# The Role of Electric Vehicles on the Green Island

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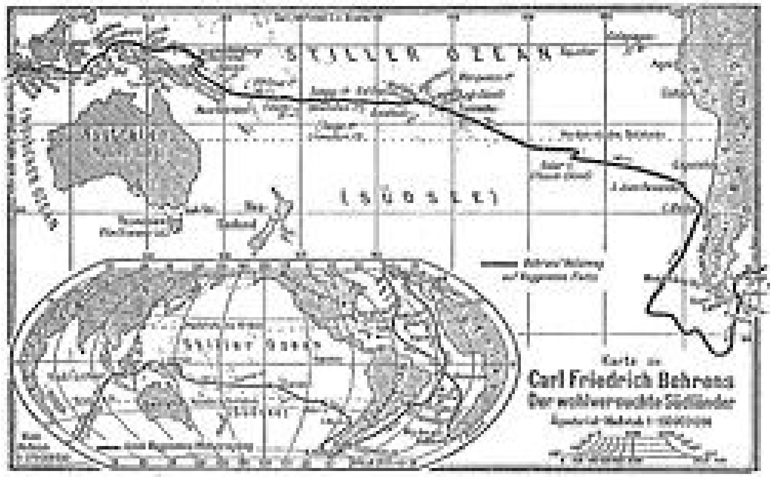
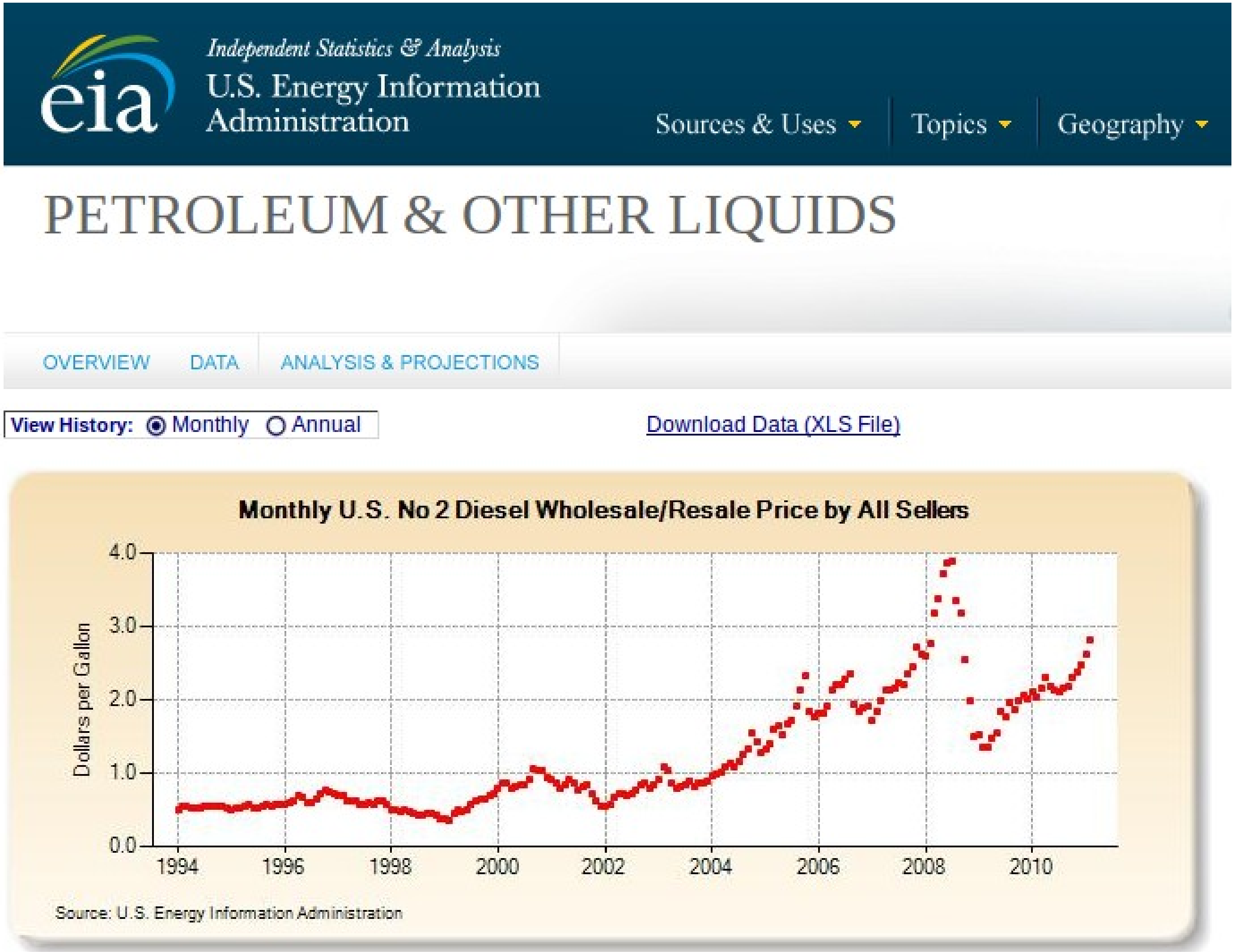
May 25 2011

