



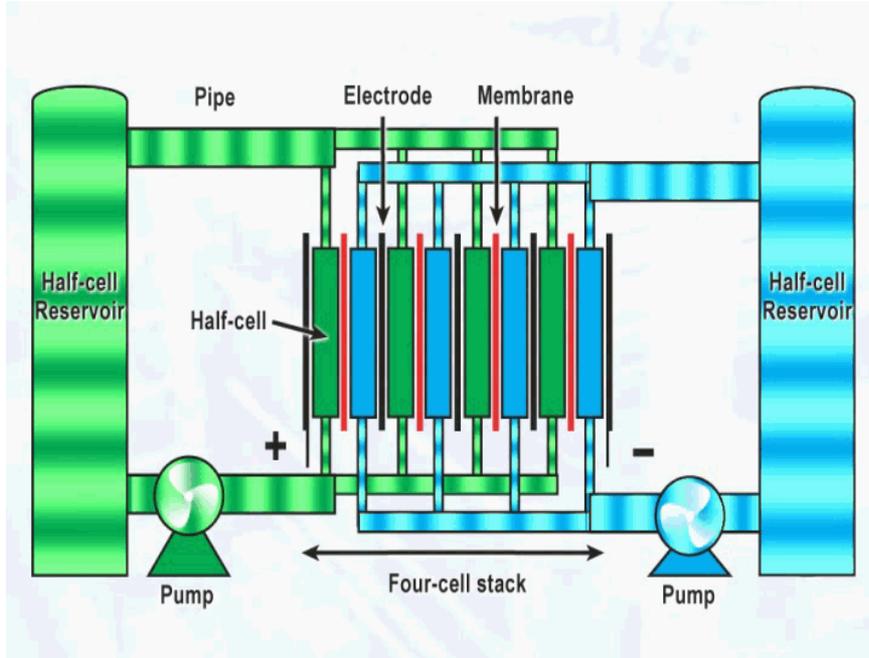
# **VRB Power Systems**

INCORPORATED



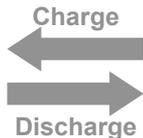
# VRB Flow Battery Technology

A liquid electrolyte that is separate from the electrode.



- An electrochemical energy storage system operating at ambient temperatures
- Reversible fuel cell – reduction and oxidation of single unique element: Vanadium\_
- No cross contamination as with other storage systems. Electrolyte never wears out – high residual value
- Very low maintenance
- Deep cycles (20 to 80%) >10,000
- Low self discharge – indefinite energy storage
- Energy can be recovered instantaneously
- Battery can recharge as fast as it discharges (1:1)
- Power and Energy separately scaleable

