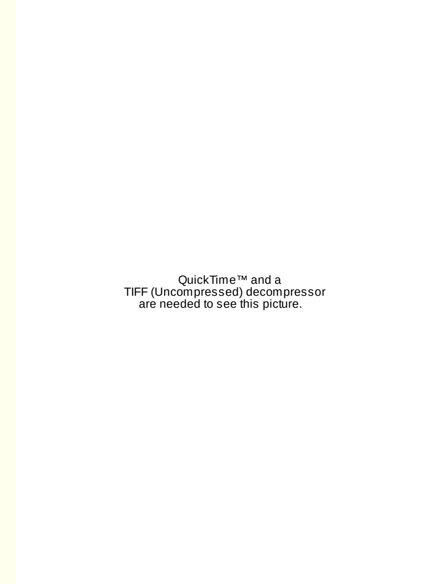
Islands as a Pathway

HOW and WHY
High Penetration Renewables
should be integrated with
Vehicle Energy Storage

OR

Where SmartGrids can
reach maturity
FIRST



Green Toolbox
Clint (Jito) Coleman

GreenToolbox
Empowering Renewable Strategies

Why integrate Renewables with Transportation?

INCREASES RENEWABLE UTILIZATION

New Power Source for Transportation

Use EV Battery To Stabilize Electric Grid

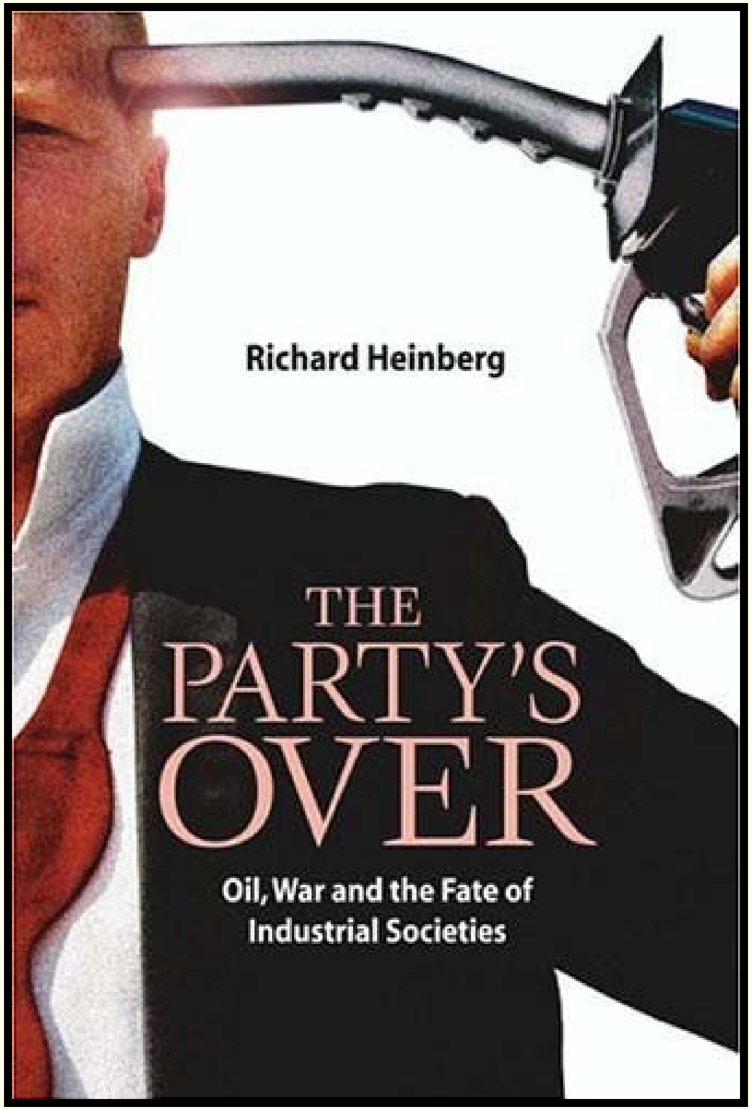
~~20%~~

Increase Renewable Energy Utilization by

400 %

Islands as a Pathway

Why are islands still run on 100% liquid fossil fuels?



