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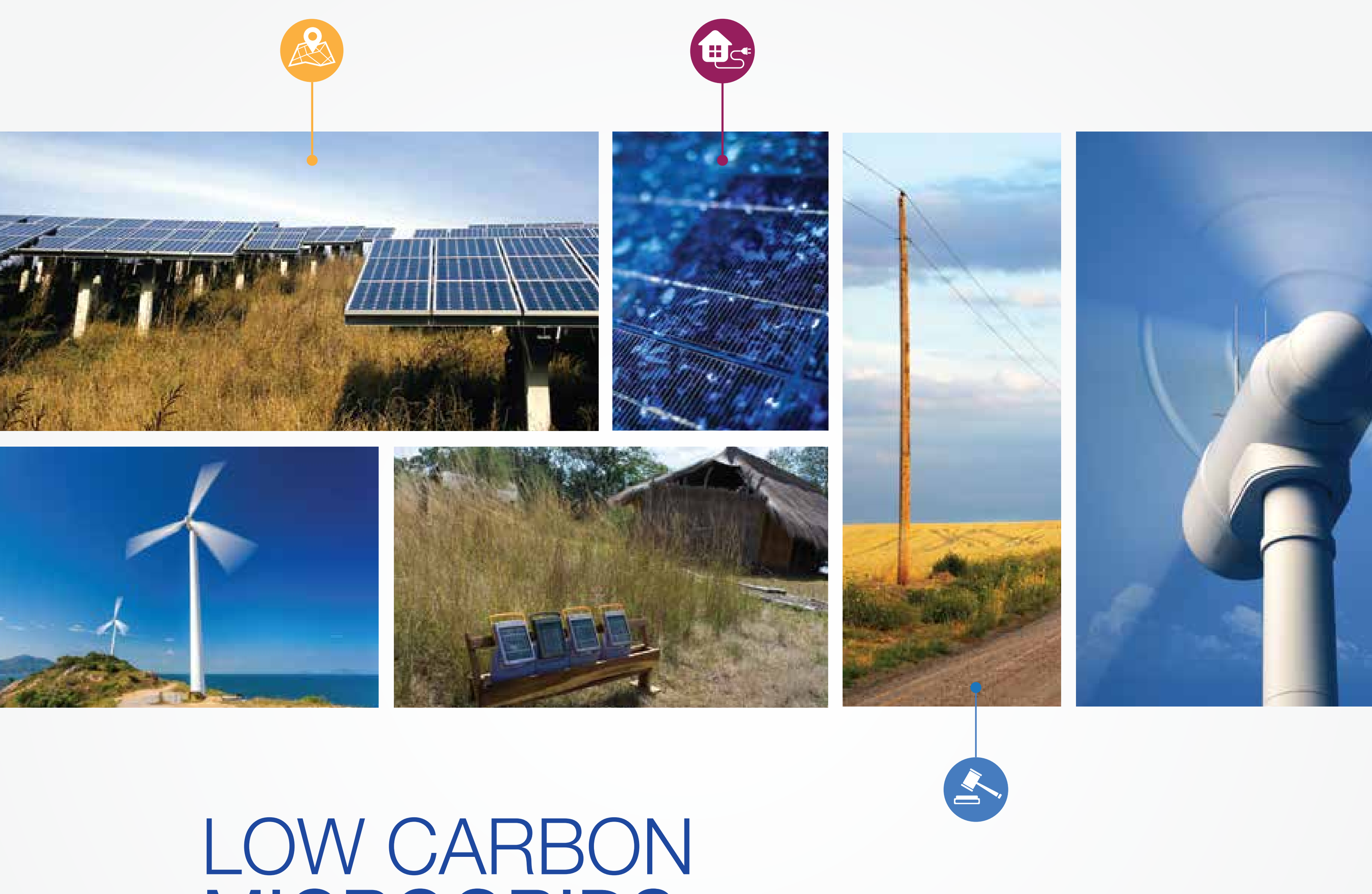


LOW CARBON MICROGRIDS

DECISION SUPPORT TOOLKIT

wbcsd

LOW CARBON MICROGRIDS – ECONOMICALLY VIABLE AND RENEWABLE-BASED SOLUTIONS TO ELECTRIFICATION OF REMOTE AREAS

Microgrids using a high share of renewable energy are today the most economical solution to providing electricity to populations and industries in remote locations around the world. The required technology for controlling and stabilising the grid exists and the vast cost reductions of key technologies components, such as photovoltaic (PV) solar, in the last years enable tariff setting in line with customers' ability to pay.

