Low-carbon microgrids

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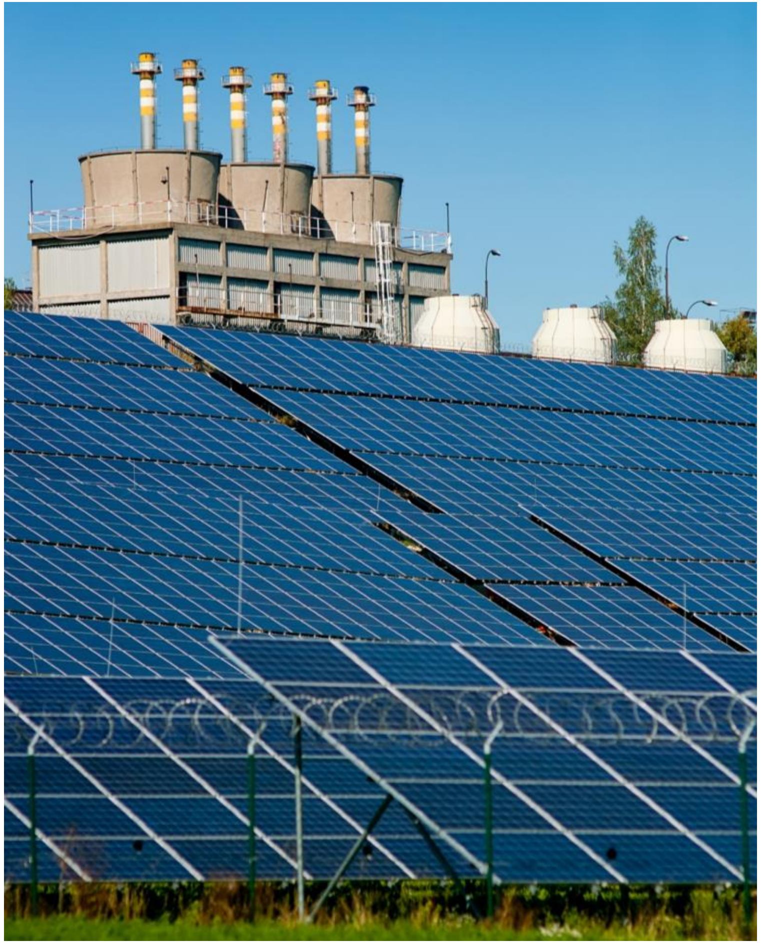
wbcsd

Table of contents

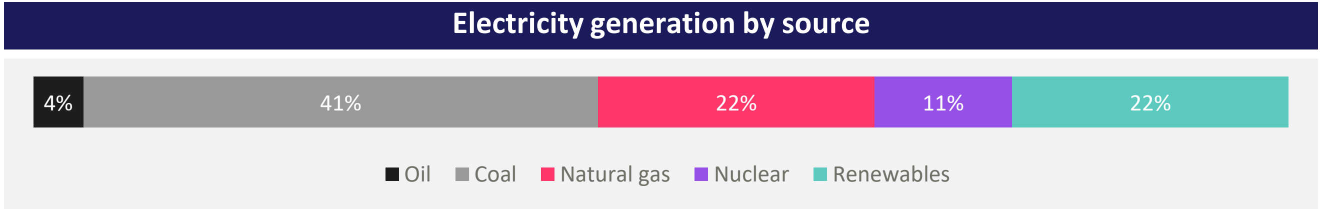


1. Background

The power sector needs to decarbonize in line with the Paris Agreement

- The power sector is currently responsible for about 13.6 GtCO_2 or about 40% of global energy-related CO_2 emissions. To align with the Paris Agreement the power sector must virtually decarbonize by around the middle of the century. Under the Reference Technology Scenario (a scenario that would result in a 2.7°C temperature increase by 2100), emissions from the power sector would grow by 6% by 2050.

- Increasing the volume and speed of renewable electricity deployment is key to decarbonizing the power system. **Companies can help to drive the transition** by purchasing renewable electricity through four methods: **(1)** purchasing from or investing directly in on-site generation; **(2)** purchasing from or investing directly in off-site generation; **(3)** purchasing renewable certificates; and **(4)** procuring green tariffs. Low-carbon microgrids are a solution for companies (named "**corporate buyers**" throughout this publication) to generate or purchase low-carbon, reliable power through options (1) and (2).



Source: IEA, 2017: *Energy Technology Perspectives 2017*.

