SPIDERS Phase II Technical Report

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Definition

*The **U.S. Department of Energy**'s official definition of a microgrid is "a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid [and can] connect and disconnect from the grid to enable it to operate in both grid-connected or island-mode."*

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One Name but Many Forms

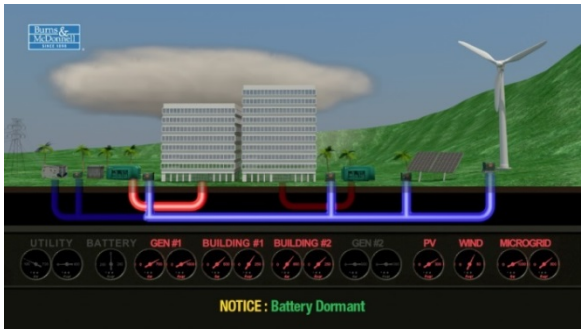
- Centralized Generation
- Distributed Generation
- Highly Renewable Focused / Net Zero

Common Features

- Decoupling of Generators from Loads
- Seamless Transitions to/from Utility
- Increased Redundancy of Generation

Common Benefits

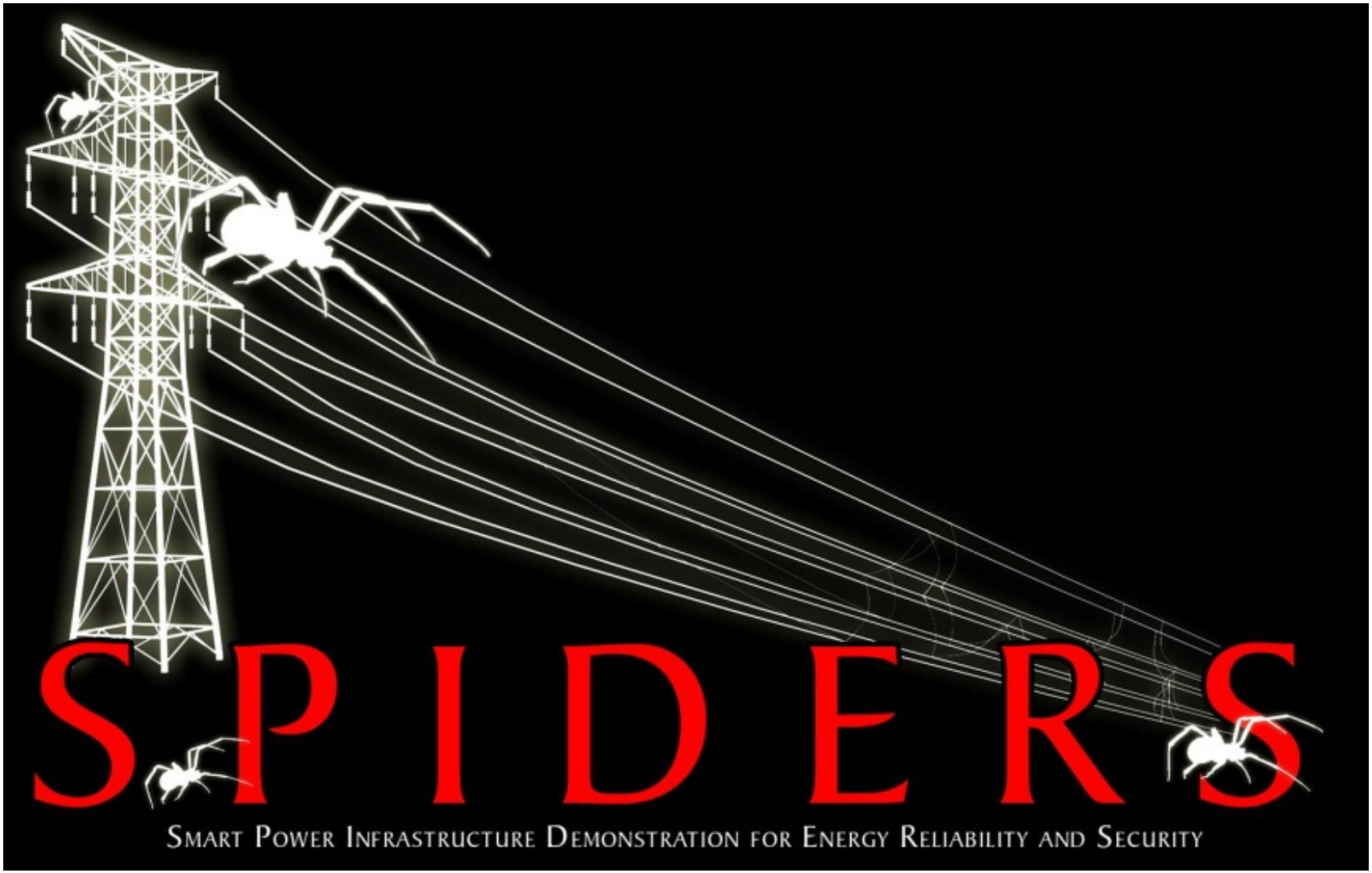
- Increased Situational Awareness for Operators
- Increased Automation of Distribution
- Integration of Renewable Resources for Backup Power
- Multiple Modes of Operation Both Islanded and Grid-Tied



What Microgrids are Not

- Uninterruptible Power Supplies (UPS)
- Controls Only Solutions
- Out-of-the-box Solutions
- Sources of Revenue (by themselves)

Burns & McDonnell
SINCE 1898



Distributed Approach

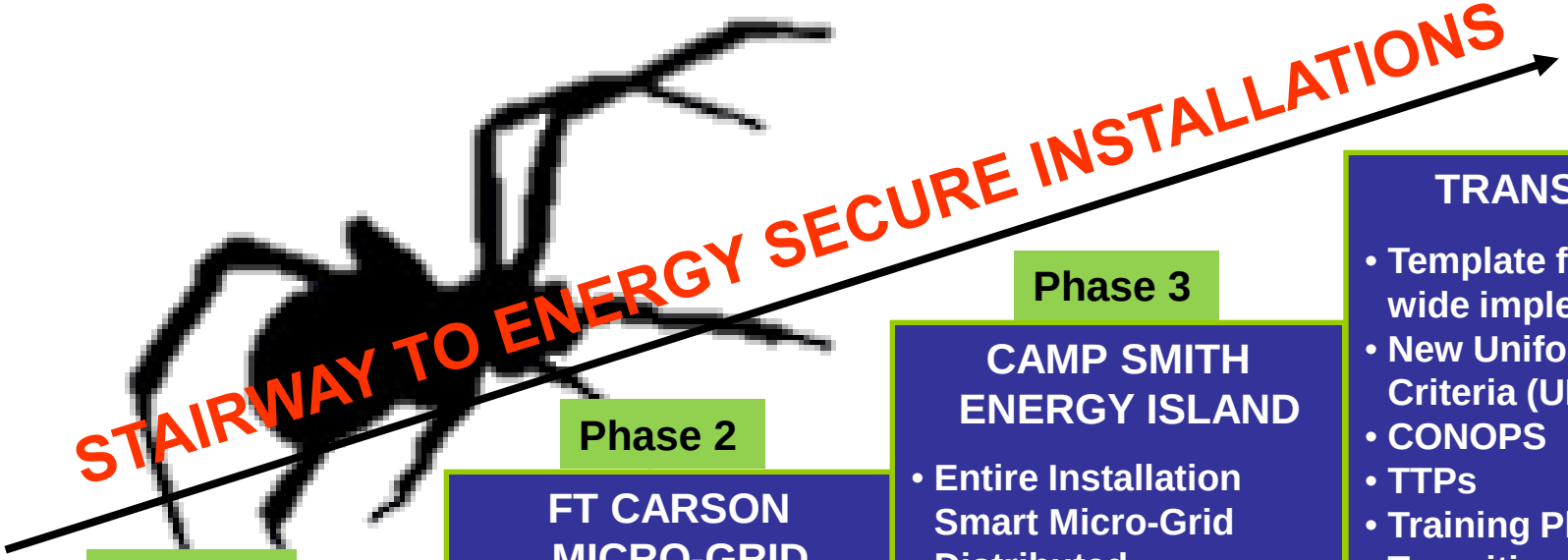
- Any Power Source Can be a SPIDERS Generator
- Controls are Distributed to Match Generators and Loads
- Dynamic Electrical Topology Responds to System Events