WBCSD member companies are engaged in several areas of work aiming to accelerate the adoption of Low Carbon Microgrids (LCMG) globally. A "Business case for Low Carbon Microgrids" - to be published at the start of 2016 - will illustrate the viability of microgrids using a number of case studies highlighting key success factors. This "Decision Support Toolkit" is a complementary area of work.

One of main barriers to commissioning a microgrid is the long time span from idea to project design. The objective of the toolkit is to assist stakeholders involved in the development of microgrids to streamline the identification process towards best available solutions. By means of a decision tree, the toolkit will outline a range of scenarios and recommend technology options and sustainable business models that are relevant to a particular scenario.

As such, it will enable faster decision-making for a microgrid design fit for the local circumstances and provide further information for financing and permitting agencies in their project screening process. In addition, customers can easily and independently use the toolkit to increase their knowledge about different possible microgrids solutions for their business /communities.

The decision tree will help users to characterise their needs in a rational approach with regards to the customers to be served, the site's specifications and the existing policy and legal framework. Solutions consisting of technical features and business model options will be proposed and will also be evaluated according to main drivers underlying the initial need (e.g. access to electricity, lower energy costs, etc.).

It is important to highlight that although the work will be technology neutral, it will clearly show the benefits of incorporating higher shares of renewable generation capacity across all microgrid projects.

This first version of the Decision Support Toolkit displayed here in paper format is "work in progress". The WBCSD LCMG working group is seeking views from stakeholders such as government agencies, project developers, financing institutions and communities, in order to develop a tool which will provide the most value to all.

The Low Carbon Microgrid working groups currently consists of the following companies:

ABB, CLP 中電, EDF, ENGIE by people for people, edp, Eskom, First Solar, nrg, Schneider Electric

NON-ELECTRIFIED COMMUNITY, AFRICA

LOCATION AND SITE
- Remote area, reachable by the main grid in less than 15 years
- Greenfield site
- Exploitable resources: solar radiation with limited seasonal variation; biomass residues
- Normal cost of diesel, USD 1 - 1.5/L

CUSTOMERS
- Small community (households, public services, commercial activities), <500 customers
- Medium customer density, 50 – 200 per/km²
- Evening peak load with limited seasonal variation
- Basic and productive electricity uses
- Low ability to pay, USD 5 - 10/mth (households)

POLICY AND LEGAL FRAMEWORK
- Existing policy & legal framework including privately-operated schemes
- Allocation of electricity distribution concessions
- Existing technical / quality standards
- Specific retail tariffs can be set, according to a legal procedure
- Unavailable national public financial support

MAIN DRIVERS
- Access to electricity
- Lower energy costs
- Reduce emissions
- Energy independence

100% SOLAR PV ISOLATED MICROGRID, PRIVATE COMPANY MODEL

Access to electricity | Lower energy costs | Security / reliability of supply | Reduce emissions | Energy independence

TECHNICAL FEATURES

POWER GENERATION
- **Technology:** Solar PV plant, energy storage and stabilization (batteries, fly wheel, etc.)
- **Dispatch:** Solar PV & storage: only source of power
- **% of renewable energies:** 100%
- **GHG emissions:** Low

DISTRIBUTION GRID
- **Current:** AC
- **Power lines:**
  - 3 phases medium voltage (11kV)
  - 3 phases & 1 phase low voltage (400V / 230V)
- **Connection to the main grid:** Not connected but "grid connection ready"
- **Mode:** 100% Island
- **Control system & grid-stabilizer**

CUSTOMER INTERFACE
- **Metering devices:** Pre-paid meters
- **Demand-side management:** Load shedding for exceptional events (several times a year)

BUSINESS MODEL

MODEL
- Ownership & operation:
  - Private energy company with utility concession
- Development strategy:
  - Cluster of microgrids
- Revenue collection:
  - Pre-payment (mobile phone / top-up card / etc.)

ECONOMICS
- **CAPEX:** High
- **OPEX:** Low
- Revenues and tariffs:
  - Electricity sales: customer class, pre-paid, energy-based, Time-Of-Use tariffs
  - Connection fees (customer class)
- Financing:
  - Equity funding from the private energy company
  - Concessional loans (& subsidies) from development finance institutions

RESOURCES & SKILLS
- Design & construction:
  - Highly skilled people for the design and the purchase of equipments (staff of the private company)
  - Local contractors for the construction
- Operation & maintenance:
  - The private company is in charge of O&M
  - Local staff recruited with in-house training program
- Management:
  - Skilled manager employed by the private company

BEST PRACTICES

Solar PV and storage design: Load shedding could be an option to avoid system over-sizing. Additional power generation capacity can be installed after several years of operations.
Social acceptance: Local community committees could be consulted to set the tariffs at a socially acceptable level.