2. Description of low-carbon microgrids

Overview

Description of the solution concept	• A microgrid is a set of energy resources that can operate, if needed, independently from the electricity grid (‘in island mode’). • Traditional microgrids relied on fossil fuels, but now low-carbon microgrids use renewable energy sources for a significant part or all of their energy supply.
Rationale for developing this solution	• There are three common use cases for low-carbon microgrids: - Companies with operations in off-grid areas who use microgrids to meet their energy needs. - Companies with inconsistent energy supply who use microgrids to provide reliable and affordable power. - Companies with operations in areas with reliable grids who wish to improve the economics for self-production, increase their resiliency and / or lower emissions. • Each of these use cases presents a different business case with project-specific drivers and benefits for the corporate buyer. • All use cases contribute to power sector decarbonization, so long as the microgrids meet the low-carbon definition specified above and use a generation mix that emits less greenhouse gases than the incumbent power supply.
Assessment of technology readiness status	• Planned and installed microgrids currently represent over 31 GW of power capacity globally[1]. 82% have low-carbon fuel sources and over a third supply energy to commercial or industrial corporate buyers. • The most common renewable energy generation type for low-carbon microgrids is solar PV, with battery storage or backup diesel/natural gas generators.

Source: [1]Navigant, 2020: *Microgrid Deployment Tracker 1Q20*.

2. Description of low-carbon microgrids

What are the benefits of low-carbon microgrids for corporate buyers?

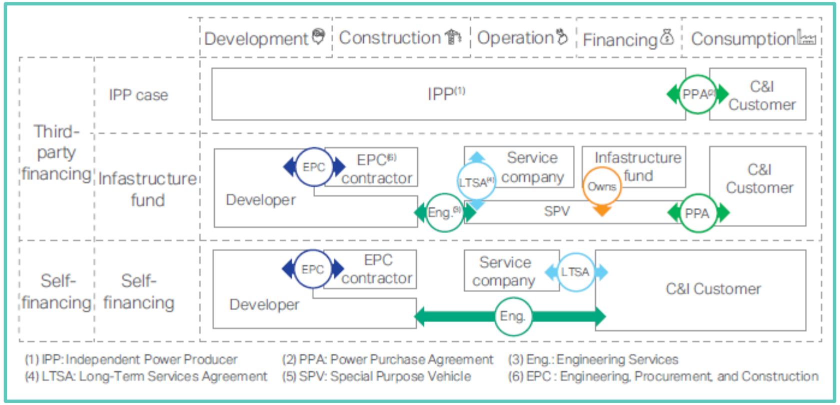
Commercial benefits	• **Self reliability and security of supply:** where corporate buyers have high security needs or unreliable grid access, or who seek to be independent of fossil fuel resource availability. • **Cheaper energy cost and price visibility:** due to low solar PV costs, falling storage costs and removing the future price uncertainty of fossil fuels. • **External revenue streams:** by selling excess power to nearby customers or offering balancing services to the grid.
Environmental benefits	• **Reduced air pollution:** where the low-carbon microgrid is replacing diesel generators, air pollution is reduced through lower power generation and removing emissions from transporting fuel. • **Reduced emissions from centralized fossil fuel plants:** in the long term, increased uptake of microgrids could reduce the need for new build centralized power stations to meet peak demand, as microgrids reduce impact on the grid at peak times.
Social benefits	• **Access to energy:** in off-grid areas, access to energy through greenfield microgrids can increase local economic growth and improve health, education, financial inclusion and local employment. • **Increased resilience:** in areas with unreliable grids or high vulnerability to extreme weather events, microgrids can improve resilience and security of supply to protect against power outages in the community.

2. Description of low-carbon microgrids

How are low-carbon microgrids financed?

- **High upfront capital costs and low ongoing operating costs are typical for microgrid investment curves.** Corporate buyers with low costs of capital can self-finance project development, construction and operation, whereas those without access to capital can use third-party financing structures (see Figure 1).
- **For third party financing, two common models exist**:
  1. The company entrusts the financing, development, construction and operation to an independent power producer (IPP) and purchases energy through a PPA
  2. The company divides the IPP role among several contractors, setting up a special purpose vehicle (SPV) to jointly own the microgrid with an infrastructure fund

- Standard renewable energy projects for corporate buyers aim to reduce the energy price and environmental impact compared to procurement through the electricity grid. For low-carbon microgrids, additional benefits and drivers such as security of supply and improved energy access mean that financing is more complex, as service providers must deliver on more than one performance indicator.