SPIDERS JCTD Objectives

Provide a Cyber-Secure Microgrid for Enhanced Mission Assurance

- Increase reliability of backup generation
- Reduce fossil fuel consumption of generators through renewable integration
- Increase efficiency of generators
- Reduce operational risk through cyber secure control systems

SPIDERS Multiphase Approach



Phase 1

PEARL-HICKAM CIRCUIT LVL DEMO

- Single, 15kV Distribution Circuit
- Two Critical Loads
- Renewable Power Island

Phase 2

FT CARSON MICRO-GRID

- Three, 15kV Distribution Circuits
- Relatively Large PV Source
- Bi-Directional EV Charging Stations
- Peak Shaving
- PF Correction

Phase 3

CAMP SMITH ENERGY ISLAND

- Entire Installation Smart Micro-Grid
- Distributed Renewables
- Blinkless Transfer of Buildings on Loss of Utility
- Load Curtailment
- ROI-Focused Approach

TRANSITION

- Template for DoD-wide implementation
- New Uniform Facility Criteria (UFC)
- CONOPS
- TTPs
- Training Plans
- Transition to Electric Utility Sector
- Transition Cyber-Security

HIGHLY SENSITIVE CRITICAL LOADS

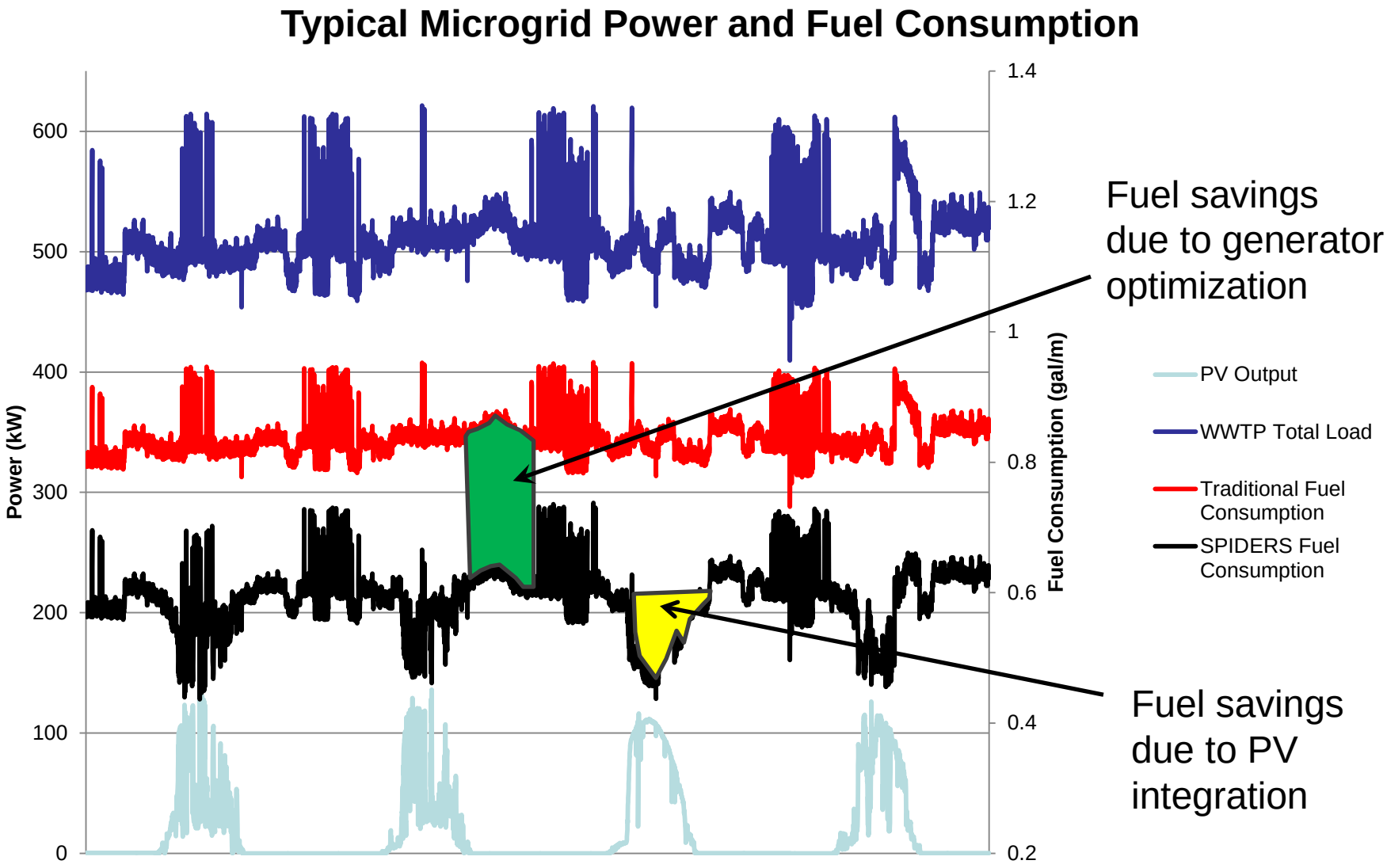
UTILITY ANCILLARY SERVICES

Purpose of SPIDERS

- More Efficient Operation of Diesel Generators
  - Supply critical load using fewer generators
  - Online generators operate at more efficient point
- Ability to Integrate Renewable Resources
  - Microgrid provides a “grid source” to allow UL compliant equipment to operate
  - Power from renewables further reduces consumption of diesel fuel
- Increased Redundancy for Critical Systems
  - Generators can serve any load in microgrid
- Implement Cyber Security for Microgrid Command and Control
  - Microgrids must be less vulnerable than the utility grid to cyber attacks
  - Control network must be responsive to rapidly changing electrical system
- Minimize Changes to Existing Infrastructure
  - In order to maximize effectiveness of SPIDERS program, it must be implemented at existing facilities, not use new ones
  - Utilizing existing infrastructure increases reliability and maintainability of systems

INCREASE RELIABILITY & REDUCE DIESEL FUEL CONSUMPTION

Performance Optimization



SPIDERS Value Proposition

Repurpose Existing Assets

- Reduced Cost
- Utilize Otherwise Stranded Assets
- Minimize Downtime of Existing Facilities

Flexibility in Usage

- Fully Functional Fail Safe Mode (Do No Harm)
- Satisfy Life Safety Codes
- Facilitate Improved Testing and Maintenance