Why Isolated Villages ?

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- Entirely dependent on expensive liquid fuels
- Smaller grids more management
- High impact with modest capital requirements
- Monitoring and verification is meaningful
- Public support can be easier in tight community
- Regulatory issues are less complex

Why Start With Isolated Grids

- **These visions need more than pretty pictures**

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Why Start With Isolated Grids

- Can Define Realistic Goals
- Early Analog for Larger Smartgrids
  - Technical
    - Design, Operations, Controls, Stability
  - Economic and Financial
    - Who is rewarded?
    - Who pays and how much?
  - Social
    - How do people feel?
  - Regulatory
    - What needs to change?

Electric Vehicles 101

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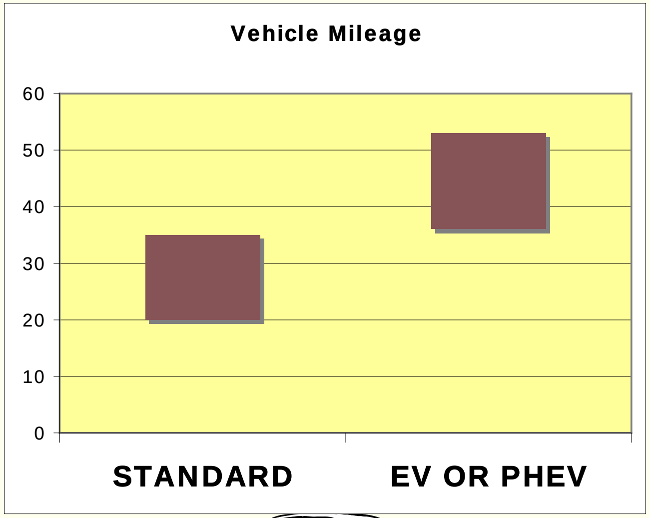
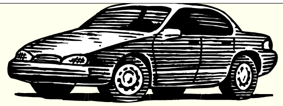
EV or PHEV

- Light Duty Fleet Average
- 3.5 miles / kwhr

Diesel Genset

- 12-15 kwhr / gallon





GENSET TO EV

1 GALLON = 42 - 52.5 mpg

EV = More Miles per Gallon !