Source: WBCSD, 2017: Microgrids for commercial and industrial companies.

Figure 1: Example microgrid ownership structures[1]

3. GHG reduction potentials of low-carbon microgrids

GHG savings vary widely depending on the project size, location and new and incumbent power supply

Example savings: OFF-GRID

Off-grid solar + battery microgrid replacing diesel generator microgrid.

	Existing	Upgrade
Size and source	500 kW diesel	500 kWp solar 200 kW storage 500 kW diesel back-up
Estimated annual consumption	624,000 kWh	624,000 kWh
Estimated annual emissions	407 tCO_2e	81 tCO_2e

325 tCO_2e saved

Assumptions:

- located in South Africa
- 20% of total consumption in the upgrade scenario is from diesel back-up generator

Example savings: ON-GRID

On-grid solar microgrid reducing demand from the electricity grid. For on-grid microgrids, GHG savings vary widely depending on the emissions factors of the local electricity grid.

	Existing	Upgrade
Size and source	Grid electricity	500 kWp solar 200 kW storage Grid electricity
Estimated annual consumption	624,000 kWh	624,000 kWh
Estimated annual emissions	449 tCO_2e	90 tCO_2e

359 tCO_2e saved

Assumptions:

- located in India
- 20% of total consumption in the upgrade scenario is from electricity grid

Source: Simplified calculations based on project examples from the *WBCSD Microgrid Hub*.

4. Cost assessment and sensitivity analysis

Low-carbon microgrid costs vary significantly depending on several physical factors

- Similarly to any renewable energy asset, low-carbon microgrids are capital-intensive, with relatively low operation and maintenance costs. This contrasts to flatter grid electricity prices or diesel microgrids which have higher operating costs due to ongoing fuel costs.

- The cost of a low-carbon microgrid for a corporate buyer will vary significantly depending on many factors, including but not limited to:
  (1) whether it is a new build or retrofit;
  (2) geographical location (including labor, land, availability of technology, access, permitting, logistics and customs tariffs);
  (3) generation technology;
  (4) size;
  (5) system complexity.

- A recent NREL study[1] of 15 commercial/industrial microgrids in the USA presented the mean cost at USD $4m/MW (interquartile range = USD $3.4m – USD $5.4m/MW).* In reality, costs for corporate buyers will depend on the aforementioned physical factors, in addition to the selected financing structure (see slide 6). For third-party financed microgrids, the corporate buyer will have no upfront capital cost but instead will agree an ongoing energy price and costs of other elements in the contract.

*Less than half the sample were defined as low-carbon microgrids.
Source: [1]NREL, 2018: *Phase I Microgrid Cost Study: Data Collection and Analysis of Microgrid Costs in the United States*.

4. Cost assessment and sensitivity analysis

The business case for low-carbon microgrids is sensitive to several external cost and regulatory factors