SPIDERS Value Proposition

Cyber Secure Controls

- Dramatically Increase Situational Awareness
- Isolated Network with Multiple Enclaves
- Distributed Controls Philosophy

COTS-Based Solution

- Adaptable to Each Site’s Unique Requirements
- Facilitate Maintenance

SPIDERS Breaker

- Existing 15kV Distribution System Used for Connecting Generators and Loads
- Generators Directly Connected to the 480V Side of the Building Transformers Using Bypass Breakers
- Automatic Synchronizers Permit Paralleled Operation to Other Generators or Utility

SPIDERS Phase II

SPIDERS Phase II

- Three Microgrid Diesel Generators (3MW total)
- 1MW Segment of PV Array
- Five Bi-Directional Hi-Speed Electric Vehicle Charging Stations (300kW / 400kWh total)

15kV Synchronizing Breaker

- Allows Seamless Transition to Utility
- New Sectionalizing Point within Circuit
- Seamless Transitions are Critical During Testing of System

15kV Sectionalizing Switch

- Replaced Existing Manual Switches with Motor Operated Models
- Workhorse of Microgrid
- Allows for Dynamic Electrical Topology

SPIDERS Breaker

- Provides Pathway for Generator to Feed Microgrid
- Switchboard Design for Compactness
- Schweitzer Relay Backing Up Typical Electronic Trip Unit

PV Array

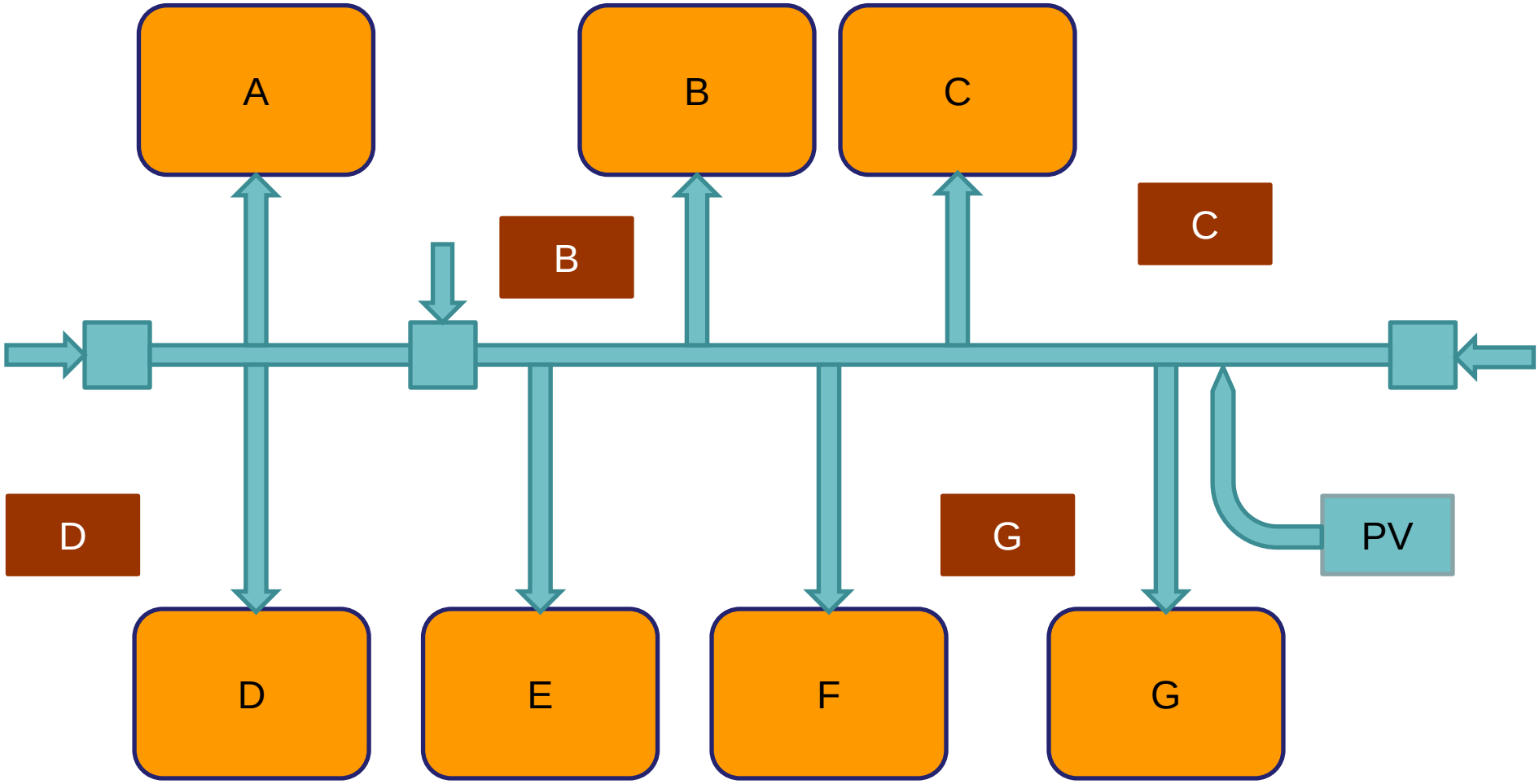
- 2MW Array with Four, 500kW Inverters
- Electrically Divided in Half
- Third-Party Owned & Operated