Fuel Comparison

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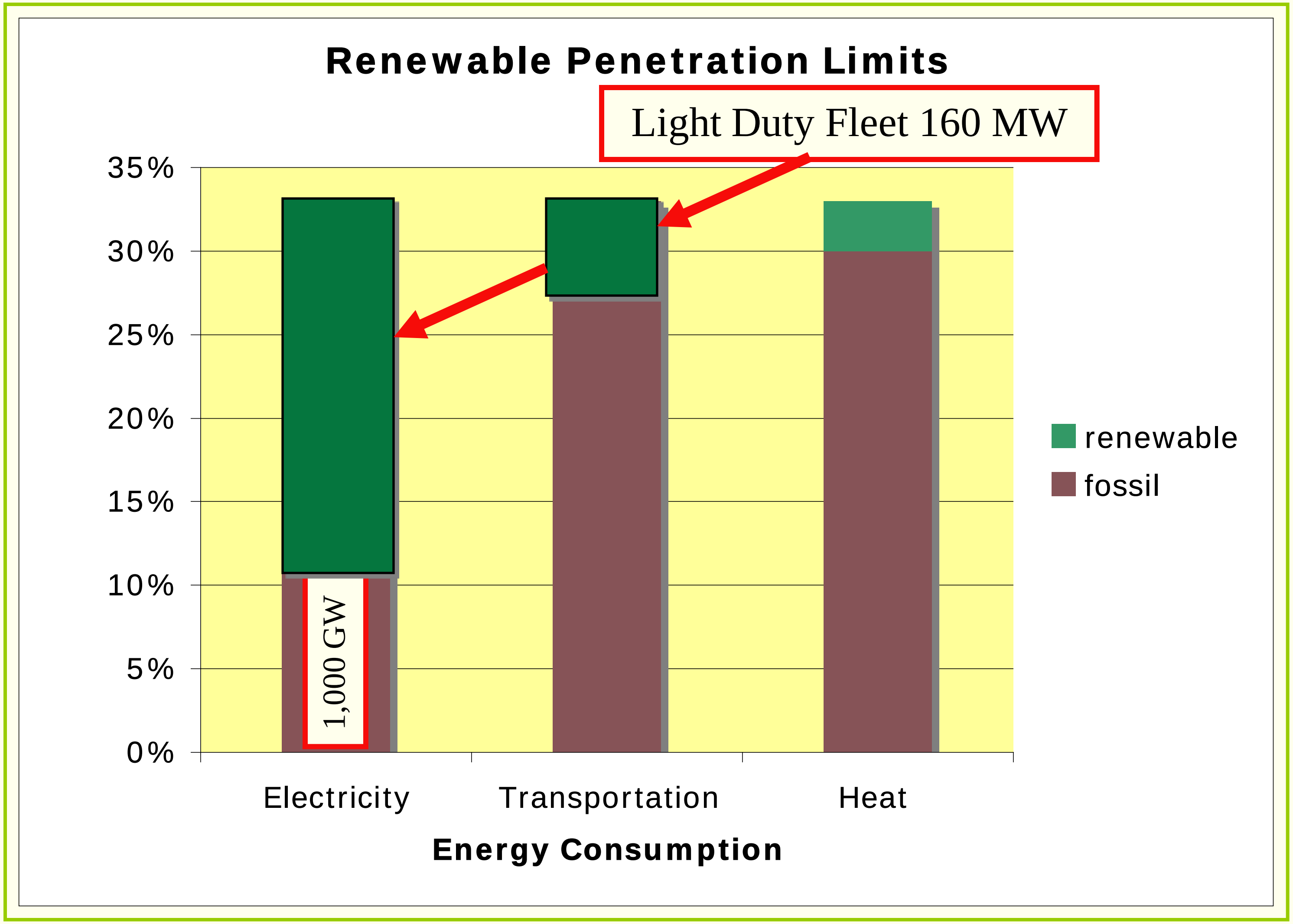
Vehicle Mileage | 25 MPG | 3.5 miles/kWh

Gasoline ($/gallon)	$/mile	$/mile	Electricicty ($/kWh)
$1.00	$0.02	$0.02	$0.08
$2.00	$0.07	$0.03	$0.12
$3.00	$0.07	$0.05	$0.16
$4.00	$0.09	$0.06	$0.20
$5.00	$0.11	$0.07	$0.24