Oxidation process



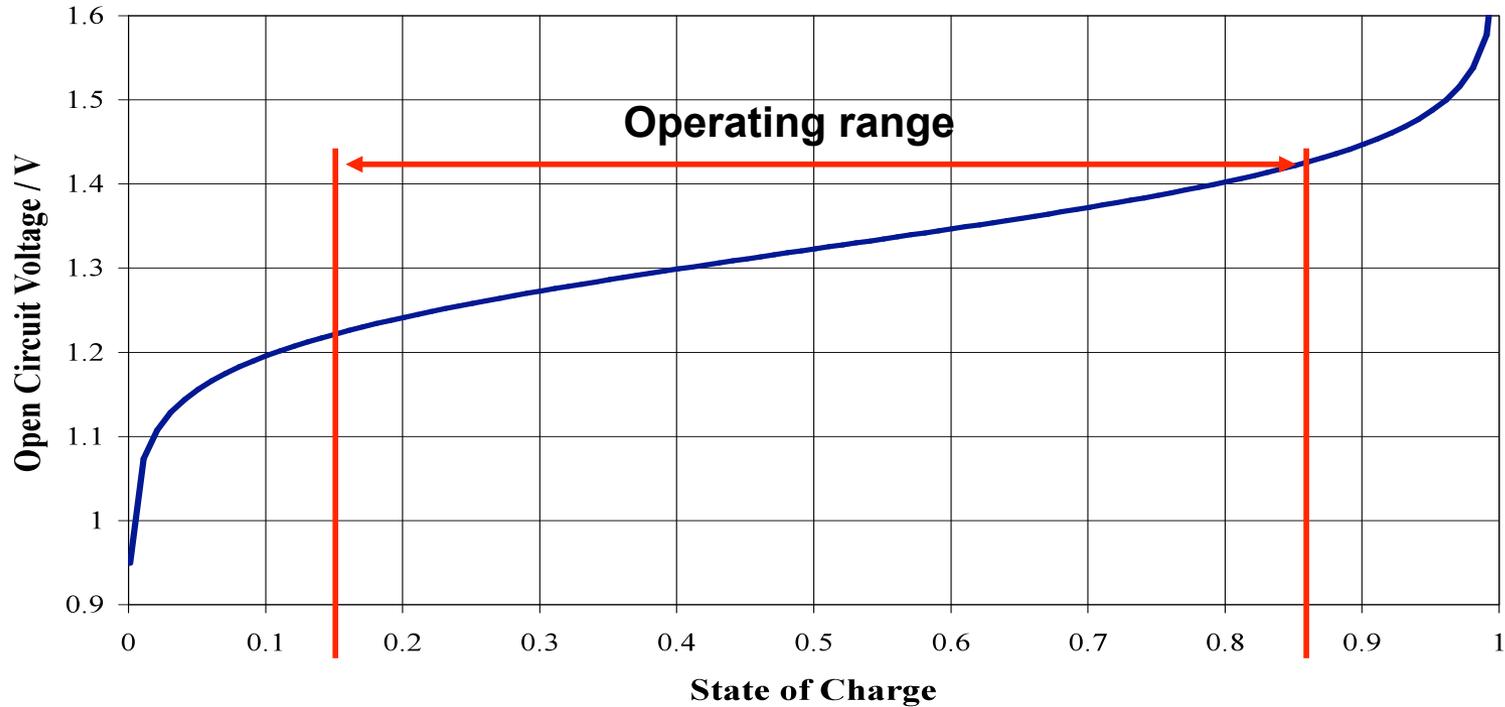
Reduction process



# VRB cell open circuit voltage – SOC indicator

**What you measure is what you get...