| Battery | Hybrid | Fuel Cell |

Vehicle to Grid - A Control Area Operators Perspective

David Hawkins

California Independent System Operator

December 13, 2001

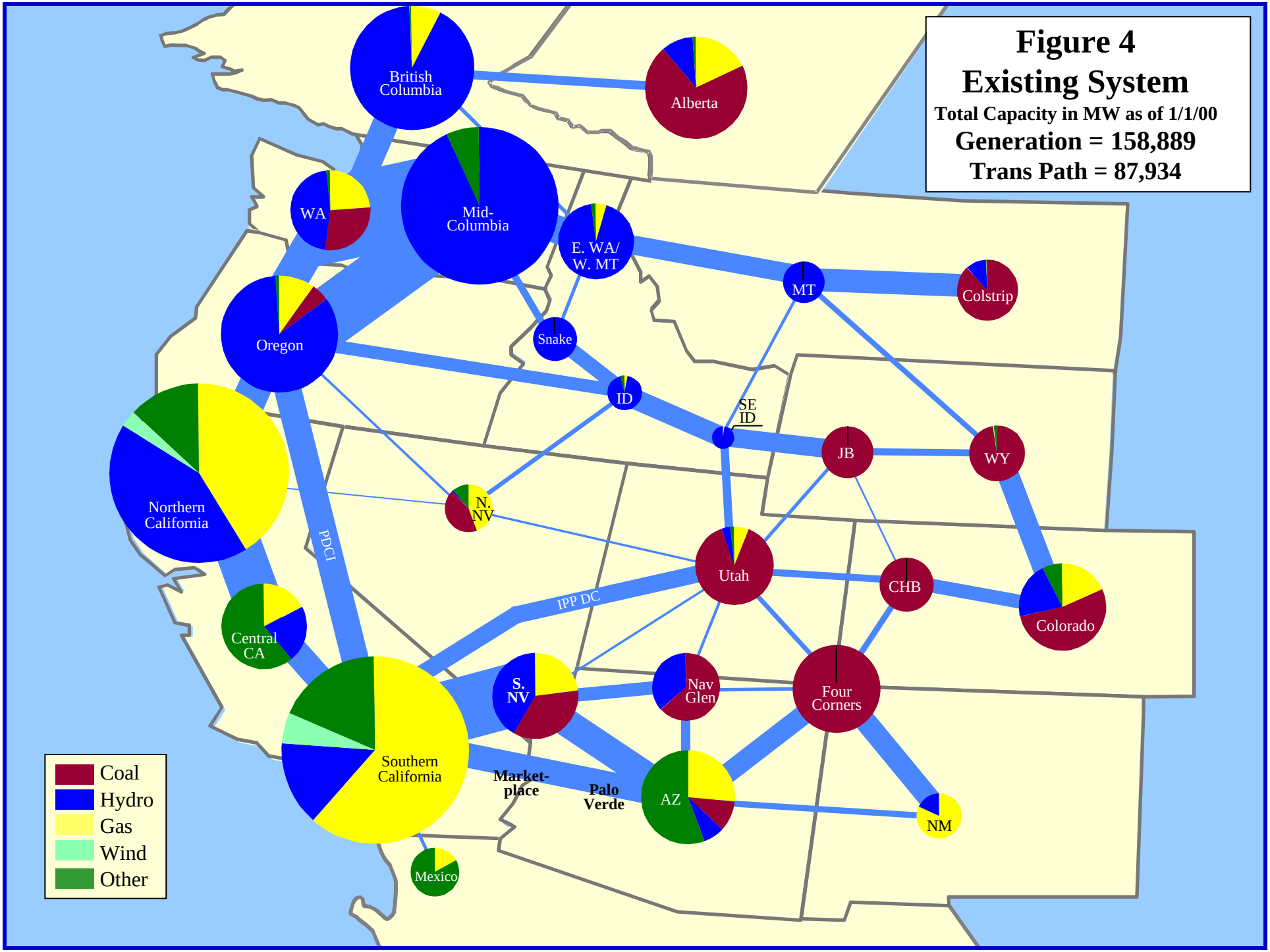
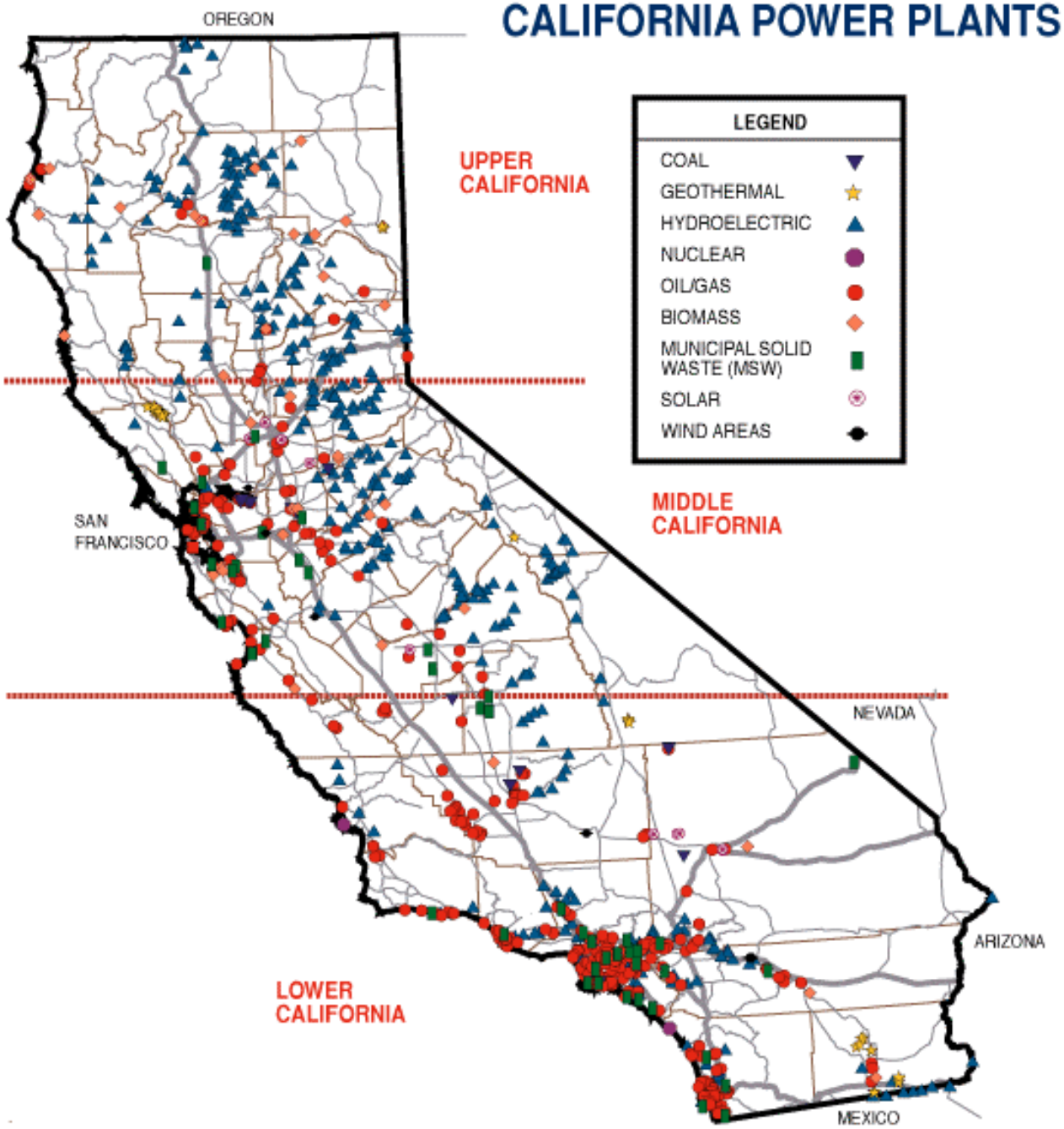


