Optimizing Wind and Diesel Systems with VRB Energy Storage

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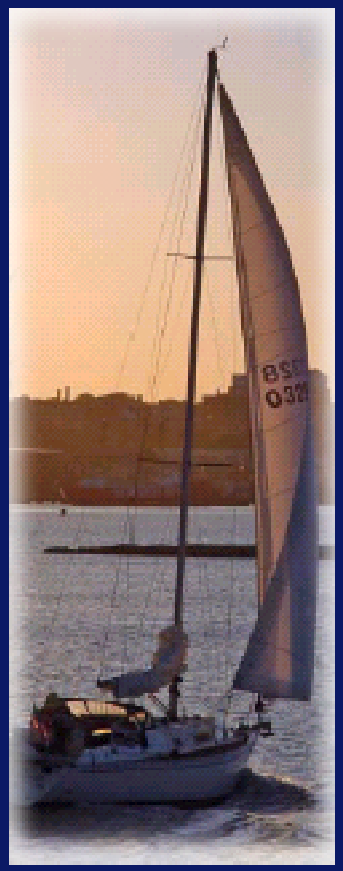
Remote Area Power Systems

- Cost of supplying diesel is high
- Frequent operation of gensets at part-load for spinning reserve and load following increases fuel usage and emissions
- Wind power or other renewable sources can be intermittent and unreliable

Capture more of the wind

- VRB-ESS stores:
  - wind energy that exceeds load
  - wind surges
- Stored energy is released during high demand