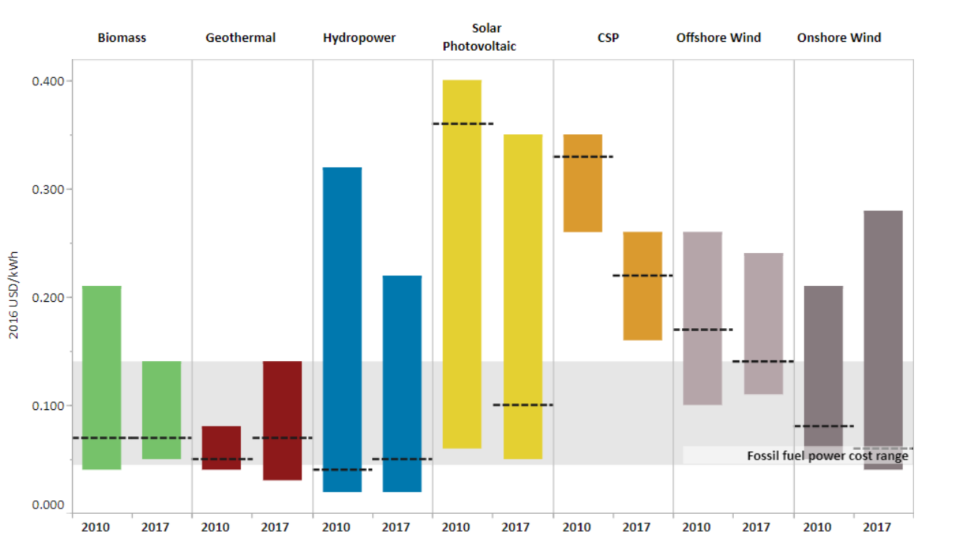
External revenue streams (on-grid)	• Project bankability is sensitive to the local availability of and access to external revenue streams • Currently focuses on income from incentives in the local geography, e.g. FiTs. • As renewable deployment increases and the need for smart grids grows, the project bankability is expected to become more dependent on whether there is a need for ancillary services for the local grid, e.g. frequency and voltage regulation.
LCOE of renewable technology	• Project bankability is sensitive to the levelized cost of energy (LCOE) for renewable technology. • LCOE for renewables has decreased significantly in the last decade, particularly for solar PV. This is due to a combination of factors, including supportive policies and falling equipment costs. Further cost reductions are expected to be driven by competitive procurement processes, increasing international competition and continuous technology innovation. • LCOE of all renewable technologies except concentrated solar power (CSP) is now competitive with thermal generation (IRENA, 2019).
Changing import tariffs	• Microgrid project CAPEX is highly sensitive to technology costs. For renewable technologies, manufacturing is clustered in certain countries, particularly in China where 60% of solar PV panels are manufactured (IEA, 2014). Changing import tariffs from those geographies impacts price sensitivity of the project as a whole.
Falling cost of storage	• A significant reduction in the cost of storage technology would positively impact both the cost-effectiveness and technical performance of the project as a whole. • Battery storage costs are predicted to fall by up to 66% by 2030 (IRENA, 2017). Such a decrease could increase proportion of renewable electricity consumed and limit or remove the need for back-up fossil fuel generators and grid electricity, reducing both CAPEX and OPEX for low-carbon microgrid projects.

4. Cost assessment and sensitivity analysis

The decreased LCOE for renewable technology improves the business case for renewable microgrids

- There has been a significant reduction in LCOE of renewable electricity generation over the past decade.
- All but one technology is now within the fossil fuel power cost range for utility scale generation.
- These cost reductions have contributed to strengthening the business case for low-carbon microgrids, particularly in the case of solar PV, which is the chosen technology for the majority of low-carbon microgrids.

Global LCOE from utility-scale renewable power generation technologies 2010 - 2017

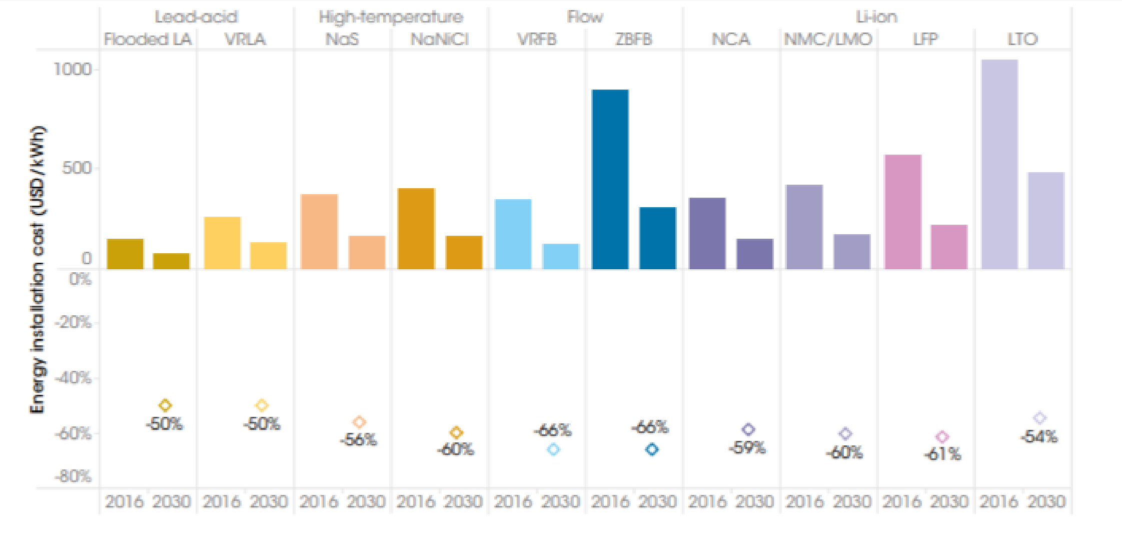


Source: IRENA, 2019: *IRENA Renewable Energy Cost Database*.