Figure 4
Existing System
Total Capacity in MW as of 1/1/00
Generation = 158,889
Trans Path = 87,934
British Columbia
Alberta
WA
Mid-Columbia
E. WA/ W. MT
MT
Colstrip
Oregon
Snake
ID
SE ID
JB
WY
Northern California
N. NV
PDCI
Utah
CHB
Colorado
IPP DC
Central CA
S. NV
Nav Glen
Four Corners
Southern California
Market-place
Palo Verde
AZ
NM
Mexico
Coal
Hydro
Gas
Wind
Other

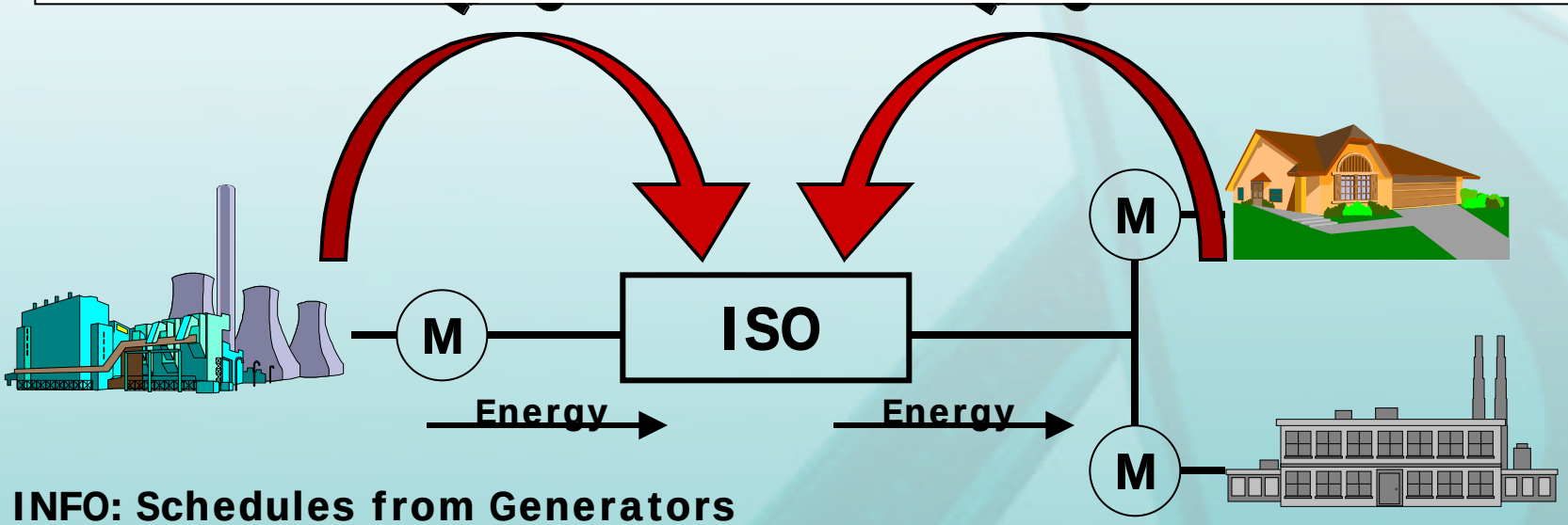
CALIFORNIA POWER PLANTS



Key ISO Roles

- Frequency Monitoring & Time Error Control
- Scheduling of Power Transfers
- Grid Planning
- Real-Time Dispatch
- Financial Settlements
- Ancillary Services Management
- Transmission Congestion Management
- Outage scheduling - Trans. & Generatio

