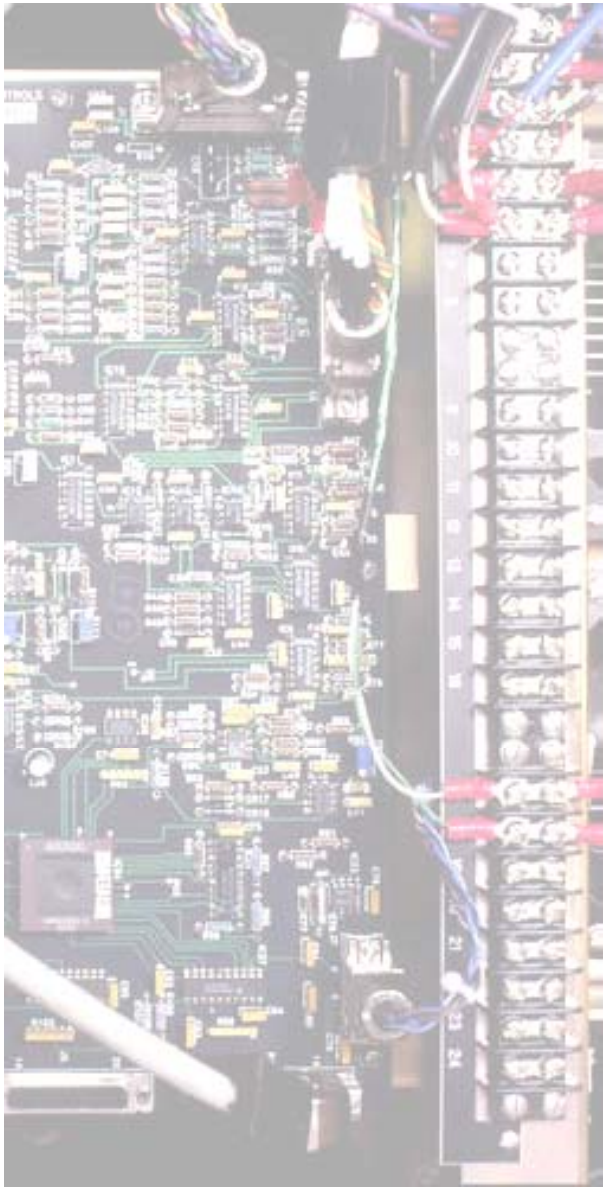

Overview of Currently Available UIT Systems

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RESOURCE DYNAMICS CORPORATION

Outline

- The interconnection system
- The Universal Interconnection Technology concept
- Current UIT-like offerings

The Interconnection System

- The interconnection system performs the functions necessary to maintain the safety, power quality, and reliability of connected area EPSs and DERs

- System complexity depends on the level of interaction required between the DER and the EPS

Interface Configurations Vary by DER Applications

	No Interconnection	Isolated DER Operation With Automatic Transfer To Area EPS	Parallel Operation To Area EPS, No Power Export	Parallel Operation To Area EPS, Power Export To Area EPS
Baseload	✓	✓	✓	✓
Cogeneration	✓	✓	✓	✓
Peak Shaving		✓	✓	✓
Emergency/Backup		✓	✓	✓
Premium	✓		✓	✓
Remote	✓			

Interconnection Systems Can Include the Following Components:

- Exciter control system for the generators,
- Synchronizer for the reliable transfer of power between the generators and the grid,
- Automatic transfer switch control,
- Import/export control,
- Protective relay functions,
- Metering, and
- Remote communications.