EV Charging Stations

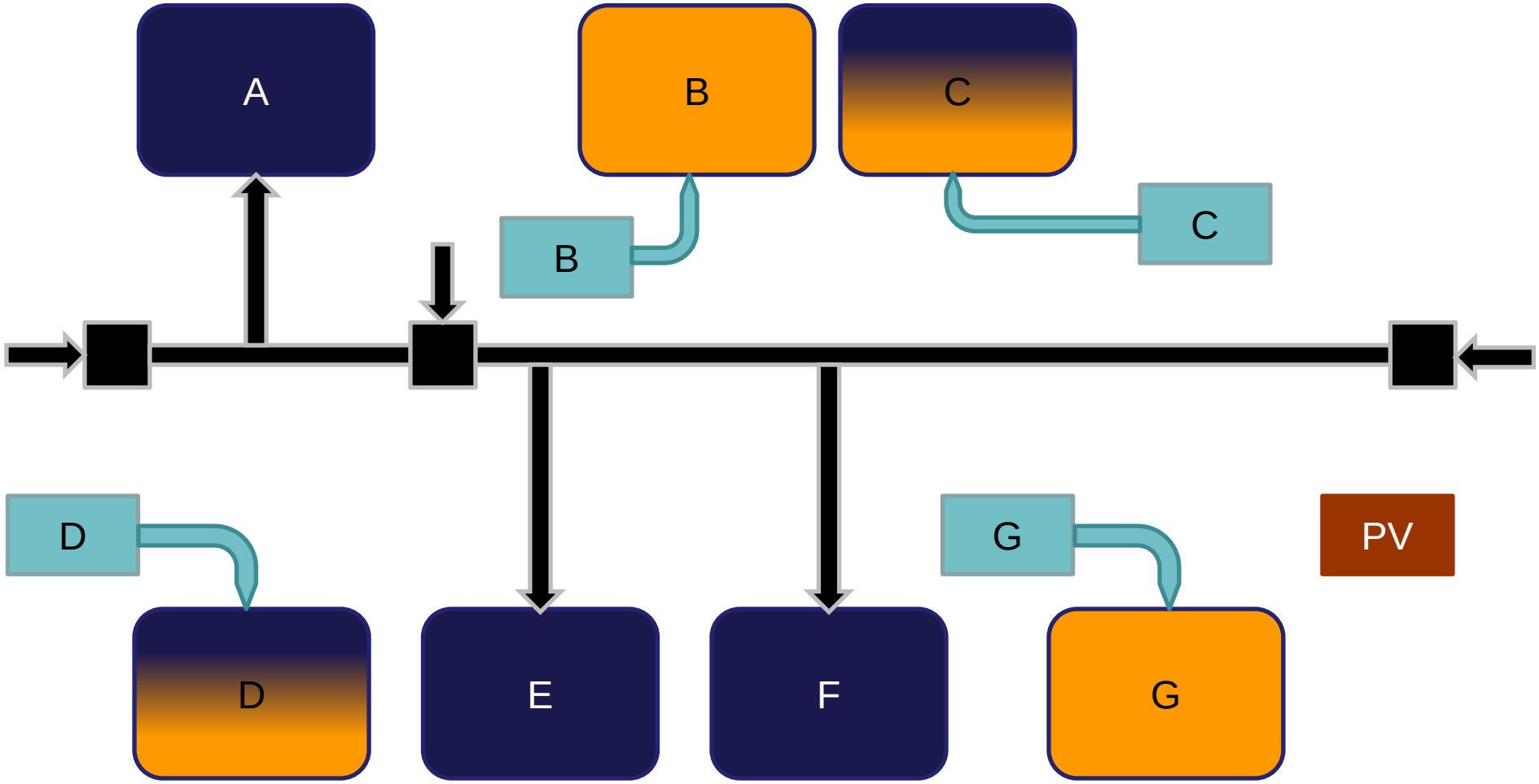
- Five, 100kVA Stations
- Four Quadrant Control Permits VAR Support of Utility or Microgrid Even Without Vehicles
- Aggregator Allows Smart Charging of Fleet Based on Utility and Functional Requirements