Match Generation Output to Loads



INFO: Schedules from Generators

1. Bilateral
2. Markets (Day-ahead, Hour-ahead)
3. Real-Time Instructions

Every 10 minutes Stamped

INFO: Schedules from Loads

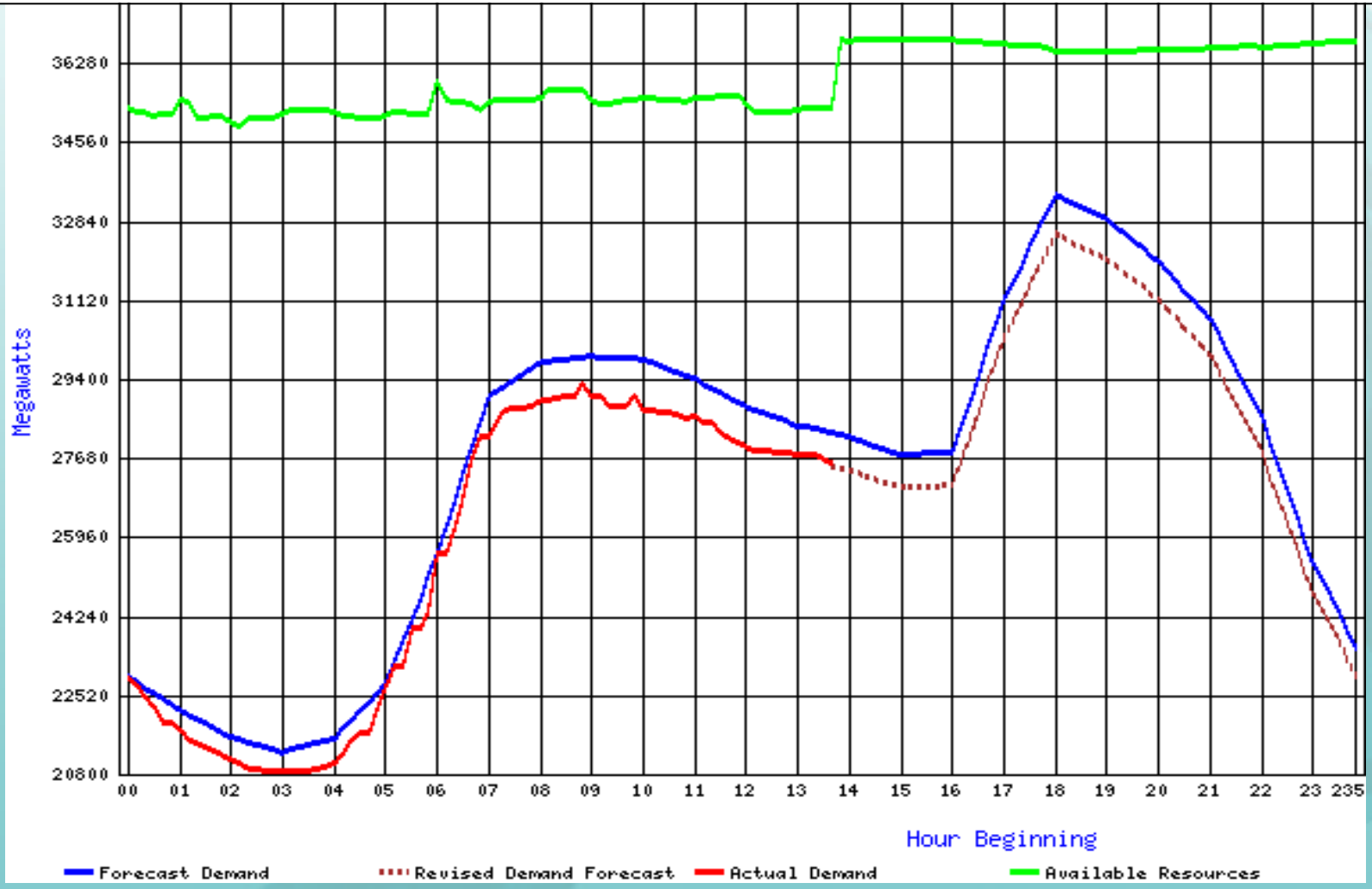
1. Consumption

Read Meter Every 30 days