**

**Cell potential vs. state of charge**  
**T = 298 K**

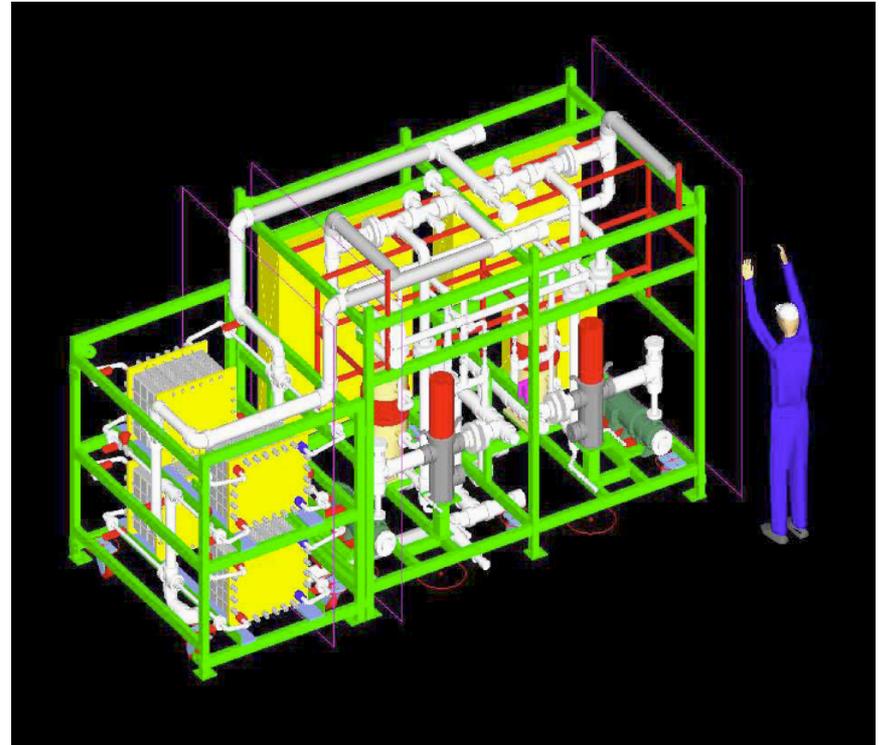
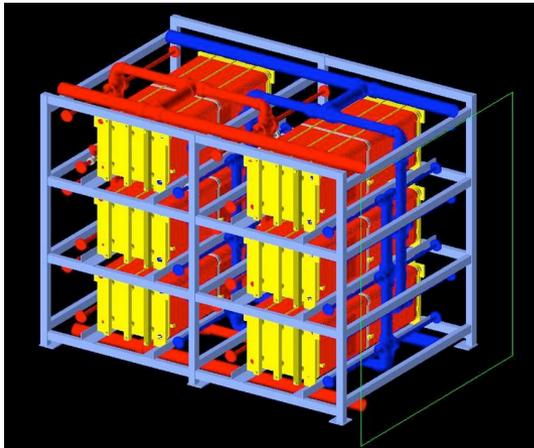


