

Energy Storage and Renewable Energy

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Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company,
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Energy Storage and Renewables

- **Intermittent renewable energy sources**
 - **Photovoltaic**
 - **Wind**
 - **Wave energy**
- **Diurnal, seasonal and random variations**



Intermittent Renewables on Electric Grids

- **Firm capacity**
 - **How much and when**
- **Stability of grid**
 - **Maintaining frequency and voltage**



Tehachapi Wind Generation in April '05

Could you predict the energy production for this wind park either day-ahead or 5 hours in advance?

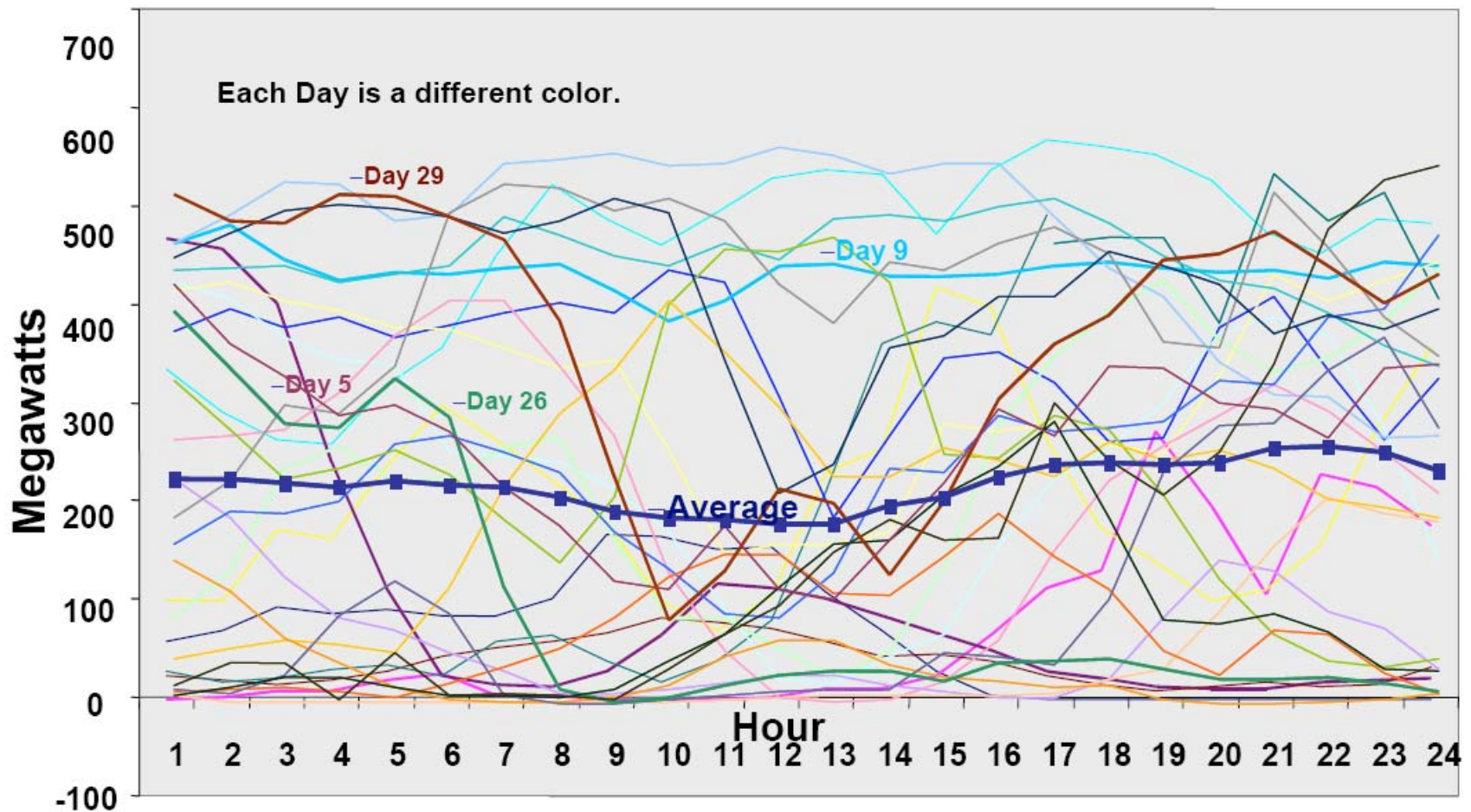
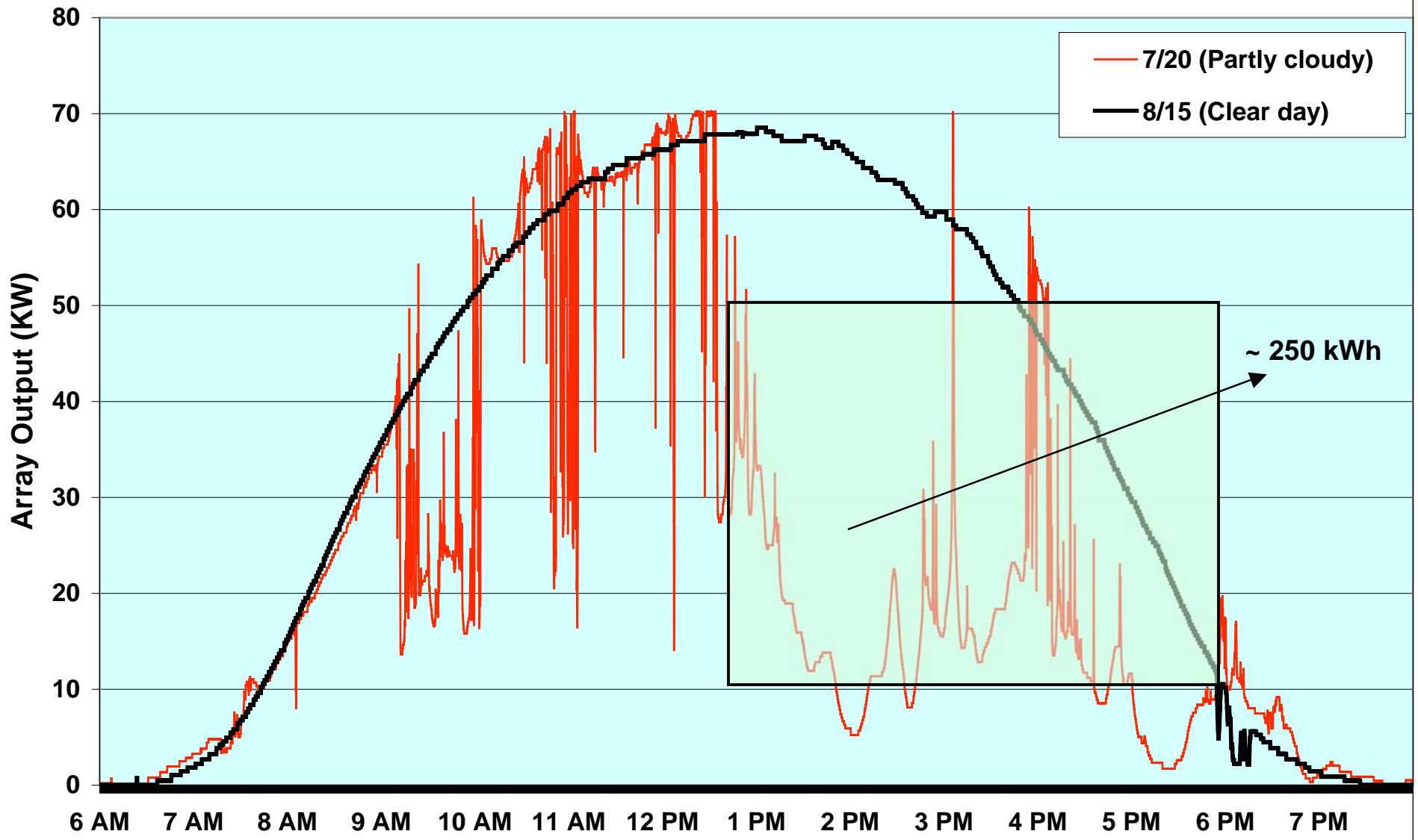