A) Profile

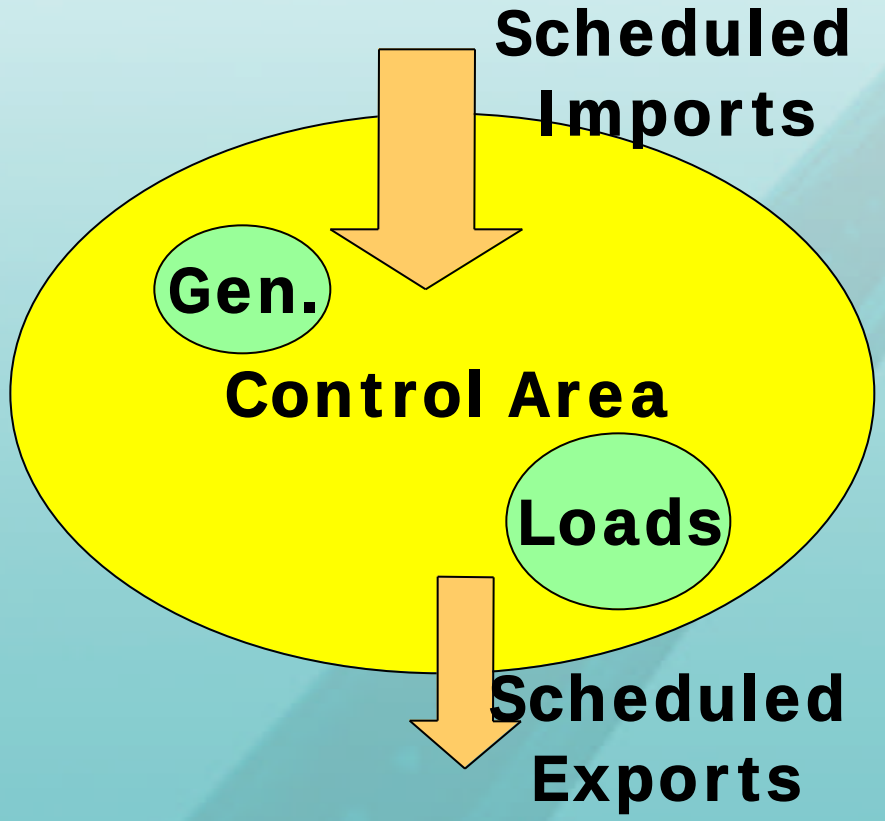
B) Interval meters

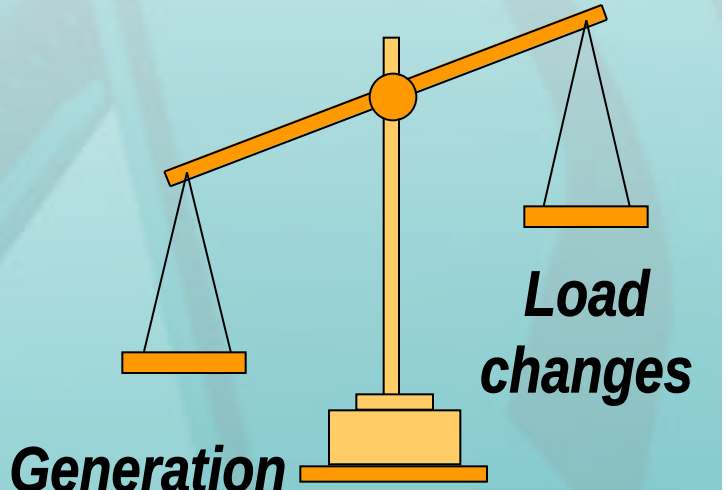
Daily Load Curve - Dec. 12th



Control Area Operation - ACE

- **ACE = Area Control Error = Zero (Ideal)**
- **ACE = Change in Generation (DG) - Change in Load (DL)**