Legal framework for grid assets: Ideal framework would allow for compensation to the grid operator for distribution assets in case of connection to the main grid.
Productive uses: A program promoting productive uses could be implemented to enhance the development of customers with a significant energy consumption.
Concessions: The company operating the grid should seek a utility concession for the surrounding area with the aim to design a microgrid cluster in the future

Evaluation of the solution regarding the main drivers of the scenario
Does not meet expextations | Partially meets expectations | Wholly meets expectations | Not a main driver for this scenario

REMOTE ISLAND

LOCATION AND SITE
- Remote island grid
- Brownfield site: existing microgrid with diesel generator
- Exploitable resources: solar radiation with seasonal variation; good wind speed
- High cost of diesel, > USD 1.5/L

CUSTOMERS
- Medium community (households, public services, commercial activities), 1000 – 5000 customers
- High customer density, > 200 per/km²
- Evening peak load with seasonal variation
- Modern electricity uses
- High ability to pay, > USD 30/mth (households)

POLICY AND LEGAL FRAMEWORK
- Existing policy & legal framework excluding privately-operated schemes
- Specific retail tariffs can be set, according to a legal procedure
- Available national public financial support

MAIN DRIVERS
- Lower energy costs
- Reduce emissions
- Energy independence

HYBRID SOLAR PV, WIND & DIESEL ISOLATED MICROGRID, UTILITY MODEL

Access to electricity | Lower energy costs | Security / reliability of supply | Reduce emissions | Energy independence

TECHNICAL FEATURES

POWER GENERATION
- **Technology:** Hybrid system with diesel generator, solar PV plant and rooftop installations, wind turbines, energy storage and stabilization (batteries, fly wheel, hydrogen, etc.)
- **Dispatch:** Solar PV, wind power & storage: main source of power; diesel generator: peak power
- **% of renewable energies:** 60 – 80 %
- **GHG emissions:** Medium

DISTRIBUTION GRID
- **Current:** AC
- **Power lines:**
  3 phases medium voltage (11kV / 33kV)
  3 phases low voltage (400V)
- **Connection to the main grid:** Never connected
- **Mode:** 100% Island
- **Control system & grid-stabilizer**

CUSTOMER INTERFACE
- **Metering devices:** Standard or smart meters
- **Demand-side management:** Incentives for load shifting to flatten evening peak load

BUSINESS MODEL

MODEL
- Ownership & operation:
  - Public utility
- Development strategy:
  - Individual microgrid
- Revenue collection:
  - Standard billing system

ECONOMICS
- **CAPEX:** Medium
- **OPEX:** Medium
- Revenues and tariffs:
  - Electricity sales: capacity-based & energy-based,Time-Of-Use tariffs
  - Connection fees (fixed)
- Financing:
  - Equity funding from public utility and/or private investors
  - Loans from financial institutions

RESOURCES & SKILLS
- Design & construction:
  - Highly skilled people for the design and the purchase of equipments (the public utility could look for external expertise)
  - Involvement of public utility's staff for the construction
- Operation & maintenance:
  - The public utility is in charge of O&M
  - Initial training of local staff is required
- Management:
  - The public utility manages the grid

BEST PRACTICES

Hybrid power generation system design: The sizing of the solar plant, the wind farm, the electricity storage system and the diesel generator should be optimized based on the economic optimum in the long run (i.e. during the lifetime of microgrid assets).

Distributed power generation: The microgrid should be designed to connect distributed solar PV systems owned by customers.
Grid operation: Innovative predictive control tools could be implemented to optimize renewable power generation and storage.

Evaluation of the solution regarding the main drivers of the scenario
Does not meet expextations | Partially meets expectations | Wholly meets expectations | Not a main driver for this scenario

UNIVERSITY CAMPUS, AMERICA

LOCATION AND SITE
- Grid proximity
- Brownfield site: existing grid, connected to the main grid; existing gas engine
- Exploitable resources: solar radiation with seasonal variation
- Normal cost of diesel, USD 1 - 1.5/L

CUSTOMERS
- Large campus with multiple consumption centers (residential & tertiary buildings, laboratories, etc.), load > 1MW
- Mid-day peak load with seasonal variation
- High-reliability / high-quality of supply required
- Ability to pay at the national tariff rate

POLICY AND LEGAL FRAMEWORK
- Policy & legal framework is not completely defined yet
- Retail tariffs must be set at the national rate level
- Available national public financial support

