Hybrid Renewable Energy Systems

Gary D. Burch
Hybrid Power Systems Manager
Office of Power Technologies, U.S. Department of Energy

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Presentation Outline

- Why Hybrids?
- Hybrid Study
- Conclusions

Hybrid Systems Definition

- Hybrid power systems combine two or more energy conversion devices, or two or more fuels for the same device, that when integrated, overcome limitations inherent in either.

- Hybrid systems can address limitations in terms of fuel flexibility, efficiency, reliability, emissions and / or economics.

Distributed Hybrid Systems Definition

Characteristics of Distributed Energy Resources:

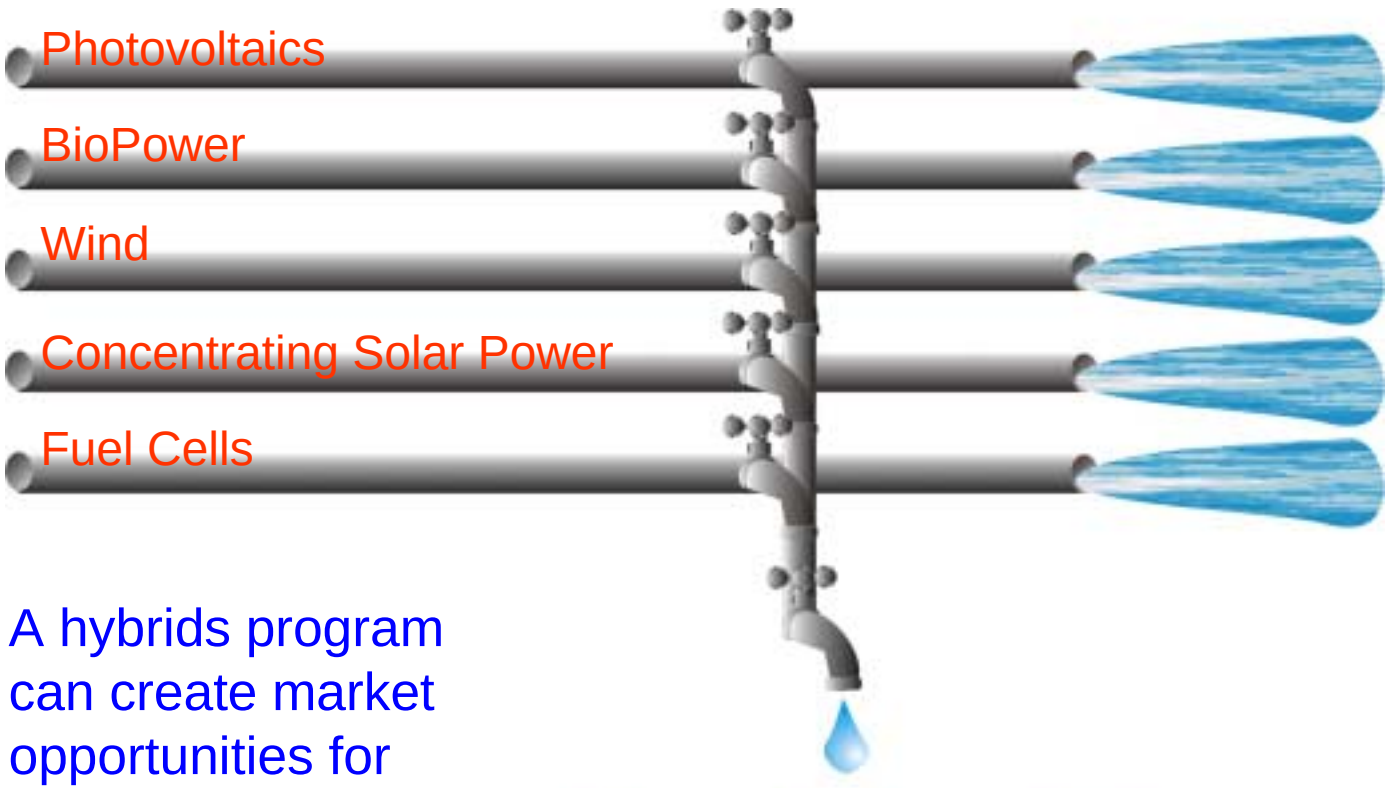
- Located at or near Point of Use
- Locational Value
- Distribution Voltage

Microturbine/Storage

Microturbine/Chiller

Wind/Engine

Focus of a new Hybrid Systems Initiative



A hybrids program can create market opportunities for emerging technologies before they are mature.

Hybrid System Applications

Hybrid Systems Premise

- The “whole” is worth more than the “parts”
- “Value” is driver for DG—not absolute “cost”

Value Propositions

Renewables

Storage

Hybrid System

Value Propositions:

High Efficiency

High Reliability

Low Emissions

Acceptable Cost

The whole is greater than the sum of its parts.

Fossil Fuel Generators

Power Electronics

Value Proposition – Higher Efficiency

Incorporating heat, power, and highly-efficient devices (fuel cells, advanced materials, cooling systems, etc.) can increase overall efficiency and conserve energy for a hybrid system when compared with individual technologies.