# A Sustainable Island ?



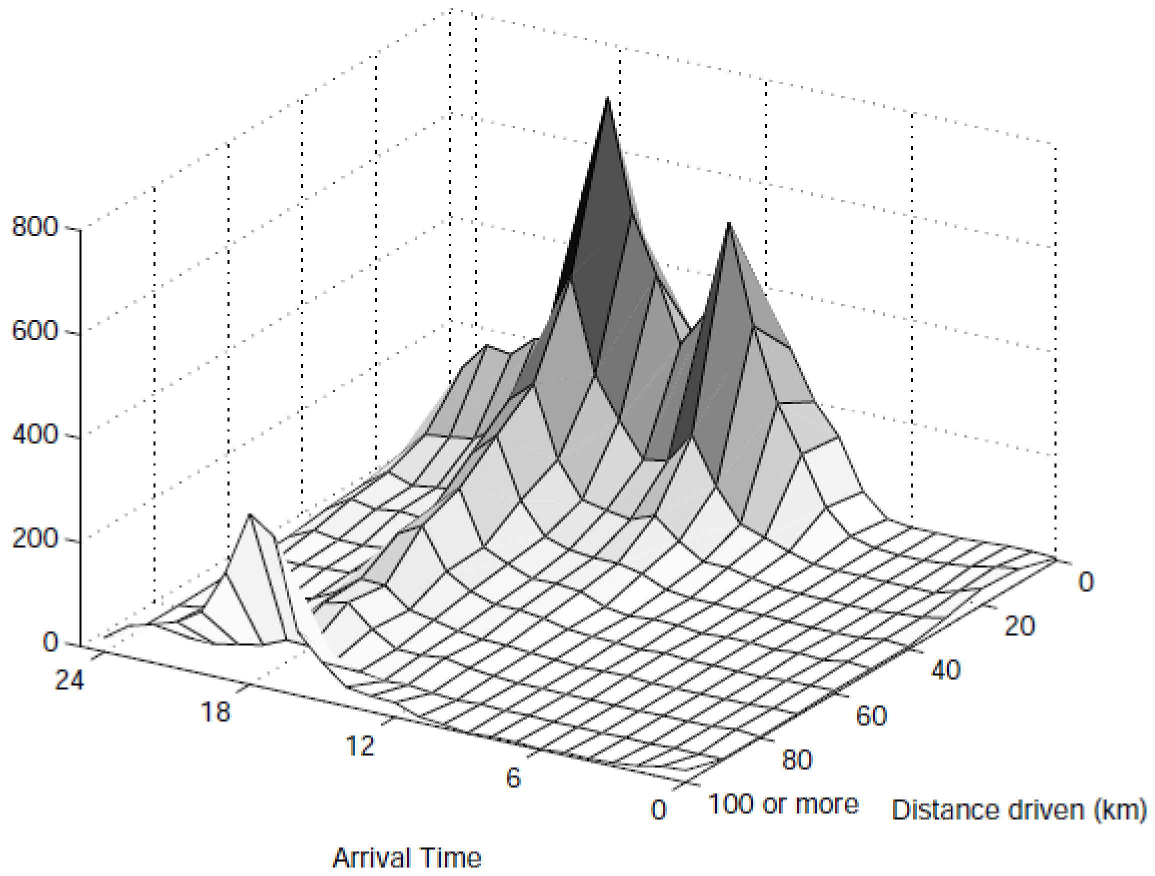

# A Sustainable Island ?



# Outline

- The model: electric vehicles, dispatch, renewables
- Results: Demand, generation, emissions, spilled energy
- Conclusions

# Electric vehicles, consumer behavior



# Charging model: Minimize charge costs, never an empty battery

Dynamic programming for finding optimal policy

Minimize total costs for charging

$$J_k(x_k) = \min_{u_k \in U_k(x_k)} \{g_k(x_k, u_k, w_k) + J_{k+1}(f_k(x_k, u_k, w_k))\}, \quad k = 0, 1 \ldots, N-1$$