Future Reality in North America



Island Energy

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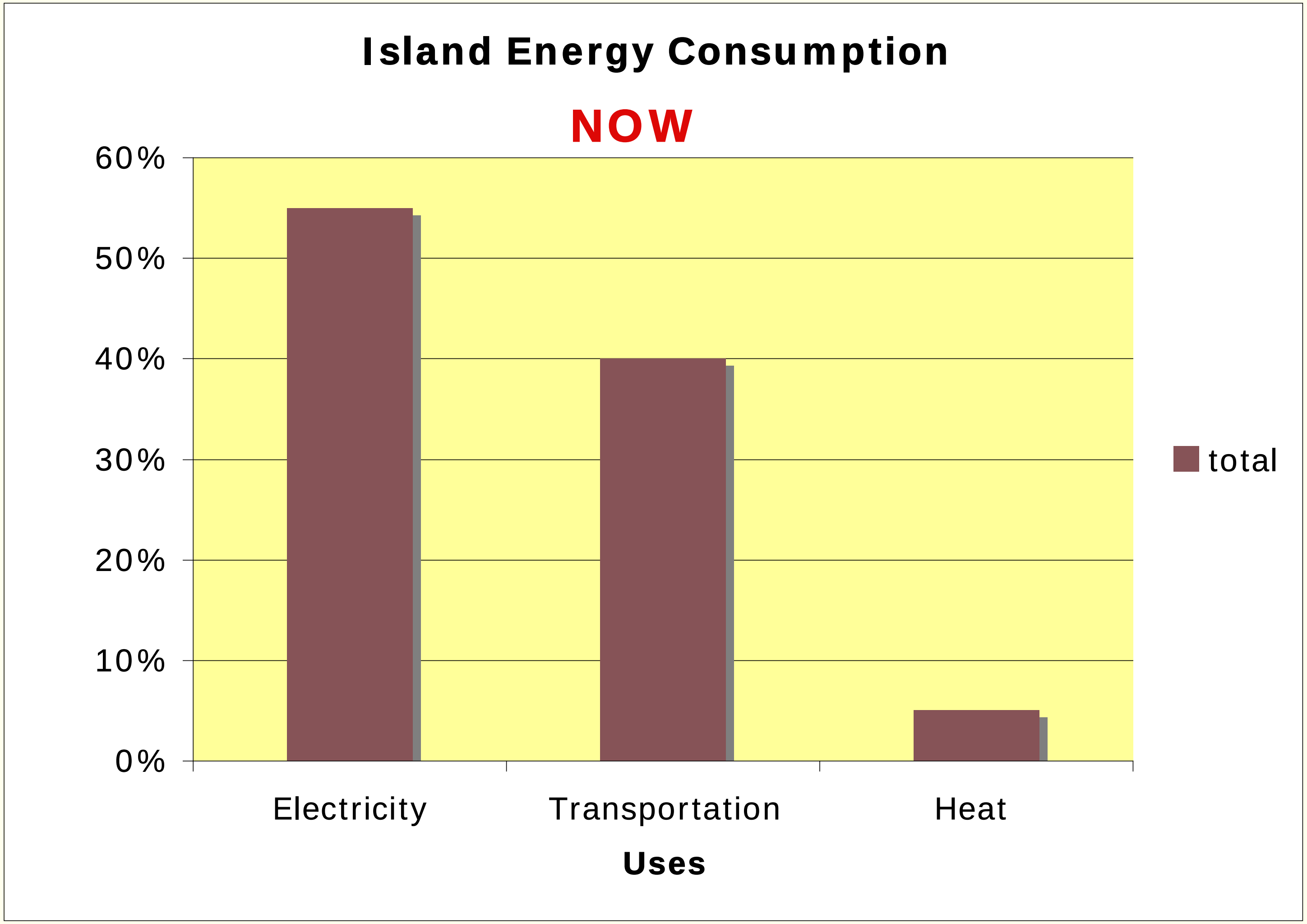
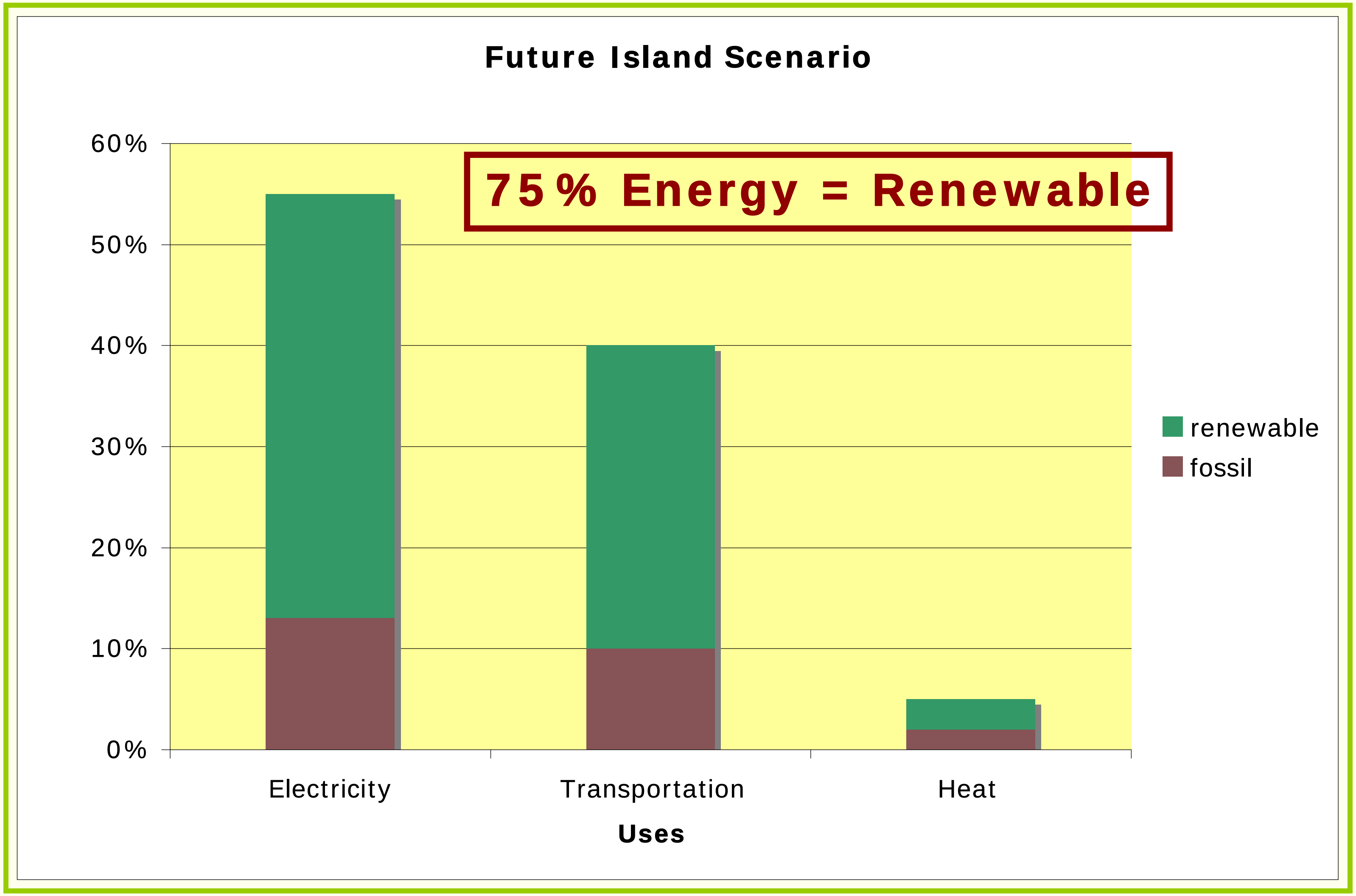