# VRB Energy Storage Systems (VRB-ESS)

5kW – 25 kWh

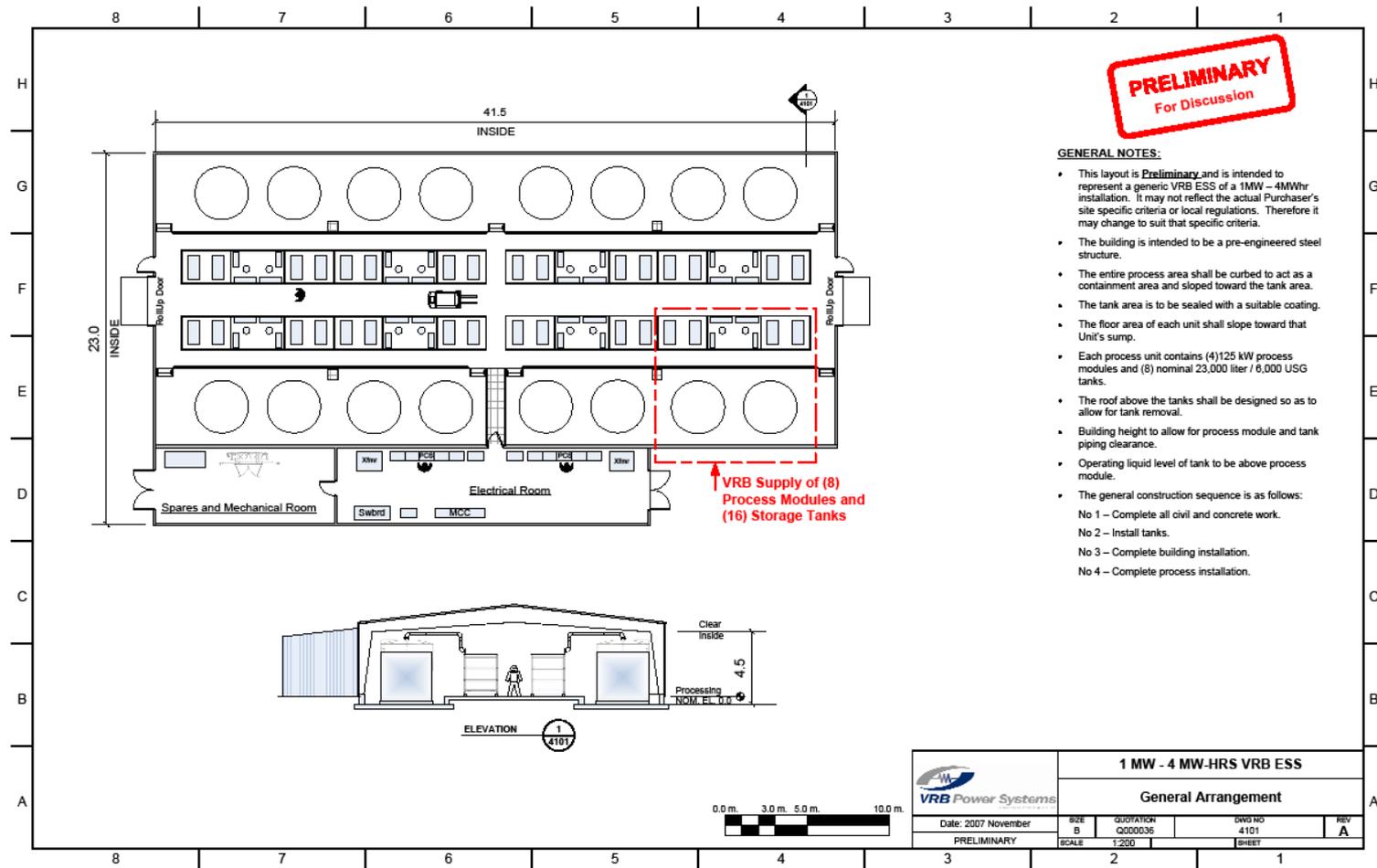
Commercial Introduction – June 2007





# VRB -ESS

# 1MW; 4MWh



**PRELIMINARY**  
For Discussion

**GENERAL NOTES:**

- This layout is **Preliminary** and is intended to represent a generic VRB ESS of a 1MW - 4MWhr installation. It may not reflect the actual Purchaser's site specific criteria or local regulations. Therefore it may change to suit that specific criteria.
- The building is intended to be a pre-engineered steel structure.
- The entire process area shall be curbed to act as a containment area and sloped toward the tank area.
- The tank area is to be sealed with a suitable coating.
- The floor area of each unit shall slope toward that Unit's sump.
- Each process unit contains (4) 125 kW process modules and (8) nominal 23,000 liter / 6,000 USG tanks.
- The roof above the tanks shall be designed so as to allow for tank removal.
- Building height to allow for process module and tank piping clearance.
- Operating liquid level of tank to be above process module.
- The general construction sequence is as follows:  
No 1 - Complete all civil and concrete work.  
No 2 - Install tanks.  
No 3 - Complete building installation.  
No 4 - Complete process installation.

		<b>1 MW - 4 MW-HRS VRB ESS</b>			
		<b>General Arrangement</b>			
Date: 2007 November	SIZE: B	QUOTATION: Q2007036	ENVD NO: 4101	REV: A	
PRELIMINARY	SCALE: 1:200	SHEET			

# Projects

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- California – CEC/SMUD/Telecommunications 20kW – 180 kWh
- Florida – Progress Energy            2 x 5kW – 25kWh            Solar
- Kenya – Winafrique                    2 x 5kW – 25kWh            Telecomms
- Denmark – RisØ                            15kW – 125kWh            Wind
- Italy – Edison                                5kW – 25kWh                Telecomms
  
- Canada – NRCan                            Completion of test program
  
  
- Engineered systems                        Design/Proposals            125kW – 20MW

# Company

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- Personnel: No. employees:                      April 2007 - 35                      April 2008 - 56