4. Cost assessment and sensitivity analysis

A significant reduction in the cost of storage technology would positively impact cost-effectiveness

Energy installation costs central estimate for battery technologies, 2016 and 2030



- All battery storage technology costs are predicted to fall by more than half by 2030.
- Falling storage costs will have a three-fold impact on the business case for low-carbon microgrids:
  - CAPEX costs will be reduced for projects including storage.
  - Increased storage capacity will allow a greater proportion of renewable energy to be used, increasing the sustainability credentials of the project.
  - Using a greater proportion of the produced renewable energy will reduce reliance on back up fossil fuel generation or electricity from the grid, decreasing OPEX costs.

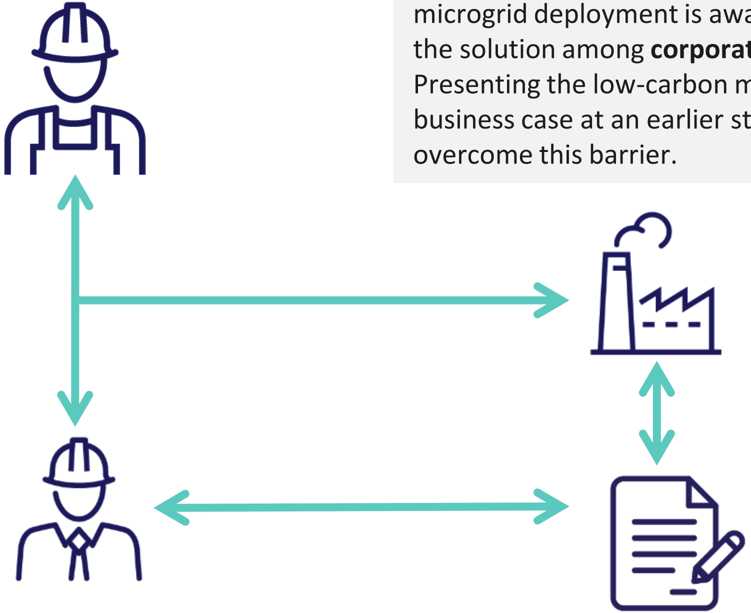
Source: IRENA, 2017: *Electricity storage and renewables: Costs and markets to 2030*.

5. New partnership opportunities

Partnerships can help overcome barriers and foster new business cases

1. Collaboration with building developers:

Microgrid developers / building developers can partner to identify opportunities for greenfield microgrids at an earlier stage in the construction process to develop solutions and inform the customer / end user of the opportunity.



A significant barrier to low-carbon microgrid deployment is awareness of the solution among **corporate buyers**. Presenting the low-carbon microgrid business case at an earlier stage helps to overcome this barrier.

5. New partnership opportunities

Partnerships can help overcome barriers and foster new business cases

2. Microgrids-as-a-service business model for utilities:

- Through partnerships with other actors, utilities can provide a microgrid-as-a-service business model, where:
  - The capital is provided by one actor.
  - The controls and contract are held by another actor.
  - The end-user is supplied with energy by the utility without investing any capital or holding the contract.

3. Utilities and component vendors collaborating to increase interoperability:

- In contrast to other sectors, the power system is dependent on proprietary components systems that cannot necessarily operate seamlessly together.
- Interoperable devices can more accurately and rapidly balance surges and short-term drops, as well as smoothly integrating irregular supply from small-scale wind and solar onto the network.
- Formed in 2013, Duke Energy's Coalition of the Willing made up of component vendors demonstrated that collaboration and design to improve interoperability can improve system operation and drive down costs.[1]

Source: [1]Duke Energy: *Coalition*.

6. Low-carbon microgrids SWOT analysis

Strengths

- **Increases self reliability and security of supply** by giving the end user more independence and control over its energy generation.
- **Potential for cheaper energy cost and provides price visibility** for the end user due to less reliance on fluctuating energy prices.
- **Reduced air pollution** where renewable generation replaces fossil fuel generation, localized (e.g. diesel generators) or centralized (e.g. reduced need for centralized power plants).
- **Potential to improve access to energy** by bringing secure energy supply to areas where it was unreliable or non-existent.
- **Availability of established financing structures** allowing end users to invest up front or pay for energy use depending on availability of capital.