Island Energy Opportunity



SAMPLE ISLAND: MOLOKAI

POPULATION: 6000 people/2500 residences

VEHICLES: 3000 vehicles = 6,000 gal/day

ELECTRIC LOAD: (5 MW peak / 2 MW low)

105 MWhr/day = 9,700 gal/day

- ***Convert 1500 vehicles to electric vehicles —***

1500 vehicles @ 40 miles/day @ 3 miles/kwhr = 20 MWhr/day increase in electrical load

ADJUSTED ELECTRICAL LOAD:

125 MWhr/day = 11,550 gal/day

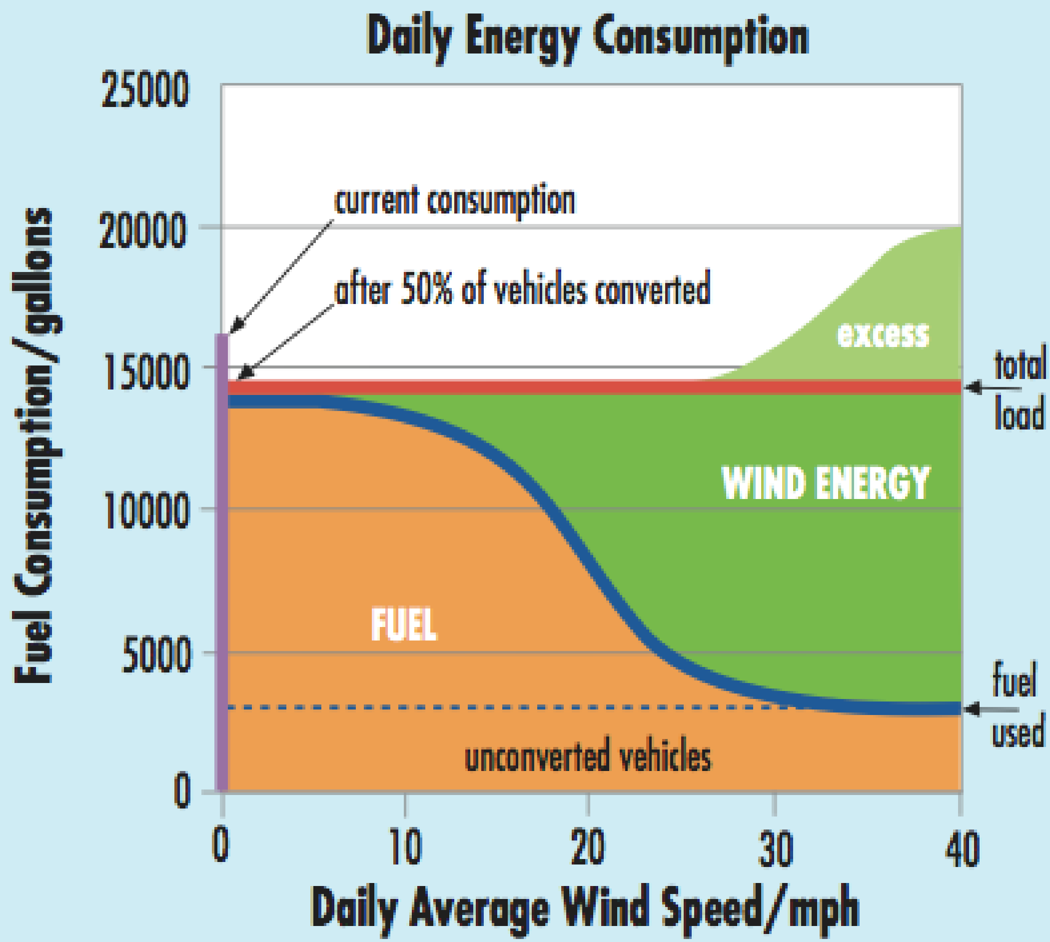
V2G Grid Stability Function —
with 80% vehicles connected

- 3MW rotating reserve (60% peak load)
- 20 MWhrs of storage (50% SOC utilization)

- ***Add 8 MW of wind turbines —***

DAILY IMPACT:

WIND SPEED MPH	WIND ENERGY MWh	FUEL SAVED gallons
0	0	1200
12	16	1472
16	38	3500
24	115	10,580
32	176	11,500



Grid Stabilization from Vehicles

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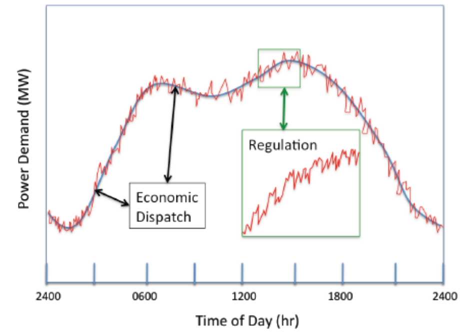

Figure 2: The inter-hour adjustments of regulation contrasted with the economic dispatch of peak power. Regulation takes place during all hours of the day, not just during times of peak demand. Only three hours of the afternoon are magnified here, but regulation is needed throughout the day.

<u>Short Term</u>: Seconds (*Regulation*)
- Line Transients: voltage, harmonics
- Switching Disturbances
- Electrical Storage Huge Value

<u>Medium Term</u>: Minutes (*Spinning Reserve - Ramping*)
- Caused by Renewable Imput Variations
  - Wind: gustiness, weather fronts
  - Solar: clouds
- System Response Limited by Diesel Ramp Rates
- Electrical Storage Huge Value

<u>Long Term</u>: Hours (*Load Shifting - Arbitrage*)
- Electrical Storage Huge Value