Combining heat and power systems, such as those at this University of Maryland test bed, can greatly improve overall energy efficiency.

Value Proposition – Enhanced Reliability

Achieving higher reliability can be accomplished with redundant technologies and/or energy storage. Some hybrid systems typically include both, which can simultaneously improve the *quality* and *availability* of power.

The PV/Propane/Battery hybrid at Dangling Rope Marina significantly increased the reliability of the power system.

Value Proposition – Lower Emissions

Hybrid systems can be designed to maximize the use of renewables, resulting in a system with lower emissions than traditional fossil-fueled technologies.

The SEGS solar thermal power plants in Southern California produce far fewer emissions than traditional electricity generation technologies.

Value Proposition - Acceptable Cost

Hybrid systems can be designed to achieve desired attributes at the lowest acceptable cost, which is the key to market acceptance.

By cutting diesel fuel consumption, the King Cove, Alaska run-of-the-river hydroelectric plant and battery system reduced electricity costs for the town's residents.

Evaluating an OPT Hybrids Program

- Assemble Team
- Inventory DOE activities
- Identify potential hybrid combinations (the matrix)
- Evaluate new opportunities for hybrids and identify R&D needs
- Produce two reports in CY 2001
  - Recommendations for Hybrid Power Program
  - Report to Congress on Partnerships

Current Hybrid Activities in OPT

- OPT/DOE has been involved in a number of hybrid system demonstration projects
- Examples:
  - Salt River Project demonstration of the Thermal Hybrid Electric (THE) SunDish
  - NREL's Wales, AK high-penetration Wind/Diesel system
  - Dangling Rope Marina PV/Battery/Propane hybrid system
  - SEGS CSP/natural-gas-fired power plants in Southern CA




THE SunDish

- 25 kW CSP dish/Stirling engine system
- Provides power during low insolation by burning liquid or gaseous fuel
  - Natural gas
  - Hydrogen
  - Landfill gas
- Demonstration by Salt River Project at Pima-Maricopa Indian Community land fill (Phoenix, AZ) since October 1999
- Benefits of hybrid system:
  - Reliable, continuous power maximizing renewable usage

Wind/Diesel Village Power

- NREL demonstration project underway in Wales, AK (pop. 160)

- High penetration – 130kW wind added to existing 365kW diesel
- Benefits of hybrid system:
  - Reduced fuel consumption 50-60%, requiring less diesel storage
  - Diesel generator provides continuous power in absence of wind

PV/Batteries/Propane

- Dangling Rope Marina (Glen Canyon National Recreation Area) electric power system installed by National Park Service in 1996 to replace diesel gensets
  - 115 kW PV Array
  - 2.4 MWh battery bank
  - Two 250kVA propane-fueled gensets
- Benefits of hybrid system:
  - Eliminated risk of diesel spills
  - Reduced annual fuel usage
  - Reduced operating costs
  - Increased reliability

CSP Trough/Natural Gas

- SEGS I-IX
  - Concentrating Solar Power trough plants tied to grid in Southern CA since late 1980's
  - Total generating capacity: 354 MW
  - Up to 25% natural gas fired

- Benefit of hybrid system:
  - Allows dispatchable generation (including periods when the sun does not shine) while maximizing renewable resource usage