The U.S. DG Interconnection System Market is Potentially Great in Size

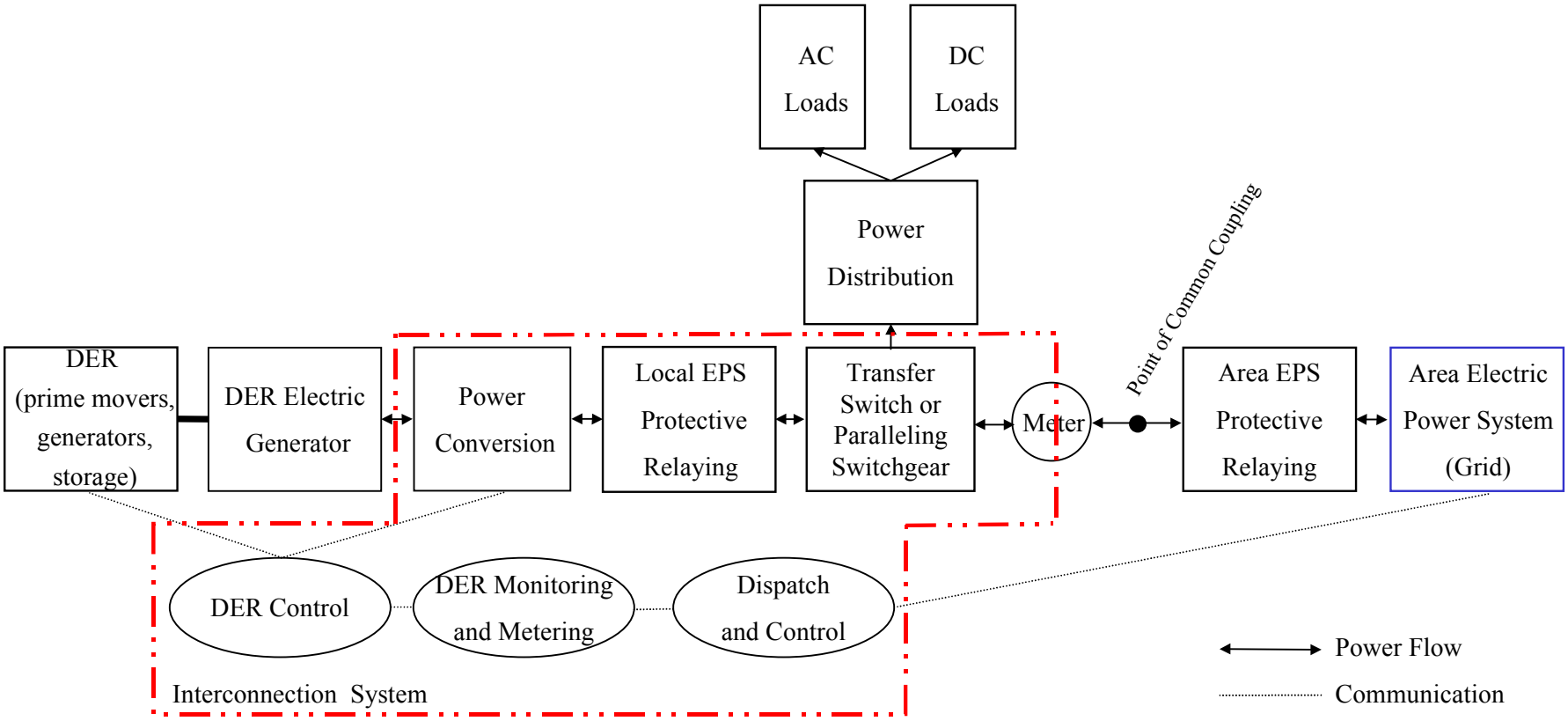
- Engines and Combustion Turbines > 100 kW in size
  - engines (184,000 units; 87,000 MW)
  - turbines (3,000 units; 58,000 MW)
- Microturbines < 100 kW in size for premium power, peak shaving, backup, power export
  - 1,200 units; 40 MW
- Fuel cell systems used for prime power
  - 200 units; 40 MW

It is important to not ignore options for interconnecting the many existing small emergency generators