MAIN DRIVERS
- Security / reliability of supply
- Reduce emissions
- Energy independence

HYBRID SOLAR PV & GAS ENGINE CONNECTED MICROGRID, PRIVATE COMPANY MODEL

Access to electricity | Lower energy costs | Security / reliability of supply | Reduce emissions | Energy independence

TECHNICAL FEATURES

POWER GENERATION
- **Technology:** Hybrid system with gas engine, solar PV plant, energy storage and stabilization (batteries, fly wheel, hydrogen, etc.)
- **Dispatch:** Solar PV & storage: main source of power (+ network services; gas engine: peak power (+ network services)
- **% of renewable energies:** 40 - 60%
- **GHG emissions:** Medium

DISTRIBUTION GRID
- **Current:** AC
- **Power lines:**
  - 3 phases medium voltage (11kV / 33kV)
  - 3 phases low voltage (400V)
- **Connection to the main grid:** Connected
- **Mode:**
  - Island mainly (main grid is a back-up)
- **Control system & grid-stabilizer**

CUSTOMER INTERFACE
- **Metering devices:** Standard or smart meters
- **Demand-side management:** Load shifting & peak shaving actions to flatten the load curve

BUSINESS MODEL

MODEL
- Ownership & operation:
  - Grid owned by the university and operated by a private company
- Development strategy:
  - Individual microgrid
- Revenue collection:
  - Standard billing system

ECONOMICS
- **CAPEX:** Medium
- **OPEX:** Medium
- Revenues and tariffs:
  - Saving on electricity purchase (fixed and variable costs)
  - Additional revenues from network services
- Financing:
  - Equity funding from university
  - Loans from financial institutions
  - Subsidies from government

RESOURCES & SKILLS
- Design & construction:
  - Highly skilled people for the design, the construction and the purchase of equipment (collaboration between the staff of the private company and the university)
- Operation & maintenance:
  - Collaboration between the staff of the private company and the university for O&M
- Management:
  - The university staff manages the grid

BEST PRACTICES

Distribution grid design: The grid can be split in several parts which can operate in isolation from each other (e.g. critical load, residential load, etc.).
Grid ownership: The privately-operated microgrid model might be only possible if grid assets are owned by the university.

Network services: Depending on the regulation and the economic value, network services can include frequency regulation, voltage support, black-start capacity, etc.

Evaluation of the solution regarding the main drivers of the scenario
Does not meet expextations | Partially meets expectations | Wholly meets expectations | Not a main driver for this scenario

GROWING THE REACH OF OUR WORK WITH NEW MEMBERS AND PARTNERS IN 2016

The time is right for creating a microgrid market which matches end-users with the electricity infrastructure they need, at a price they can afford. We aim to seize this moment with our members and partners. In 2016, the aim is to leverage a critical mass of companies and partners to scale up implementation of low carbon microgrid solutions. The expected deliverables could include:

