICRC, Nairobi, Kenya

(Solar, Diesel, Storage, Grid)



Microgrid system consists of:

- 150 kW/100kWh PowerStore Battery
- Microgrid Plus Control System
- 30 kWp rooftop solar PV plant
- Diesel generators (1 x 150 kVA)

Customer benefits:

- Reliable and stable supply despite outages and power quality issues.
- Seamless transition between grid-connected and islanded mode
- Reduced fuel costs and carbon footprint

Johannesburg, ZA

(Solar, Diesel, Storage, Grid)



Microgrid system consists of:

- 750 kWdc rooftop PV plant
- 1 MVA/380 kWh PowerStore Battery
- Microgrid Plus Control System

Customer benefits:

- Reliable and stable power supply
- Optimized renewable energy contribution to the facility
- Transition to island operation without supply interruption
- CO2 reduction: over 1,000 tons/year

Energy storage for microgrids

Resilient and cost effective power anywhere, anytime

Market enablers

Reliable, proven technology

Plug and play

Easy to transport and to install

Scalable and modular



Summary

Energy storage enables reliable and affordable power in cities, industries and remote communities.



ABB