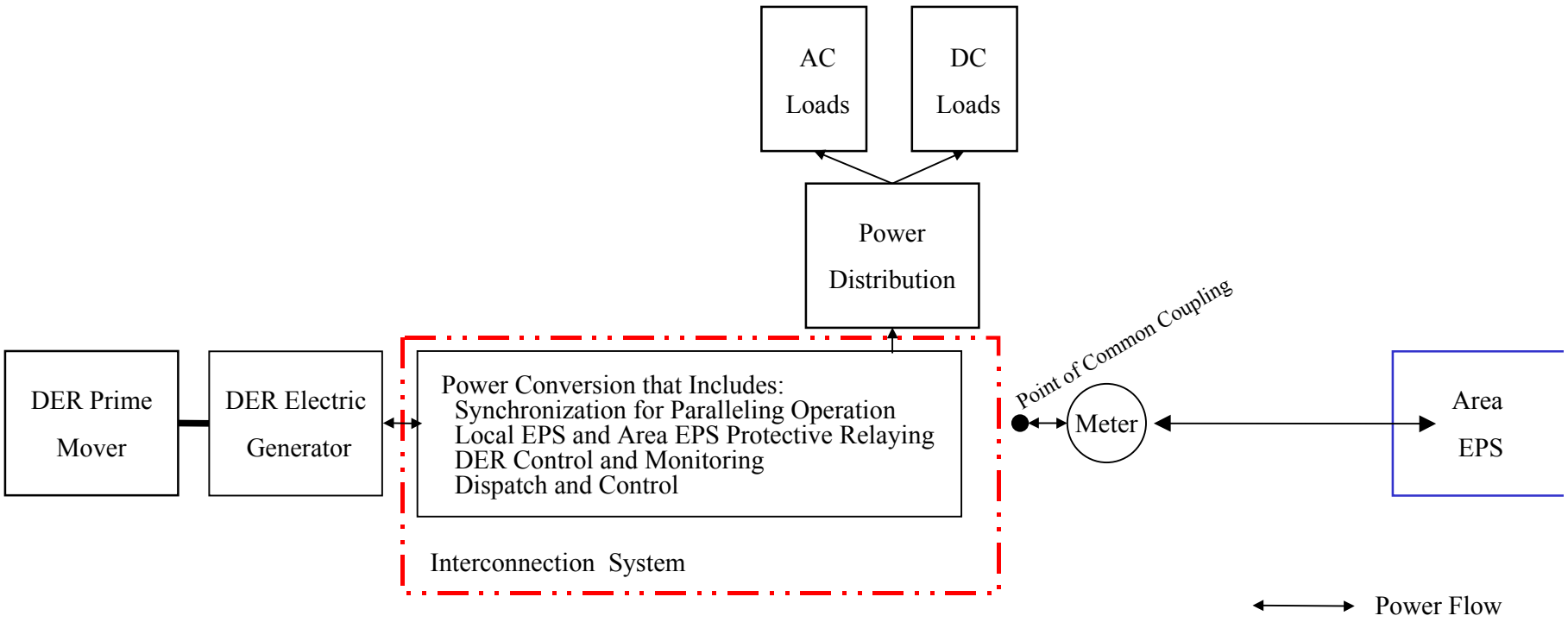
A Universal Interconnection Technology (UIT) Would:

- Define a standard architecture for functions to be included in the interconnection system,
- Meet the needs of the DG Interconnection market,
- Make DER Installations
  - cheaper,
  - quicker,
  - more reliable,
- And will also provide benefits to distribution companies.

Interconnection Schematic (1)



Interconnection Schematic (2)



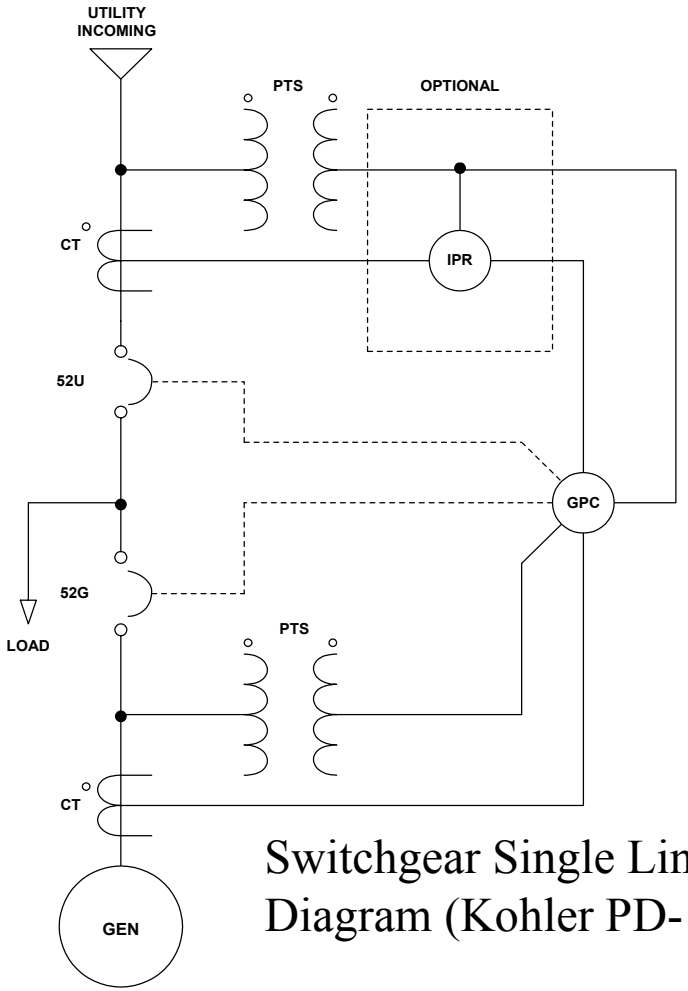
There are Two Types of UIT-Like Systems Currently in Development