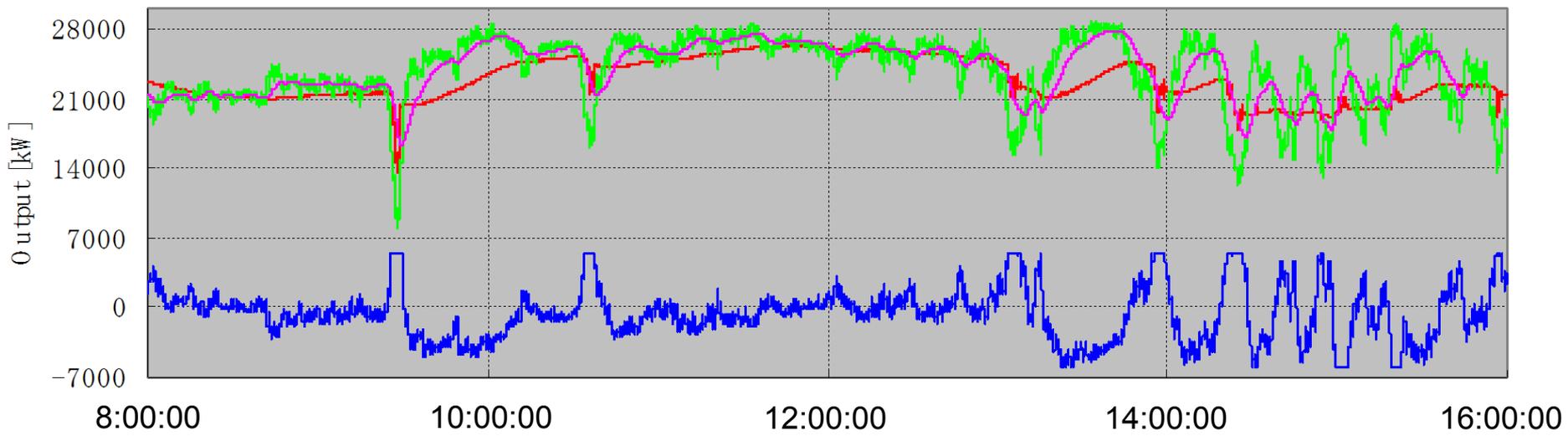
- Facilities



# Daily Wind Output Smoothing at J-Power

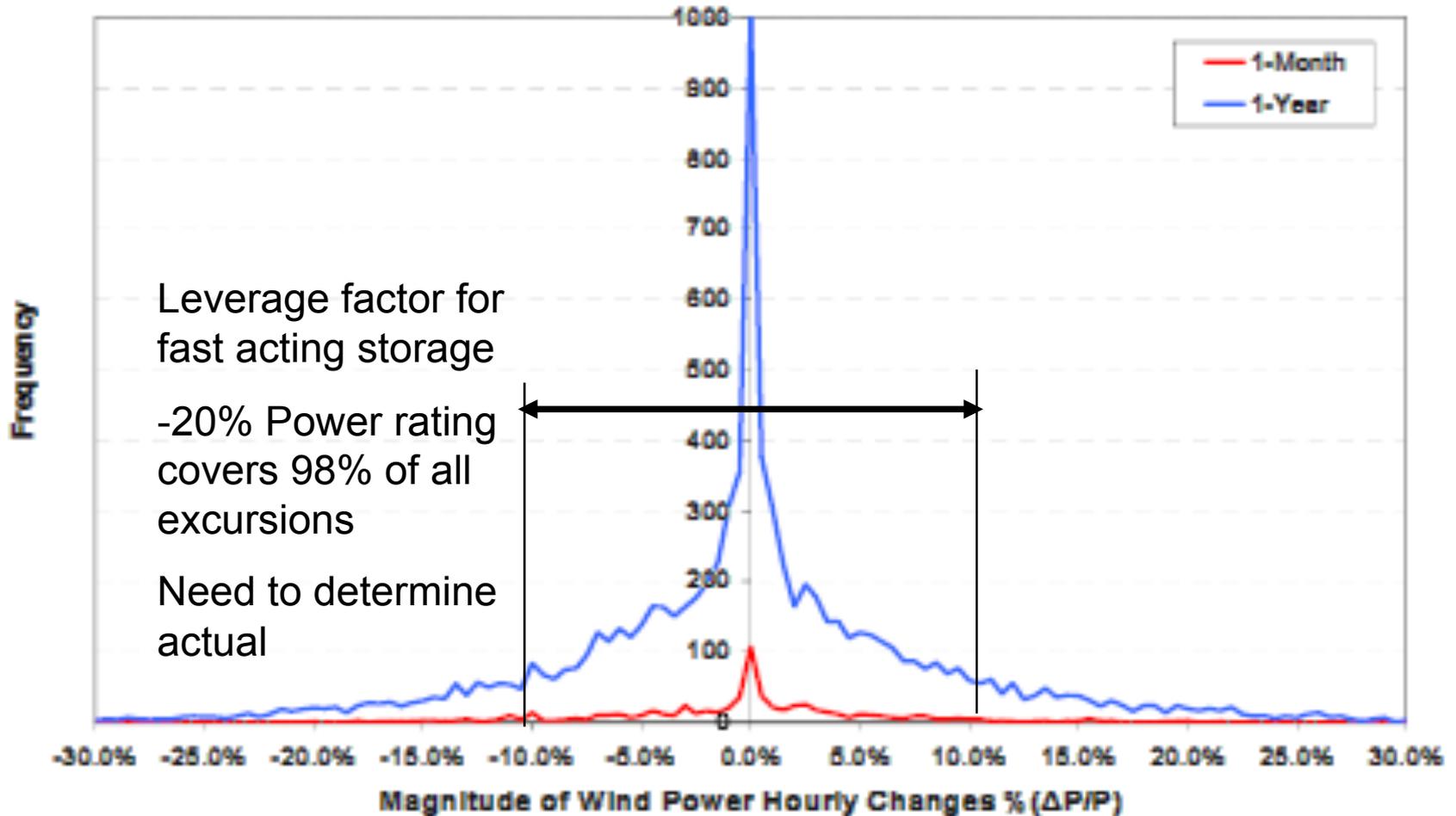
2005/12/10

— GEN+BAT OUT — GEN SUM OUT — BAT OUT — SIG (BNKCNT:SIM)