Value of EV to Utilities

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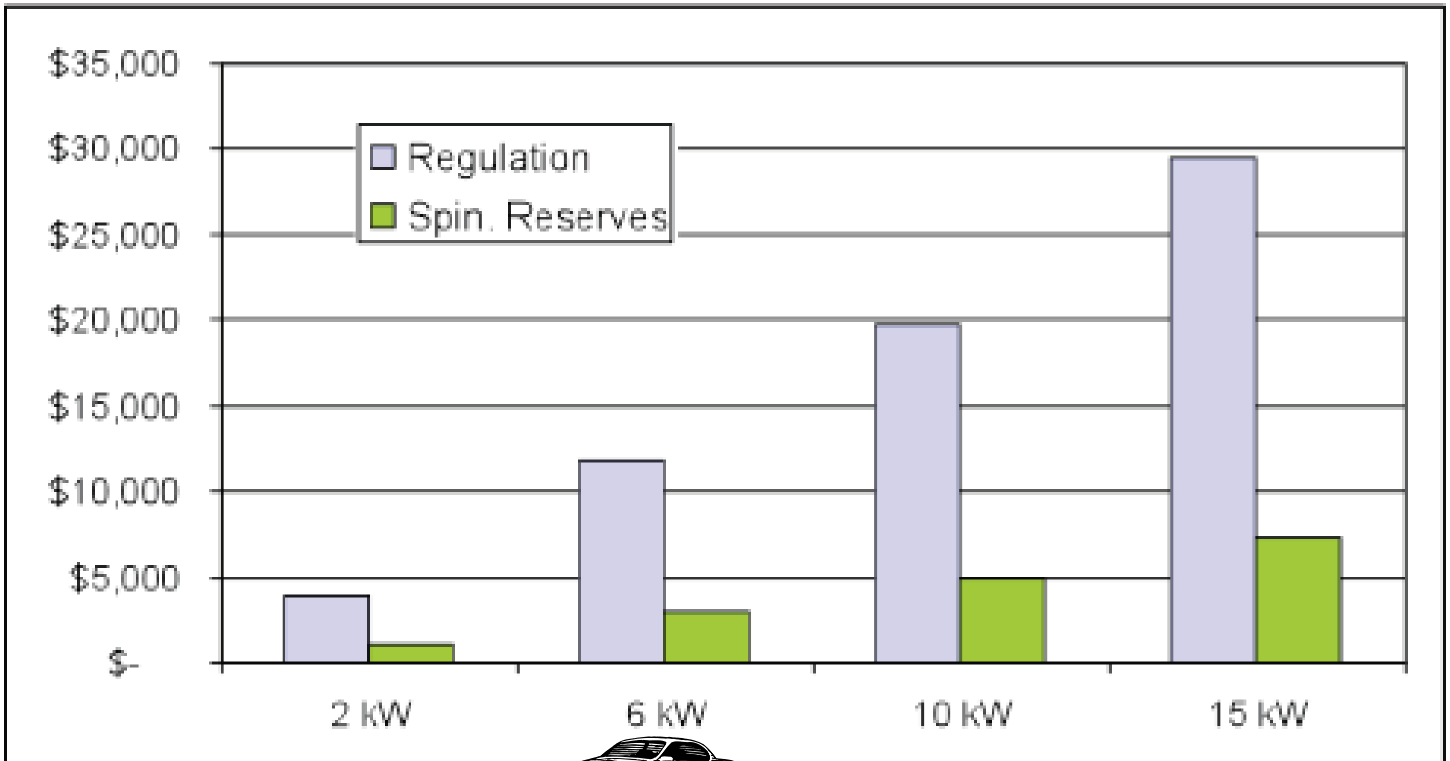
Present Value Revenue Potential (10-yr.)