Opportunities

- **External revenue streams** such as selling power back to the grid, and frequency and voltage regulation can diversify end user's business model.
- **Reduced need for centralized fossil fuel plants** leading to further GHG abatement.
- **Falling storage costs** could improve business case for renewable microgrids by improving the technical performance (higher proportion of generated renewable electricity can be consumed) and reducing capital costs.

Weaknesses

- **Requirement for building permits and generation licenses** slows planning permission and adds expenses.
- **Limited business case for on-grid use cases** with reliable grid connection, compared to off-grid or unreliable energy supply user cases.

Threats

- **Restrictive grid codes** for on-grid microgrids can limit the right for microgrids to reconnect after operating in island mode.
- **Grid extension** could threaten business case for off-grid microgrids, if the end user can agree a lower energy price with the grid.
- **Increases in import tariffs** on renewable technology can impact project CAPEX and threaten projects at feasibility stage.

7. Success factors

Enabling regulation

Favorable grid codes, licensing regulations and import tariffs.

Ownership structures that meet the energy buyer's needs

The developer / counterparty must be able to fill knowledge gaps and accept risk where appropriate.

Financing options that meet the energy buyer's needs

Availability of third-party financing or availability of capital for self-financing.

Availability of land (on-site only)

Sufficient space for the renewable generation asset to be sited.

Selection of location-appropriate technology

Renewable and back-up generation / storage selected according to location (availability of fuel source and access for construction).

Suitably sized renewable generation capacity

Correct sizing of the asset to meet agreed energy demand, and back-up generation / storage where appropriate.

Technology cost-competitiveness

Low cost of renewable technology (higher LCOE of thermal generation is an advantage).

8. Low-carbon microgrids: Case studies (1/3)

Industrial plant

Eaton Wadeville Microgrid Energy System (South Africa)	
Context	• **End-user:** Eaton • **Owner:** Eaton • **Contract type:** Turnkey
User case	• Unreliable or unsatisfactory grid • Industrial facility
Benefits	• **Energy security:** Production keeps running without interruptions, even during grid power outages. • **Cost savings:** Achieves 40% savings in energy costs through reduction in peak demand charges and offsetting time of use tariffs. • **Sustainability:** Increases renewable energy fraction to 18.7% annually. • **Other:** Effectively manages power and generation assets to meet the site's individual needs.

Assets	
Existing	**Upgrade**
Grid	Grid 400 kVa diesel generator 200 kWp solar PV 275 kW / 200 kWh battery storage

Source: WBCSD, 2019: Microgrid Hub.

8. Low-carbon microgrids: Case studies (2/3)

Gold mine

Essakane Mine (Burkina Faso)	
Context	• **End-user:** IAMGOLD • **Owner:** EREN RE-AEMP • **Contract type:** PPA agreement with EREN RE-AEMP
User Case	• Off-grid • Mining
Benefits	• **Energy security:** Allows the mine to be fully autonomous, despite long distance from the nearest grid • **Cost savings:** Decreases fuel consumption by around six million liters • **Sustainability:** Decreases CO_2 emissions by 18,500 per year • **Other:** Creates a number of local jobs during both the construction phase and its ongoing operation

Assets	
Existing	**Upgrade**
55 MW oil power plant	55 oil power plant 15 MW solar PV

Source: WBCSD, 2019: *Microgrid Hub*.

8. Low-carbon microgrids: Case studies (3/3)

Commercial building

Boston One Campus (USA)	
Context	• **End-user:** Schneider Electric • **Owner:** Duke Energy • **Contract type:** PPA agreement with Duke Energy (REC solar)
User case	• Reliable grid • Commercial building
Benefits	• **Energy security:** Powers the building in emergency outage cases (natural event, etc.) • **Cost savings:** Saves 5% of energy costs (estimated) Optimized performances based on integration of weather forecast and available storage capacities (e.g. electric vehicles) • **Sustainability:** Reduces greenhouse gases emissions the equivalent of those produced by more than 2,400 passenger vehicles a year

Assets	
Existing	**Upgrade**
Grid	Grid 448 kW solar 500 kW / 1 MWh battery Backup natural gas generator