Figure 1. Daily Wind Generation in Tehachapi for April 2005

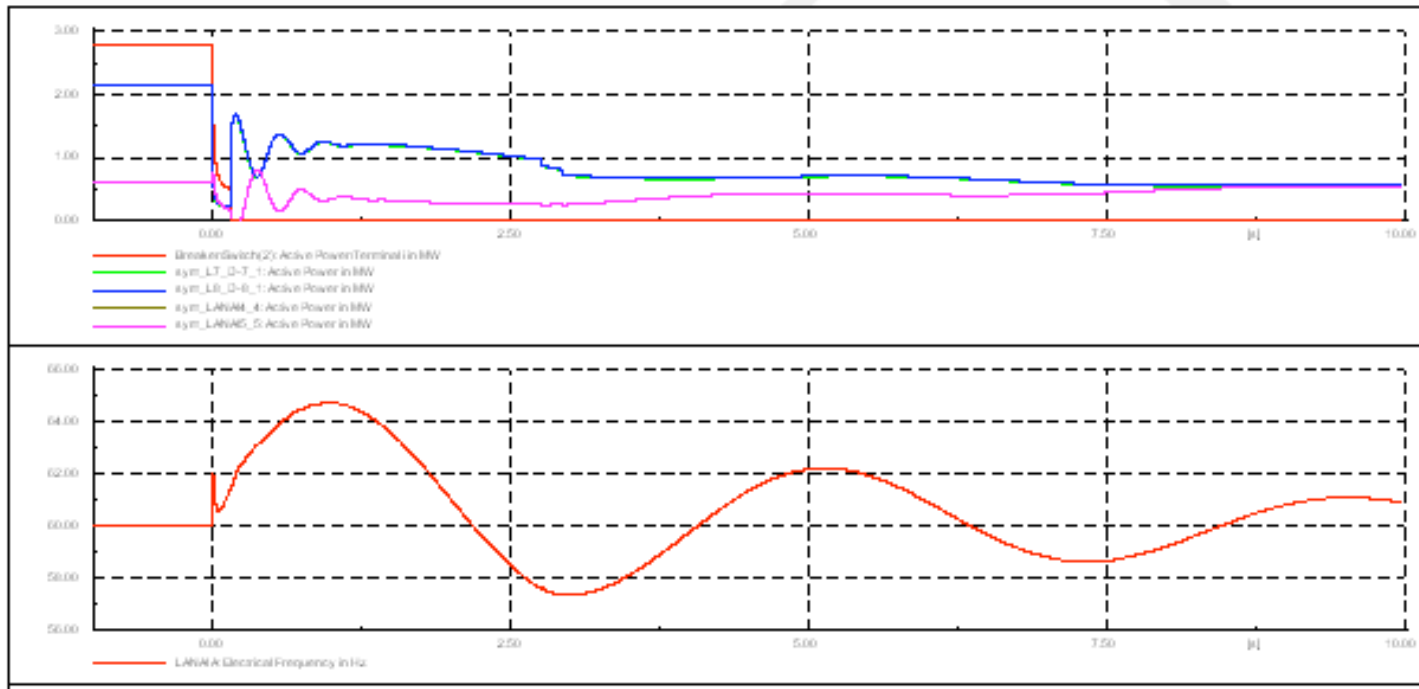
Output from a 70 kW PV Array



Benefits of Storage to Renewables

Smoothing function

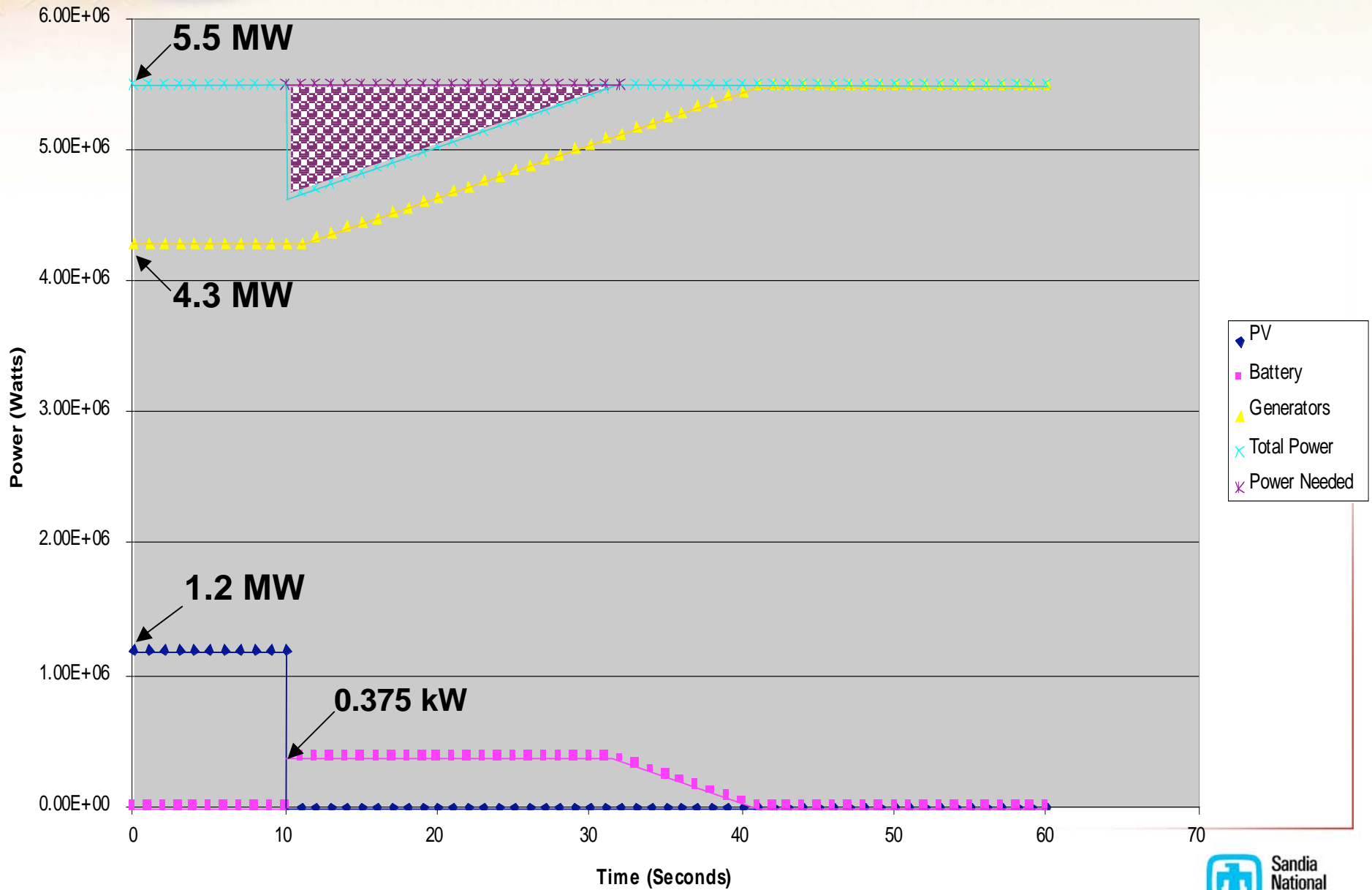
Source: Lanai PV Interconnect Study, 2008; KEMA, Inc.



Additional Benefits →

- Extends dispatch capacity
- Captures “spillage”

Lanai Power System





Energy Storage Requirements

Application	Storage Support Time
Smoothing Function	1 second – 5 minutes
Extending dispatch	15 minutes – 6+ hours
Capture Spillage	1 – 4 hours

Energy Storage Technologies

- **Pumped storage (*and CAES*)**
 - **Proven technology**
 - **Lower cost on a large scales (100's MW, 8 – 10 hours)**
 - **Significant environmental impact**