Burn less fuel, create fewer emissions

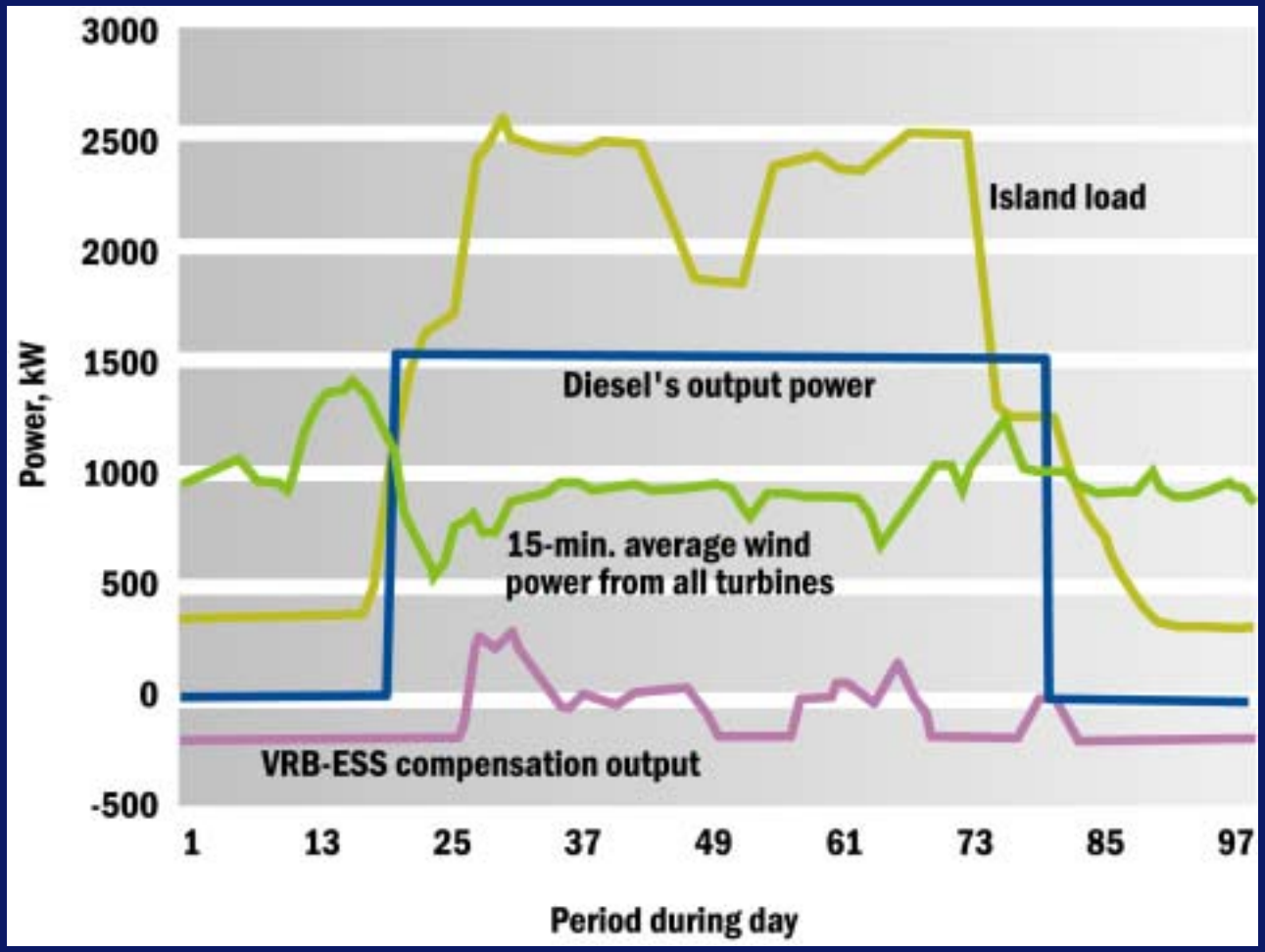


- With VRB-ESS, diesel can be run at peak output all the time
  - Genset clocks fewer run-hours
  - Less maintenance is required
  - Fewer greenhouse gases are released into the environment

Case Study: King Island

- Four 1,500-kW diesel engine generators
- Three 250-kW turbines
- Two 850-kW turbines
- Wind power is neither reliable nor constant; does not coincide with island's electrical load

Case Study: King Island



King Island Project Benefits

- VRB-ESS smooths short-term wind output variations, implements “load shifting”
- VRB-ESS raises level of deliverable power, allows for ability to provide “firm capacity” from existing wind generation

King Island Project Benefits

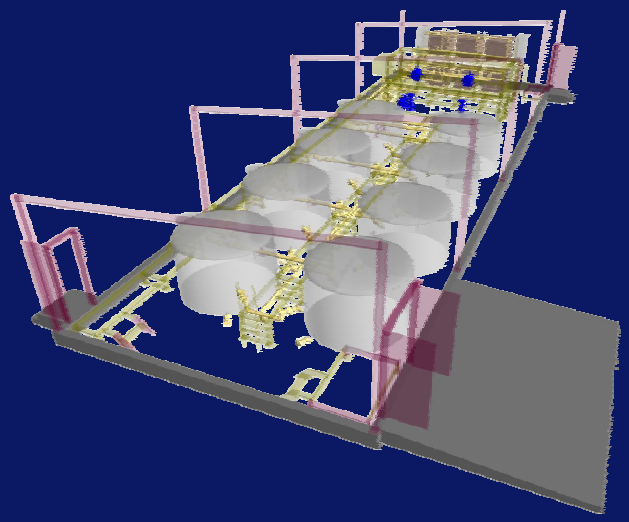
- Capture “spilled” wind - $185,000/y
- Reduce spinning reserve - $75,500/y
- Improve operating efficiency - $68,600/y
- Reduce maintenance - $23,000/y
- TOTAL: $352,100, or 2.47 year payback

King Island Project Benefits

- Reduce emissions
  - 4,000,000 kg/year CO_2
  - 99,000 kg/year NO_x
  - 75,000 kg/year unburned hydrocarbons

What is VRB-ESS?

- Vanadium Redox Battery - Energy Storage System
- System based on patented vanadium redox regenerative fuel cell technology



How does the VRB-ESS work?

- Chemical energy is converted to electrical energy
- Energy is stored chemically in different ionic forms of vanadium in dilute sulfuric acid
- Electrochemical reaction in flow cells across a membrane is reversible, allowing the battery to be charged, discharged, and recharged

VRB-ESS outperforms traditional batteries

	VRB-ESS	Lead Acid
Lifetime	12,000	1,500
Range of discharge	Can discharge down to 20% state of charge	Discharges down to only 75% state of charge
Efficiency	70%	45%
Maintenance/ disposal costs	None	Significant