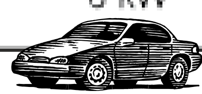


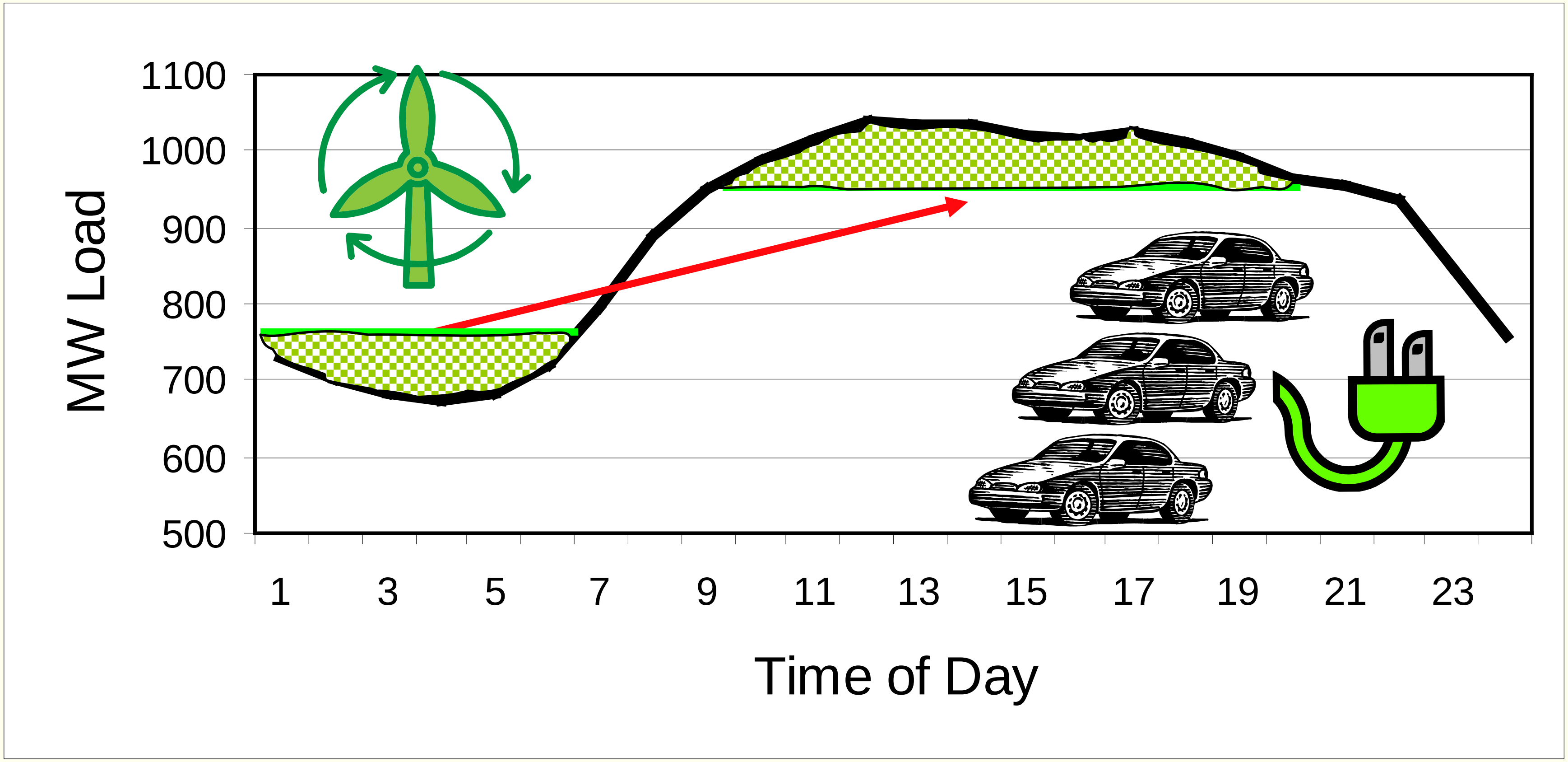
Figure 4: Discounted present value of gross revenues generated from selling regulation and spinning reserve, at varying power levels.

Load Shifting - Arbitrage

Longer Term: Hours

- Load shifting and Renewable Energy Shifting
- EV charging/discharging

"PHEVs are the perfect dance partner to wind energy" with smart charging. EPRI



Big Issue

Utility must embrace SmartGrid Vision

Early Adopters: Boulder, Austin, Portland, San Francisco

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Islands as a Pathway

Isolated villages

FIRST

SmartGrids