Phase II Microgrid

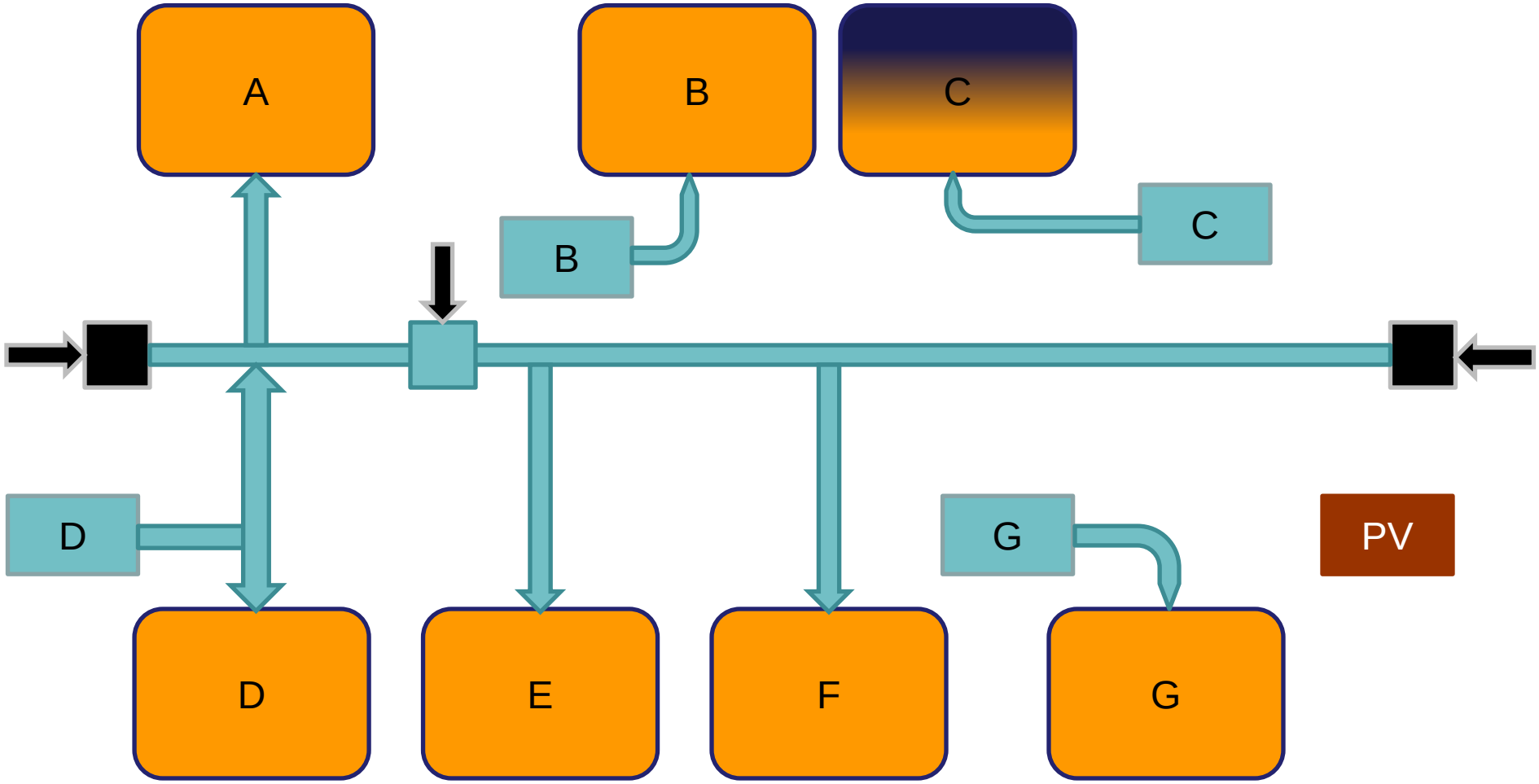
Normal Operation



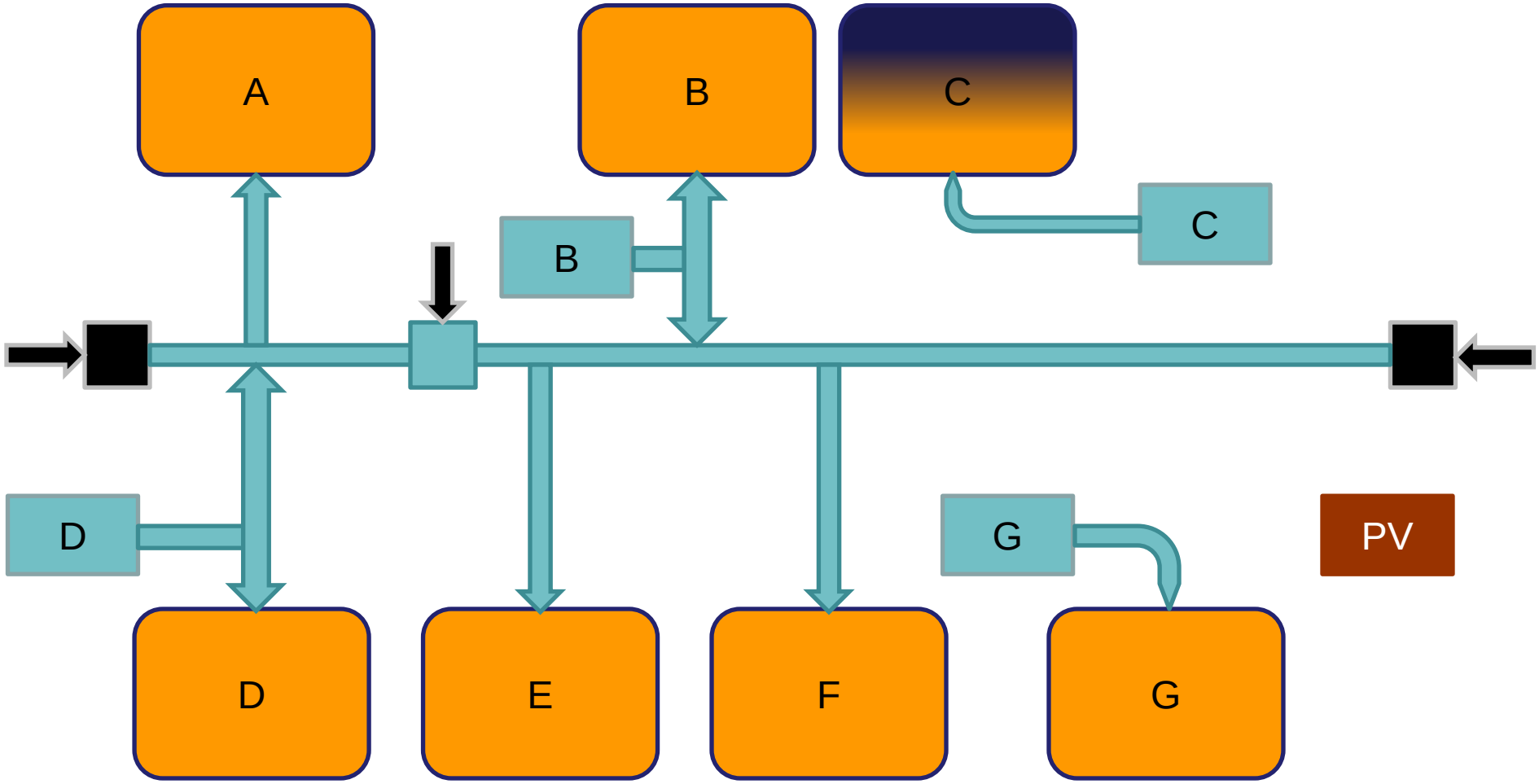
Utility Failure



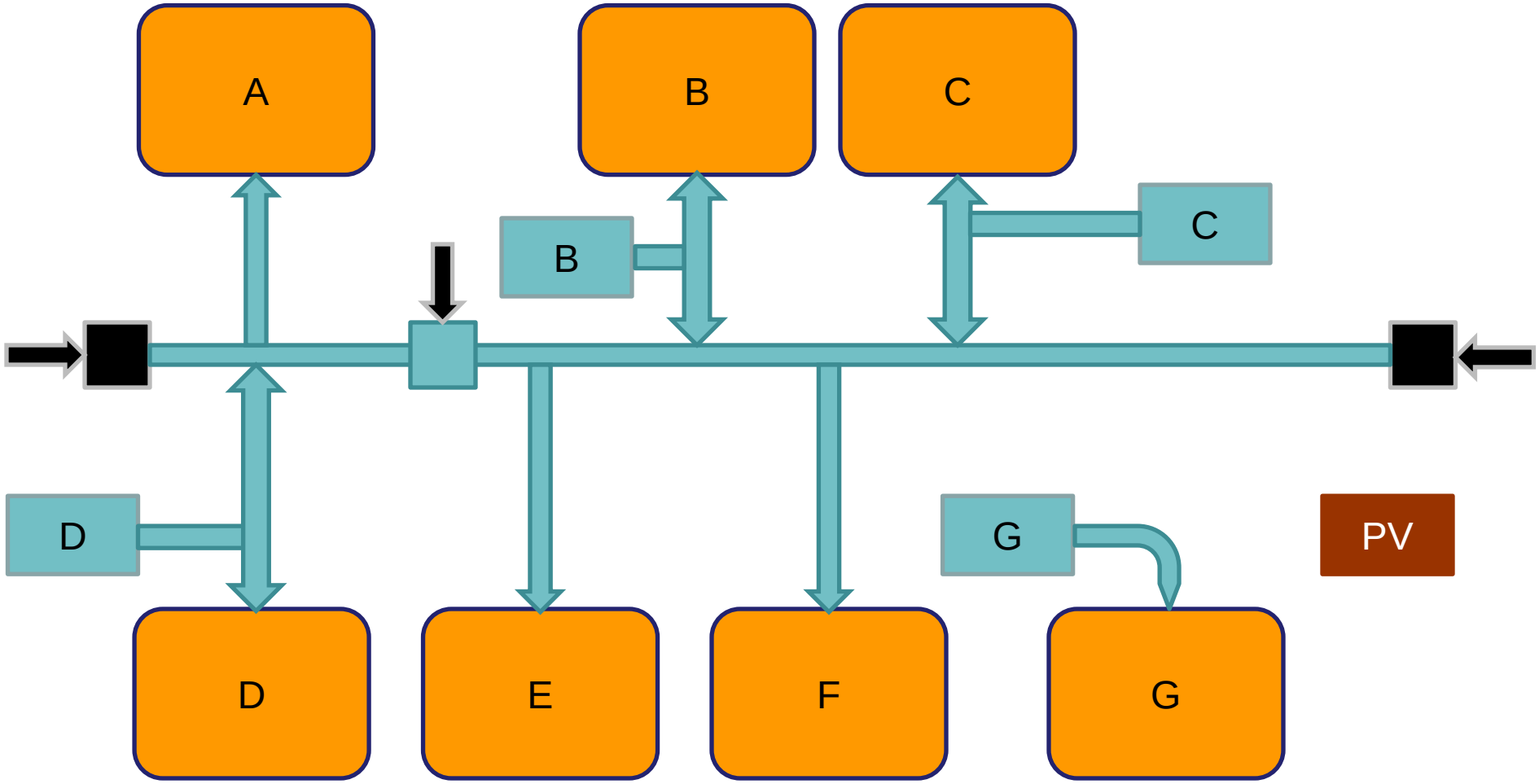