Pieces of the Puzzle

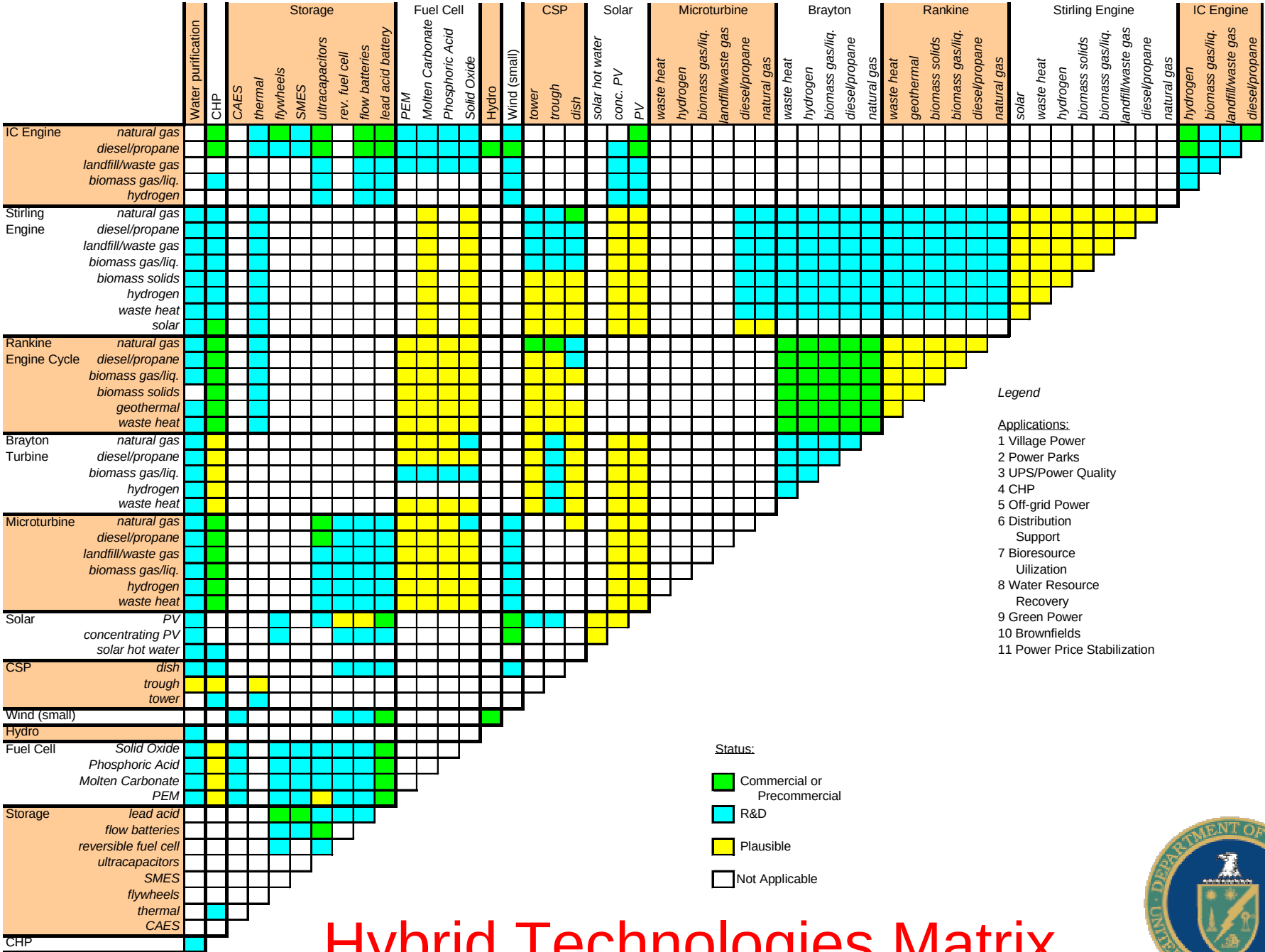
Fossil Fuel Engines
- IC Engine
- Stirling Engine
- Rankine Engine Cycle
- Brayton Turbine
- Microturbine

Renewables
- PV, Concentrating PV
- Solar Hot Water
- Concentrating Solar Power
  - Trough
  - Dish
- Wind
- Geothermal
- Hydro

Fuel Cells
- Solid Oxide
- PEM
- Phosphoric Acid
- Molten Carbonate

Storage
- Lead acid batteries
- Flow batteries
- Reversible fuel cells
- Ultra-capacitors
- SMES
- Flywheels
- Thermal
- CAES

CHP



Hybrid Technologies Matrix

Applications

- Village Power
- Commercial Power Parks
- Industrial Power Quality
- Integrated Building Efficiency (CHP+)
  [Zero Net Energy Buildings]
- Remote (Off-Grid) Power
- Distribution (Grid) Support
- Water Resource Management
- Green Power
- Brownfields (to Brightfields)
- Power Price Stabilization

Hybrid Power Systems Report Objectives

- Define the thrust of a new program
  - Compile a set of activities that may tap into existing technology programs to “fill in the gaps”
  - Coordinate but not overlap with technology programs
  - Stimulate innovative thinking that leads to creative business opportunities
  - Encourage cross-programmatic interactions and benefits
- Define how a hybrid power program will accelerate introduction of all DER technologies that include renewables
- Make determination on the need for an integrated *distributed* hybrid power program

Program Strategy

- Focus on designing, testing, validating, and promoting optimized DER hybrid power systems for identified market applications
- Have **“market focus”,** in contrast with the “technology focus” of existing technology programs
- Coordinate with technology programs to:
  - determine best available technology
  - communicate with customers (users) to understand their needs
  - conduct systems analyses and produce software tools to optimize performance
  - partner with system integrators to design these features into products
  - test and validate system performance
  - promote regional partnerships to encourage deployment

Program Content

- *Management and Systems Analysis* – the "software" component of the program, to manage and implement efforts including planning and analytical functions.
- *Systems Integration* – the "hardware" aspect of the program, to work with national laboratories and system integrators to design, test, and validate early DER hybrid power systems.
- *Regional Partnerships* – the "outreach" effort within the program, to work with customers, state/regional governments, and private sector to deploy DER hybrid power systems as rapidly as possible.

Conclusions

- Hybrid power systems can offer solutions and value to customers that individual technologies cannot match.
- Hybrids offer market entry strategies for technologies that cannot currently compete with the lowest-cost traditional options.
- Some renewable hybrid power systems are commercially available today.
- OPT/DOE is evaluating a new hybrid power systems initiative with an emphasis on *distributed* applications.
- The OPT hybrid power initiative would include substantial private/public partnership effort.
- Recommendations and report will be available in 2001.