- The VRB-ESS (blue line) runs continuously to smooth wind farm production (green line)
- At only 20% of the wind-farm's nameplate capacity, the VRB ESS has a significant smoothing effect to total wind-farm + battery output (red line)
- The VRB-ESS intelligently recharges throughout the day so that it maintains 50% SOC

# Sizing - Distribution of Hourly Step Change Values



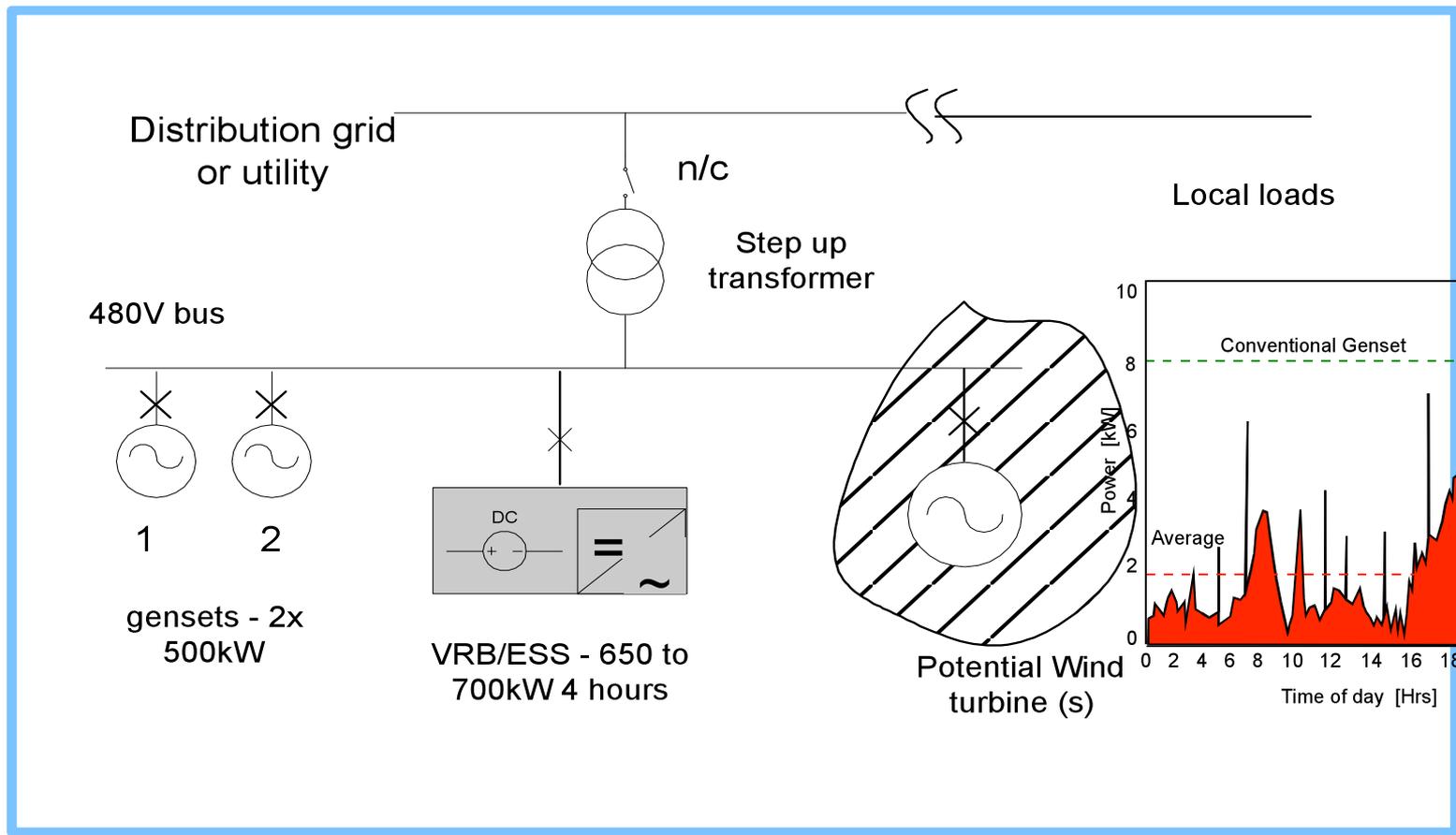
NREL 2004

# Ancillary Services

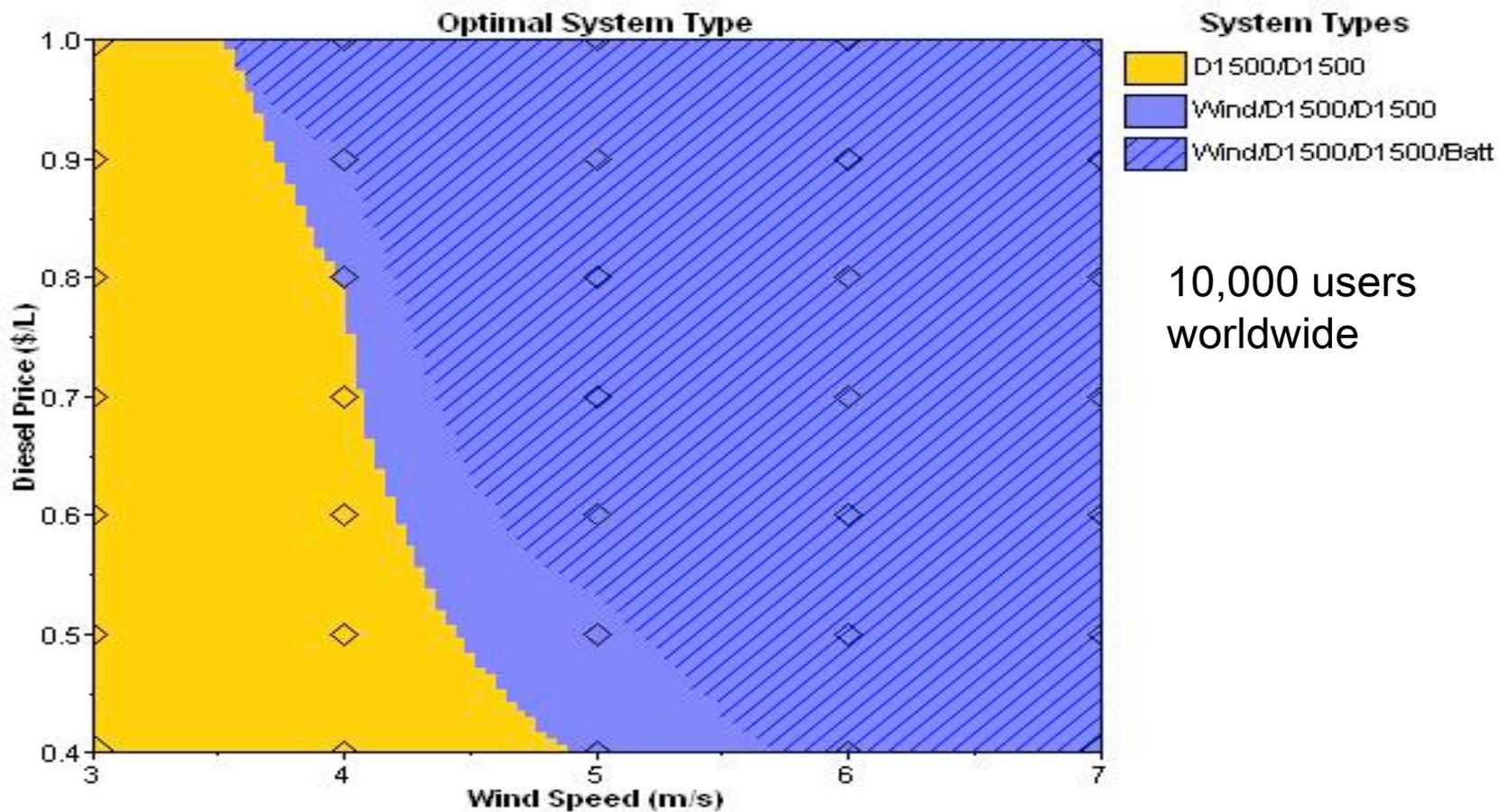
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- Regulation 'up'.
  - Regulation 'down'.
  - Voltage support.
  - Black start.
- 
- Merchant storage.

# Single line for VRB-ESS™ RAPS application



# NREL and HOMER - Wind Diesel Storage



10,000 users  
worldwide

HOMER chooses the flow battery for almost all the scenarios in which it chooses wind turbines.



# **VRB Power Systems**

INCORPORATED



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