Microgrid Forms



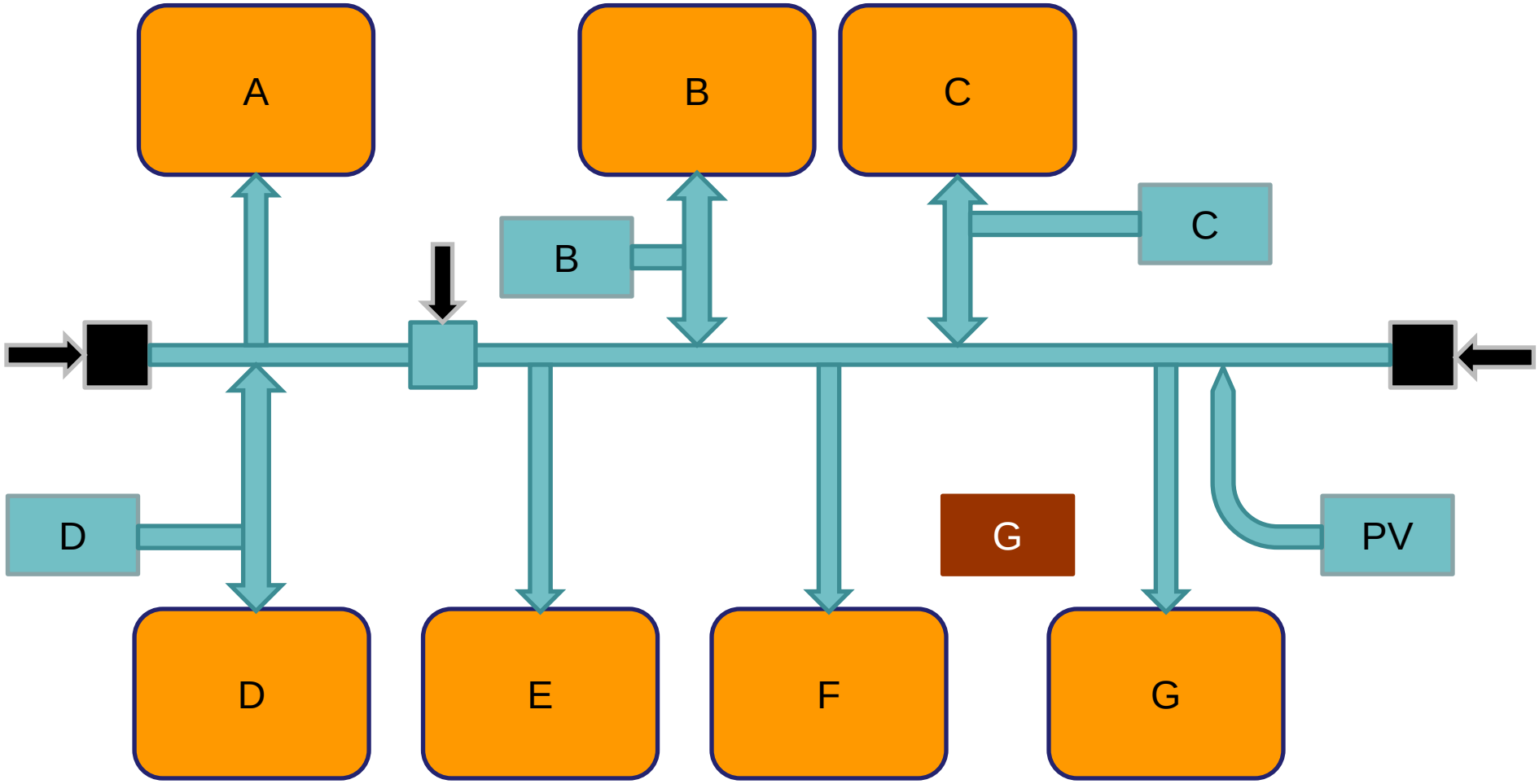
Microgrid Forms (Step 2)



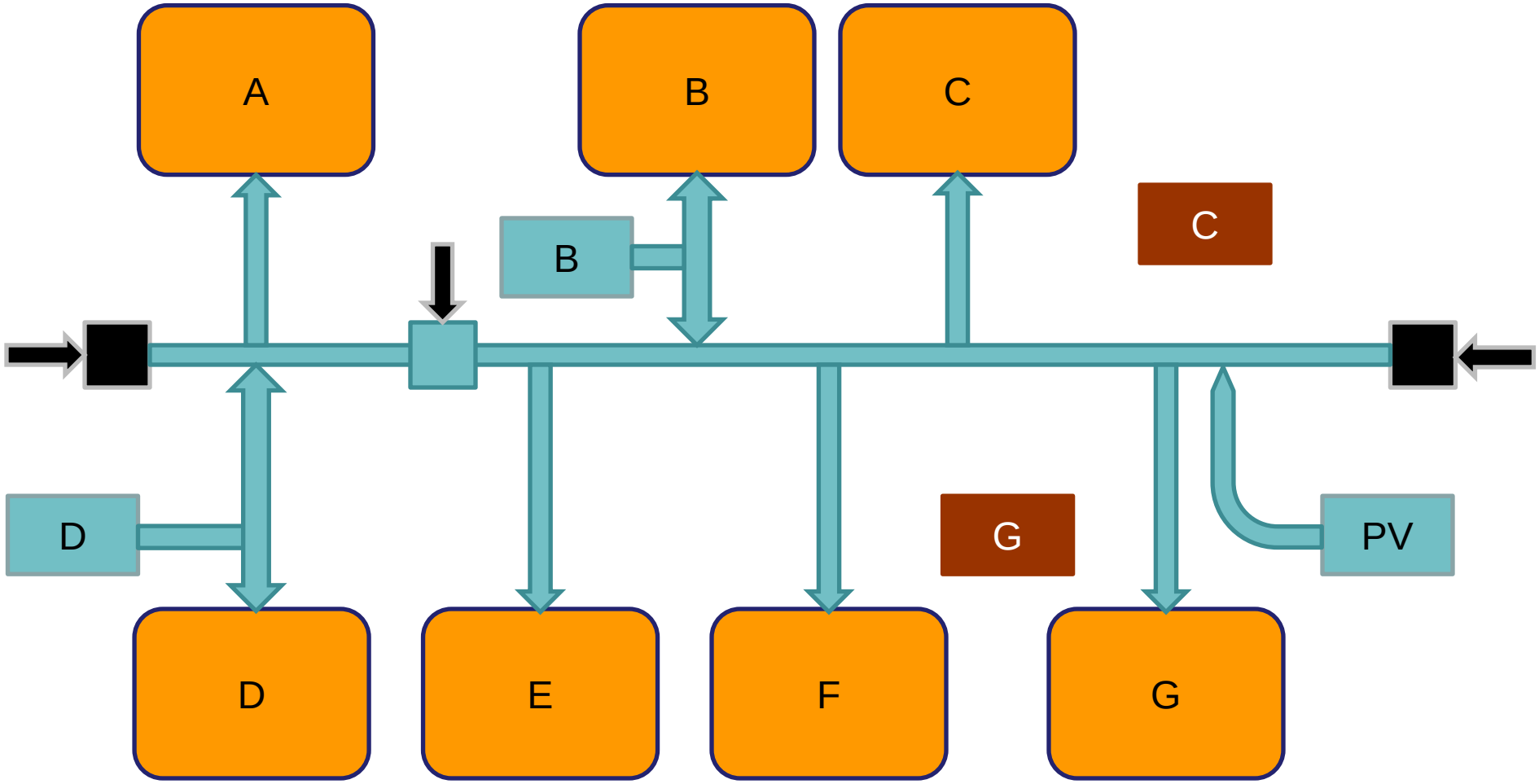
Microgrid Forms (Step 3)