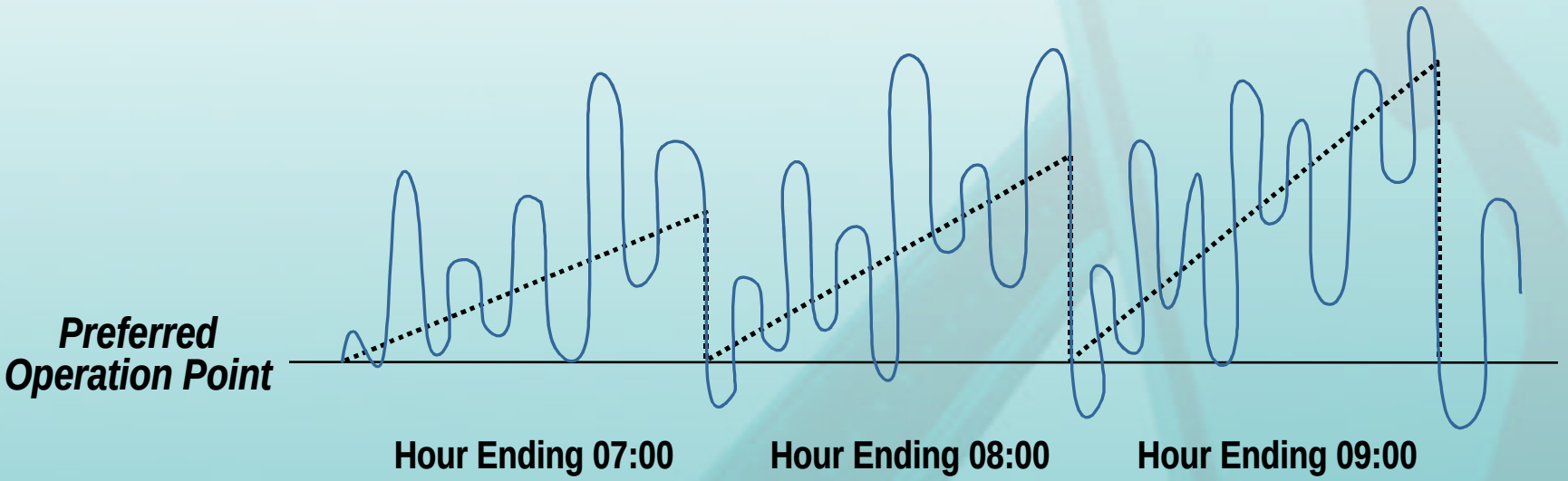


should equal

| Battery | Hybrid | Fuel Cell |

How Balancing Energy Works

Balancing Energy Purchased in 10-minute increments as needed in Real Time



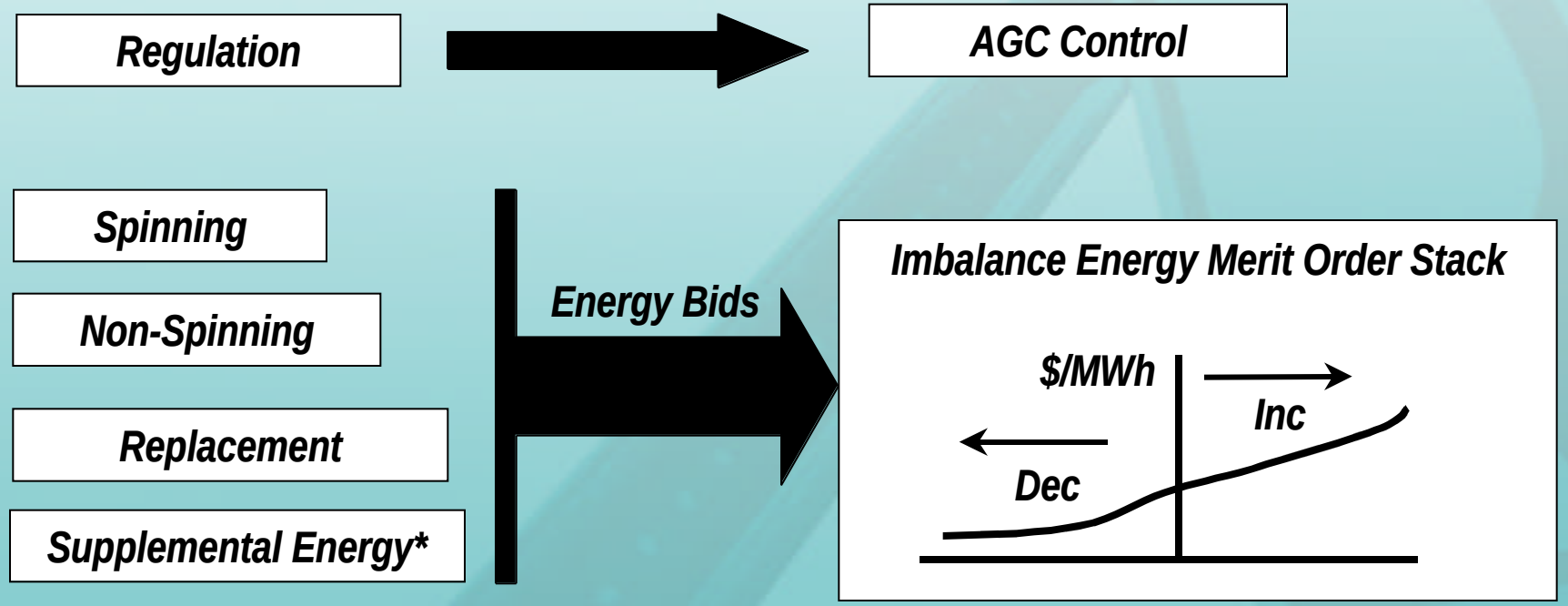
..... = Typical morning energy ramp-up by hour