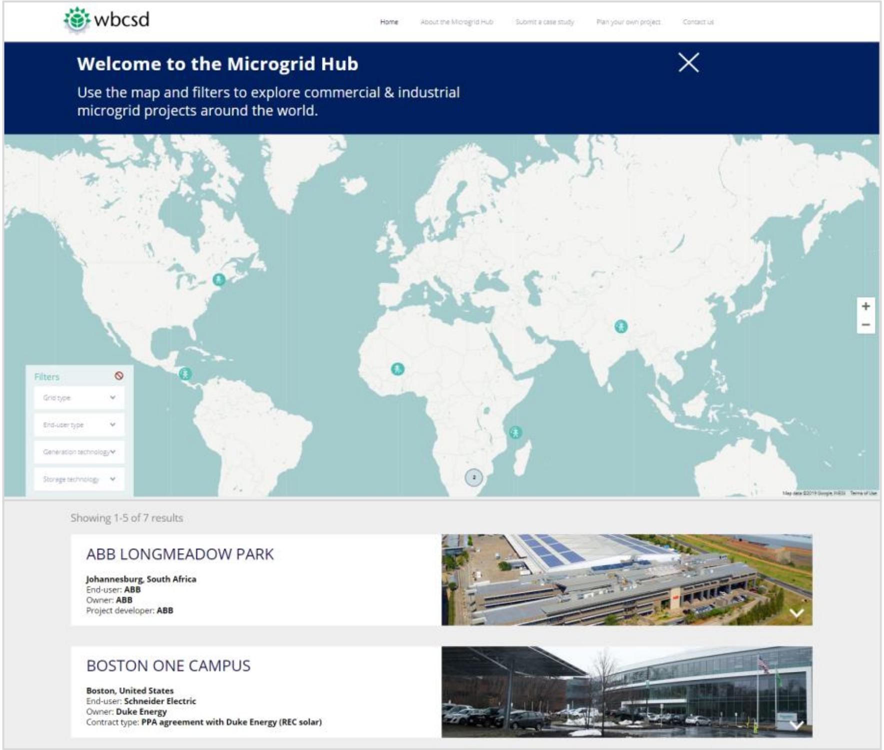
Source: WBCSD, 2019: Microgrid Hub.

9. Summary

Emissions and energy	• The power sector is currently responsible for about 13.2 gigatons of carbon dioxide ($GtCO_2$) or 41% of global energy-related CO_2 emissions. • Increasing the volume and speed of renewable electricity deployment is key to decarbonizing the power system.
Solution	• A microgrid is a set of energy resources that can operate, if needed, independently from the electricity grid. • Traditional microgrids relied on fossil fuels, but now low-carbon microgrids use renewable energy sources. Solar PV, with battery storage or backup diesel/natural gas generators, is the most common generation type for low-carbon microgrids.
Avoided GHG emissions and co-benefits	• GHG emissions savings vary widely depending on the microgrid's new and previous energy generation sources. • Low-carbon microgrids also provide access to energy, increase energy security and resilience, reduce air pollution, lower energy costs and offer new revenue streams through the selling of excess power or the offering of balancing services to the grid.
Readiness status	• Microgrid technology is already mature, with planned and installed microgrids currently accounting for over 31 GW of power capacity globally. • Some 82% have low-carbon fuel sources and over a third supply energy to commercial or industrial energy buyers.
Barriers	• High upfront capital costs can be critical, although third-party financing models can remove this. • Requirements for building permits and generation licenses may slow down or block projects. • Restrictive grid codes may also impair uptake.
Success factors	• Enabling policies such as favorable grid codes, licensing regulations and tariffs for imported technology components. • Falling levelized costs of renewable electricity and battery storage costs. • Ownership structures and financing options that meet energy buyer's needs.

10. Key sources and references on low-carbon microgrids

WBCSD Microgrid Hub



- The **Microgrid Hub** is an online library of case studies that showcases low-carbon microgrids for commercial and industrial companies across the world.

- The objective is to use existing project examples to inspire companies and help them to successfully implement new microgrid projects in different geographies.

- Visit the Microgrid Hub to view case studies and contact project developers.

10. Key sources and references on low-carbon microgrids

- Duke Energy: Coalition
- Navigant, 2019: Microgrid Deployment Tracker 4Q18
- NREL, 2018: Phase I Microgrid Cost Study: Data Collection and Analysis of Microgrid Costs in the United States
- WBCSD, 2017: Microgrids for Commercial & Industrial Companies
- IEA, 2018: IEA 2018 Emission Factors
- IEA, 2017: Energy Technology Perspectives 2017
- IRENA, 2017: Electricity storage and renewables: Costs and markets to 2030
- WBCSD, 2017: Microgrids for commercial and industrial companies
- WBCSD, 2018: Microgrid Hub

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