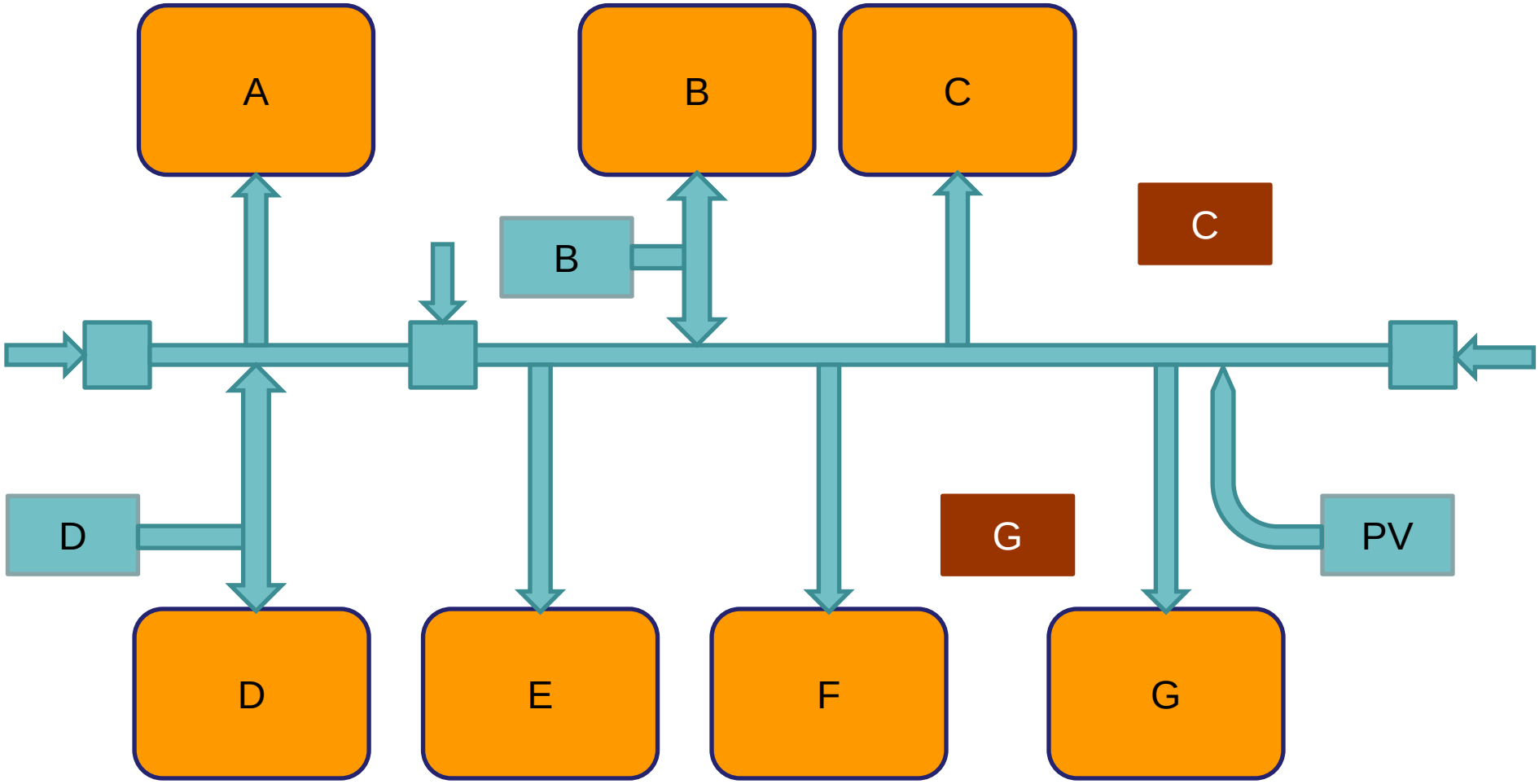
Microgrid Fully Formed



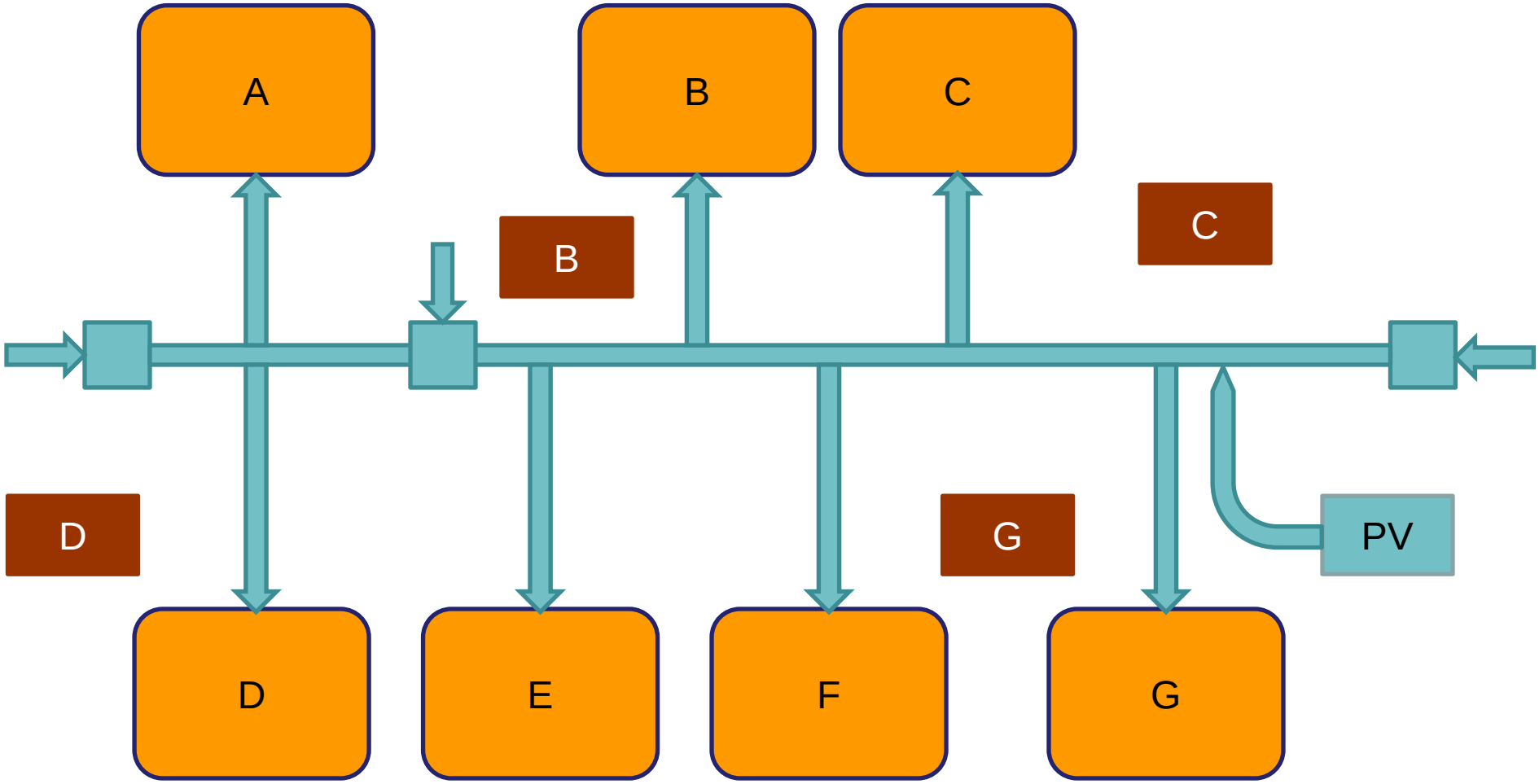
Generator Optimization



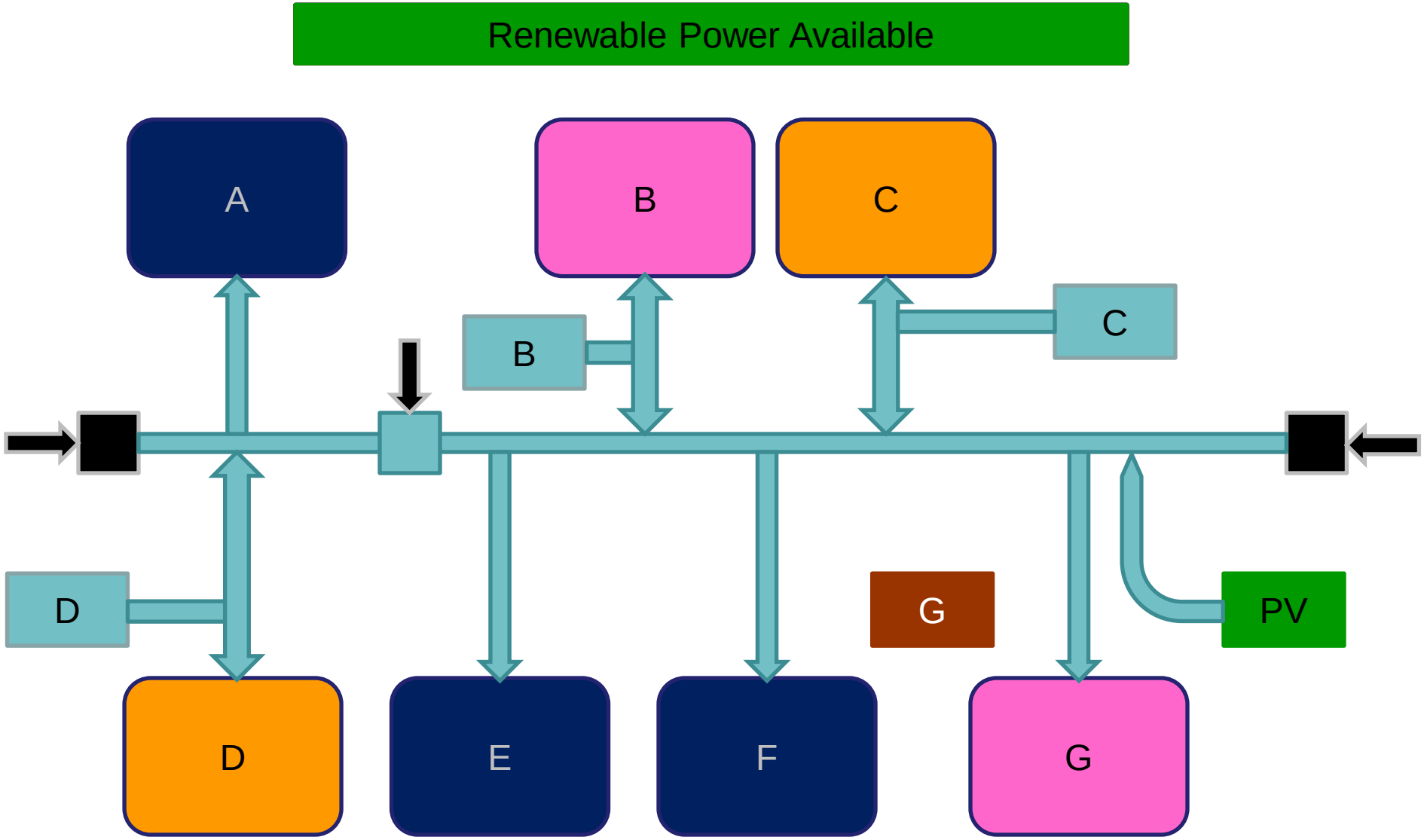