——— = Typical balancing energy needed to fill-in energy needs during morning ramp-up

ACE - Dec. 11th
Megawatts
2 Min. Intervals

Frequency - Dec. 11th
60 Hz
Hz
2 Min. Intervals

Real Time Use of Ancillary Services and Supplemental Energy



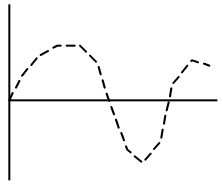
Regulation via Load vs. Generators

- **Advantages**
  - **Fast response to AGC signals - improved freq. control**
  - **Reduces wear & tear on generators**
  - **Could also provide Freq. Response Service & Line Overload Relief**

- **Disadvantages & ?**
  - **Impact on Distribution systems**
  - **Lack of visibility to EMS computer system**
  - **Lack of experience in dealing with Distributed Resources**

Grid Regulation with Electric Vehicles

Grid Operator

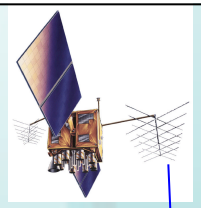


Power Command

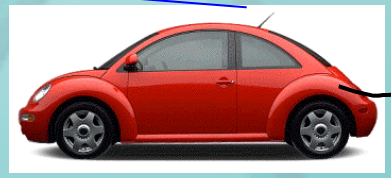
Internet

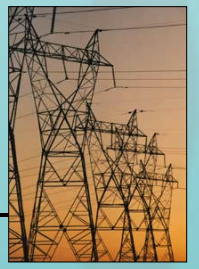
Aggregator

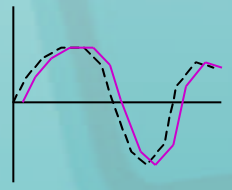
Wireless Provider