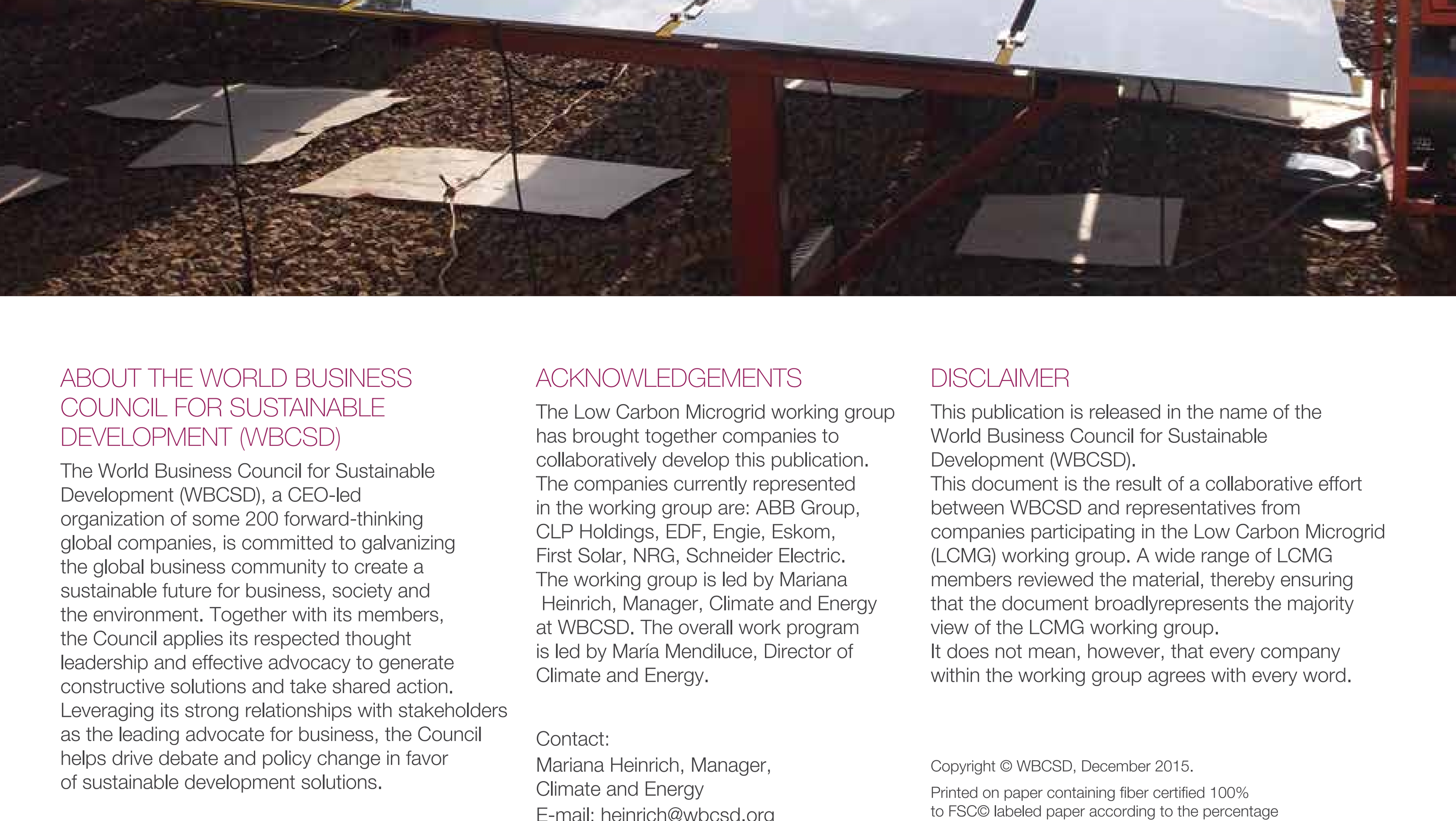
- A web-based decision tree toolkit;
- A web portal to support stakeholders in knowledge sharing, identification of solutions and identifying potential partners; and
- An online marketplace for posting tenders and creating partnerships for bids and projects.

As end-users and other stakeholders are key in judging the merits of the toolkit to be developed, we are actively seeking feedback on our work, by:

- Engaging in dialogue with key institutional investors about potential application of the Decision Support Toolkit to their project screening process; and
- Working with partner organisations to share knowledge about low carbon microgrids and support their deliverables where possible.

We recognize the strong role of and need to work with different government organizations and international non-governmental organizations to create a healthy investment environment, including the infrastructure and social fabric necessary, that supports implementation at scale. We are consistently reaching out to relevant experts and organisations and also welcome expressions of interest from others in this inclusive process.

For further information, please contact Mariana Heinrich, Manager Climate and Energy at WBCSD: heinrich@wbcsd.org



ABOUT THE WORLD BUSINESS COUNCIL FOR SUSTAINABLE DEVELOPMENT (WBCSD)

The World Business Council for Sustainable Development (WBCSD), a CEO-led organization of some 200 forward-thinking global companies, is committed to galvanizing the global business community to create a sustainable future for business, society and the environment. Together with its members, the Council applies its respected thought leadership and effective advocacy to generate constructive solutions and take shared action. Leveraging its strong relationships with stakeholders as the leading advocate for business, the Council helps drive debate and policy change in favor of sustainable development solutions.

ACKNOWLEDGEMENTS

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DISCLAIMER

This publication is released in the name of the World Business Council for Sustainable Development (WBCSD).
This document is the result of a collaborative effort between WBCSD and representatives from companies participating in the Low Carbon Microgrid (LCMG) working group. A wide range of LCMG members reviewed the material, thereby ensuring that the document broadlyrepresents the majority view of the LCMG working group.
It does not mean, however, that every company within the working group agrees with every word.

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DECISION TREE

This decision tree is composed of three parts: customers, location and site, policy and legal framework. A number of different criteria - such as load profile, natural resources available, tariff regulation - are used in each part to define a specific microgrid scenario.
As this work is still in progress, there might be changes to the criteria. "…" signals where the decision tree will be further filled in a future version. Each defined scenario, such as "Remote island", is linked to one or more relevant microgrid solutions which recommend technology options and sustainable business models.