Rocky Mountain, GA commissioned 1995, 800+ MW

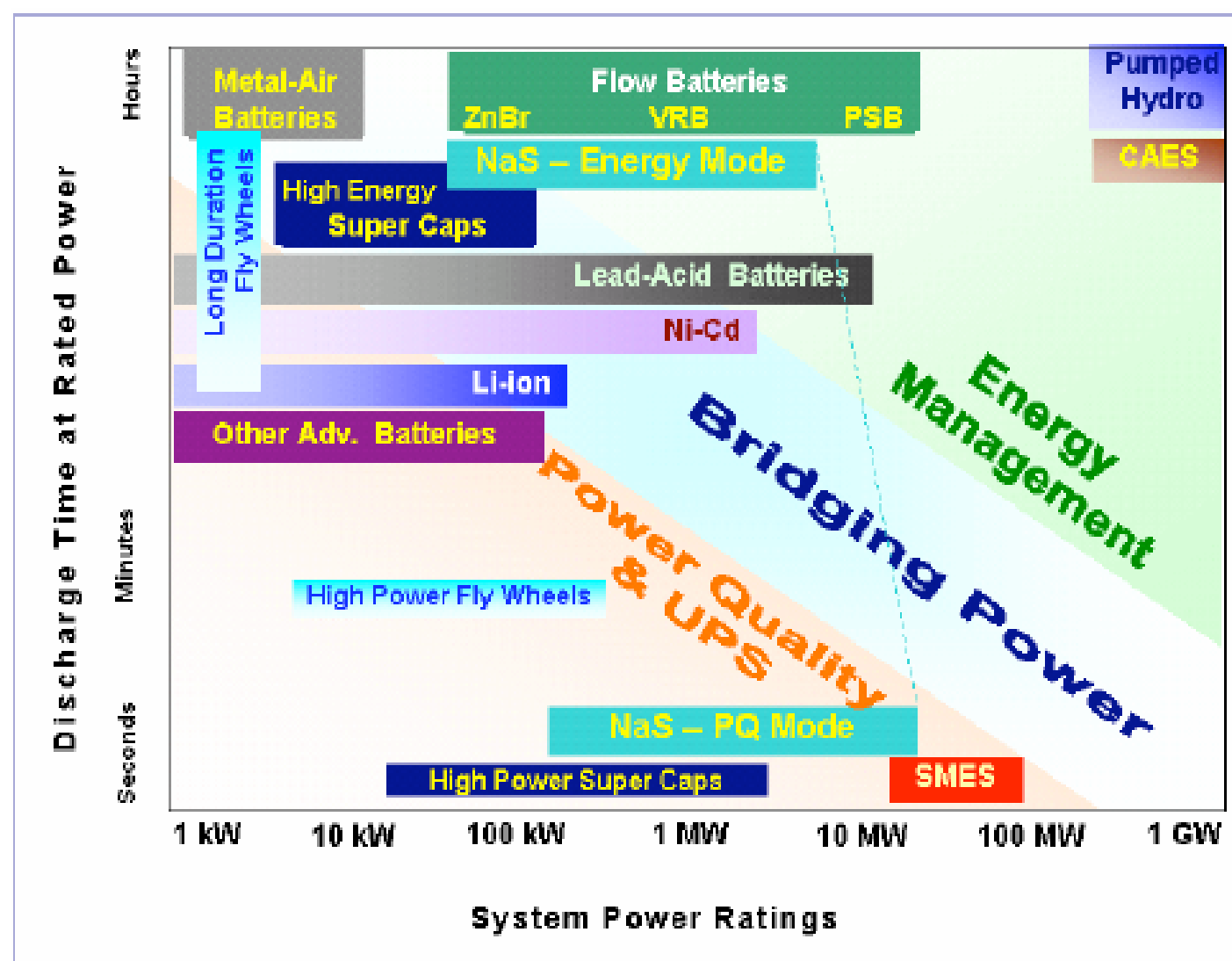


US Storage capacity = 21,461 MW
(Source EIA/Electric Power Annual 2006)

Energy Storage Technologies (Continued..)

- **Battery Energy Storage**
 - **Lead-acid**
 - **Nickel-cadmium**
 - **Sodium Sulfur**
 - **Flow batteries: Zinc-Bromine; Vanadium Redox**
 - **Lithium ion**
- **Flywheels**
- **Super conducting magnetic energy storage (SMES)**

Energy Storage Technologies



Three Choices

- 1. Ask questions here**
- 2. Go to the beach**
- 3. Ask questions on the beach**

Four Seasons Resort Beach, Manele Bay, Lanai.



Manele REGIS - January 2009