- Traditional *non-inverter based pre-engineered systems* that allow for synchronization and parallel operation with the grid (switchgear)

- *Inverter based* UIT-like systems for prime movers with DC or high frequency AC output (i.e. PV systems and fuel cells)

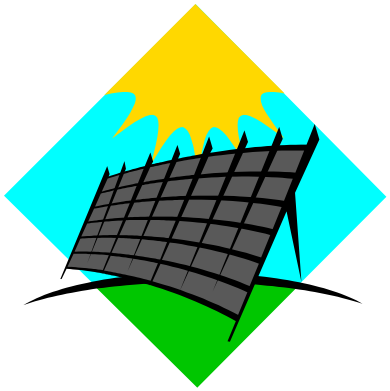
Traditional Non-Inverter Based Switchgear

- Pre-engineered structures that contain the functions necessary for synchronization and parallel operation with the grid:
  - operator interface,
  - controls,
  - protective relays,
  - circuit breakers,
  - synchronization,
  - and much more.
- Generally used for DER units with more traditional AC output.



Switchgear Single Line Diagram (Kohler PD-100)

Inverter Based Systems

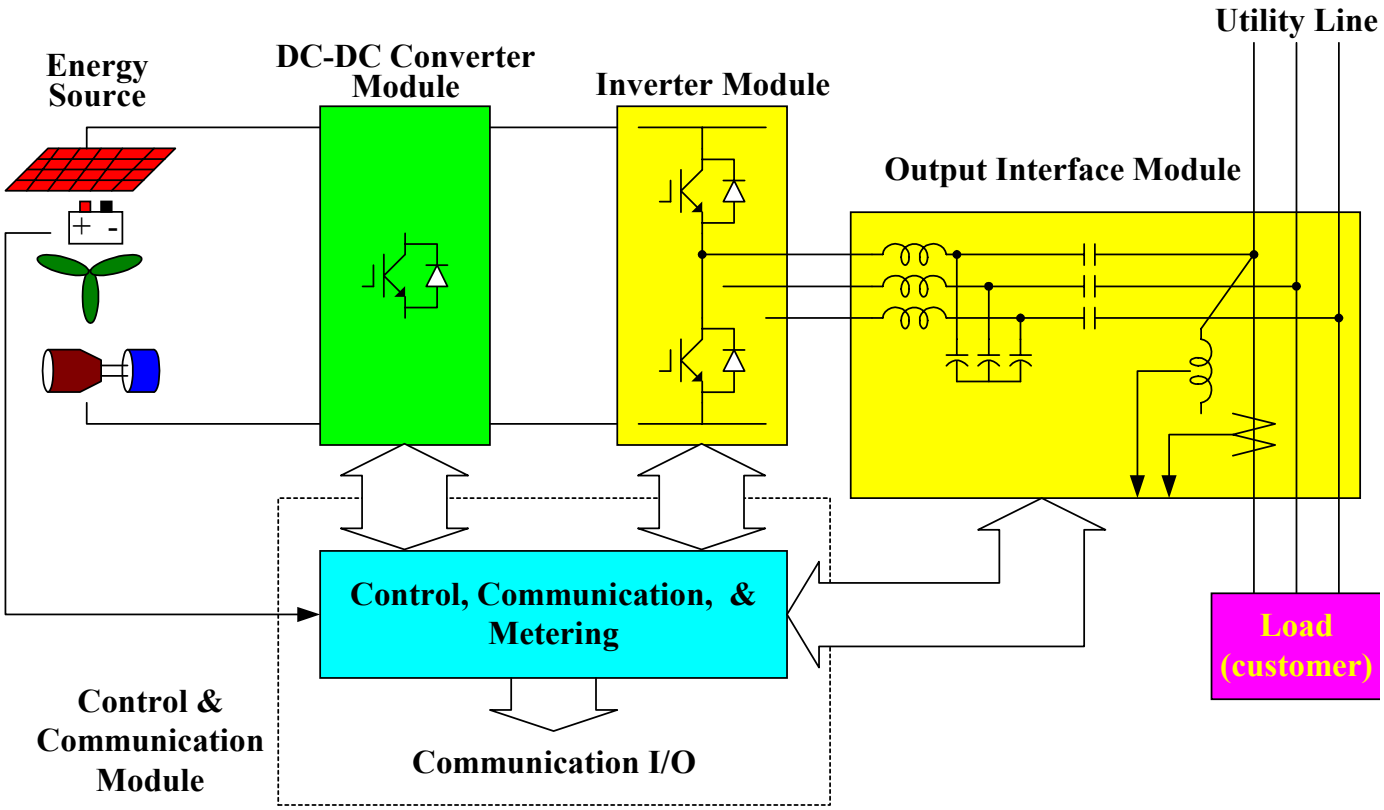


- Designed for use with prime movers with DC or high frequency AC output (i.e. PV systems, fuel cells, and microturbines).
- In the future, inverter based interconnection systems may be applied to standard reciprocating engine gensets.