GPS







Power Response

Driver Usage Profile and Preferences

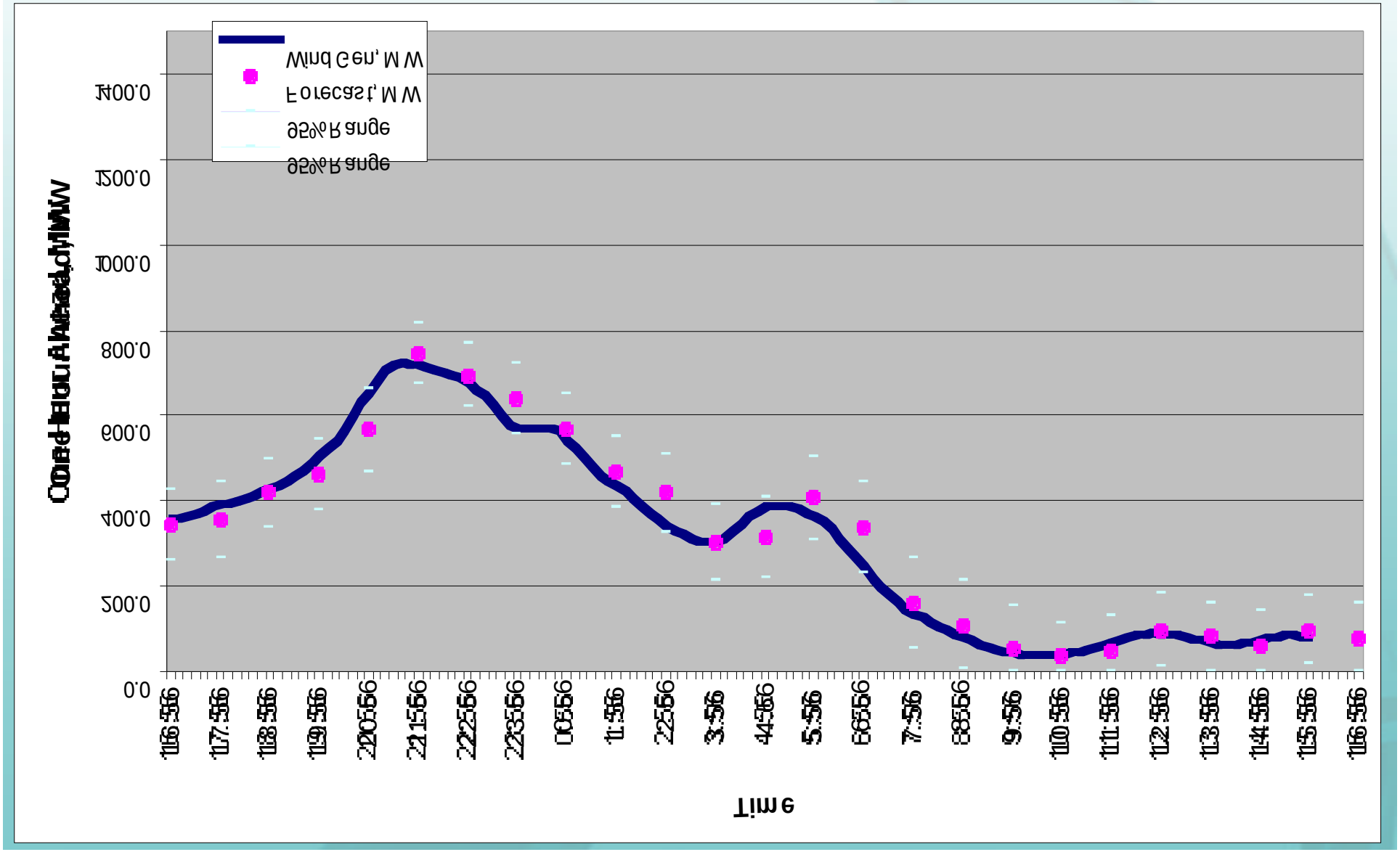
New Wind Generation

The State would like to encourage construction of new wind generation facilities

- Primary objective is to encourage the building of 2000-3000 MW of additional Wind and Solar Generation
- State needs alternatives to gas fired plants
- Wind Generation tends to peak between 10PM and 2AM when the loads are low and CA doesn't need the power
- **EV Load would be an ideal complement to Wind Generation power production**

| Battery | Hybrid | Fuel Cell |

Wind Generation - Dec. 11-12



Future Directions

- **Continue testing and validation of the concept of sending dispatch notices to Electric Vehicles and evolve the model for services provided by loads.**
- **Identify software / infrastructure requirements**
- **Investigate the potential for Frequency Response Services**
- **Evaluate impact on Distribution Systems and deployment limitations**