Seamless Return to Utility

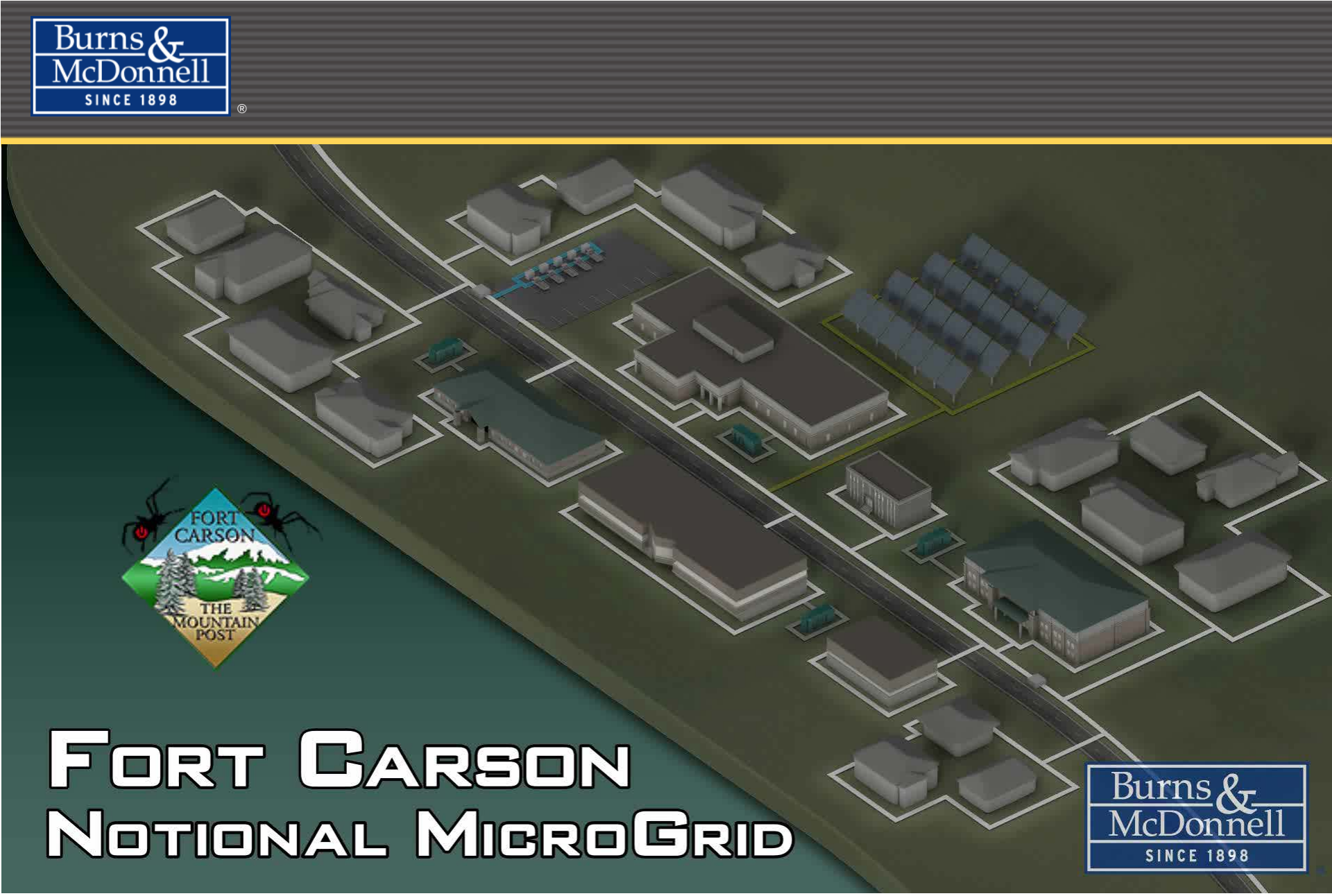


Normal Operation



Microgrid Differences





Fort Carson
Notional MicroGrid

Questions?