Reciprocating Engine Inverter-based System

- Benefits
  - Higher efficiency, lower emissions at part-load
  - Better power quality
- Honda EU3000is (3 kW)
  - 200 volts at 14-17 Hz
  - Rectified to 12 volts
  - Inverted

Universal Inverter Modular Building Blocks



Issues Current Inverters Must Address to Meet the Requirements of a UIT

- Switching device ratings (and associated reliability issues)
- Transformers (and associated design limitations)
- Limitations on voltages that can be attained
- Creation of high levels of harmonic distortion
- Lower cost
- Control limitations

Some Currently Available UIT-Like Systems

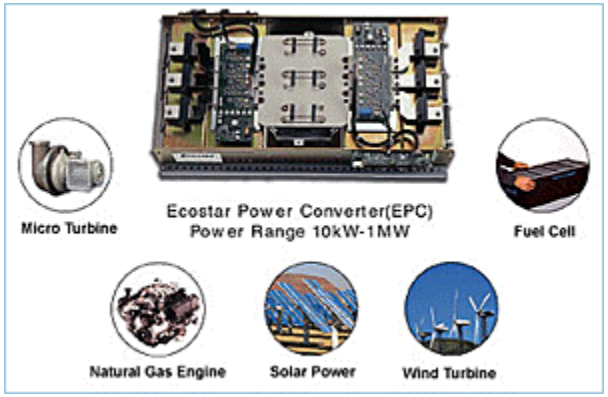
Company	Unit	Inverter	Non-Inverter	Electrical Specification
Advanced Energy Systems	*MM-5000 – Grid-Connected MultiMode Power Conversion System*	X		5 kVA
	GC-1000 1kW Grid-Connected Photovoltaic Inverter	X		1 kVA
AstroPower	*SunChoice Program*	X		8.5 kVA
Ballard	*EcoStar Power Converter*	X		Up to 110 kVA
Cummins Power Generation	*PowerCommand Digital Paralleling Equipment*		X	Up to 2,500 kVA
Detroit Diesel	*Spectrum SD-100*		X	Up to 2,400 kVA
Encorp	enpower-GPC powered "paralleling switchgear"		X	800-5000 amp
Fire Wind and Rain Technologies, LLC	*Power Streak Inverter*	X		5kVA
Kohler	*PD-100 Switchgear*		X	Up to 2,500 kVA
Thomson Technology	*Distributed Generation Switchgear System/ GCS 2000-DG System*		X	Up to 4,000 amp
Vanner Incorprated	*RE Series Inverters*	X		5.6 kVA
Xantrex	*Grid Tie Inverters*	X		Up to 125 kVA
ZTR/Shallbetter	*DGX Switchgear*		X	Up to 4000 amp

Several systems integrate components from multiple manufacturers

Kohler PD-100

- 20-2,000 kW 800-4,000 amps
- New units and retrofits
- 1/3 the size of typical switchgear
- Modes of operation
  - ATS (closed, open, or soft load)
  - Interruptible rate
  - Peak shaving
  - Export to utility
- Uses Encorp controller

Ballard Ecostar Power Converter



- 10 kW - 1 MW size range
- Variety of “prime movers”
- Modes of operation
  - Grid mode and stand-alone mode operation
  - Grid mode and stand-alone mode transition
  - Stand-alone mode to grid mode transition
  - Standby generator start/stop, remote wake-up, and standby function
  - Multi-unit capability up to 1 MW for grid and stand-alone operation
  - Reliable synchronization to the grid
  - Remote monitoring/controls/dispatch

Built-in Systems

- Many DER manufacturers have been either building in, or offering as an option, some of the key interconnection equipment components as part of their DER genset offerings

- Thus far, DER manufacturer systems are the only systems to be certified though California Energy Commission's Rule 21 certification though it seems likely that UITs could benefit from this process as well

Rule 21 Certified Units

- Capstone
  - Model 220 and 60
- PlugPower
  - 5 kW PEM fuel cell
- Both have built-in UIT-like functions
- Currently, interconnection companies have not approached California regarding Rule 21