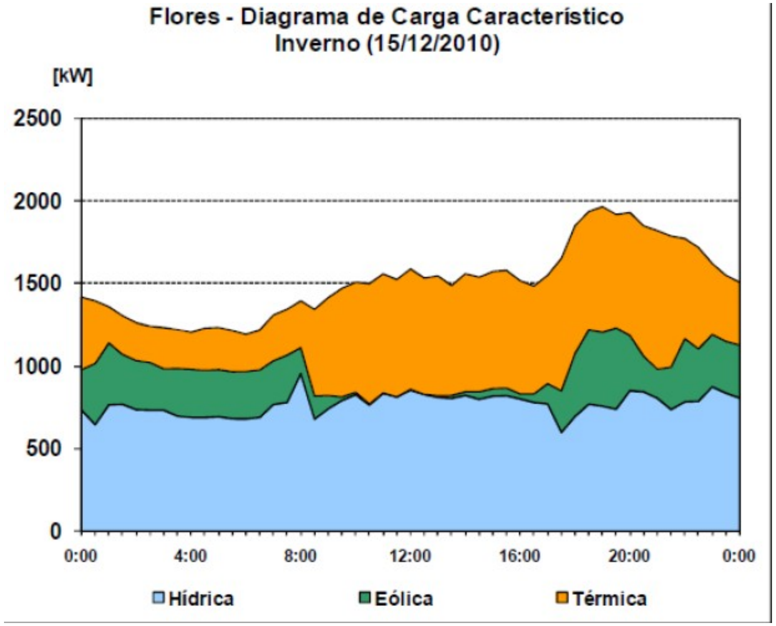
Charge costs given by

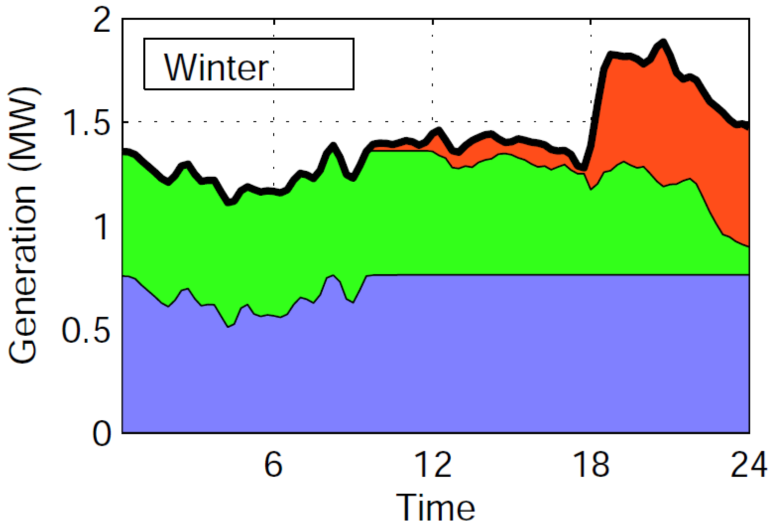
$$g_k(u_k) = \begin{cases} C_{el}(k) u_k \Delta t & \text{if } u_k \geq 0 \\ (C_{el}(k) - C_{degr}) u_k \Delta t & \text{if } u_k < 0 \end{cases}$$

Electricity price

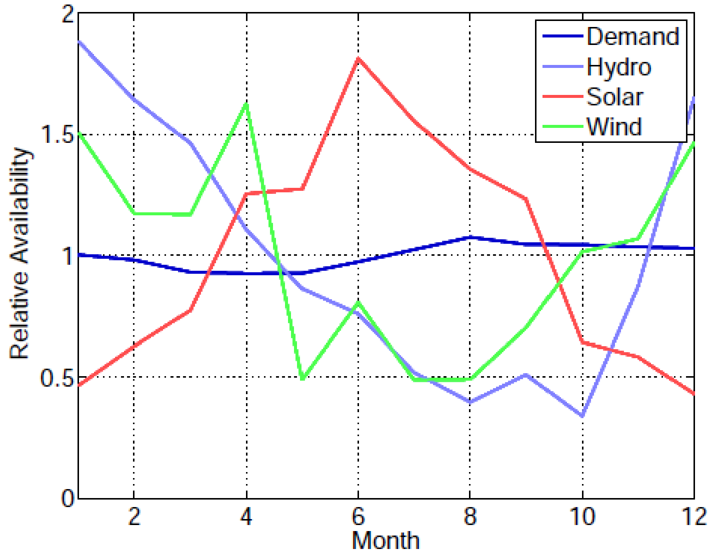
Costs of battery degradation

# Current and modeled dispatch



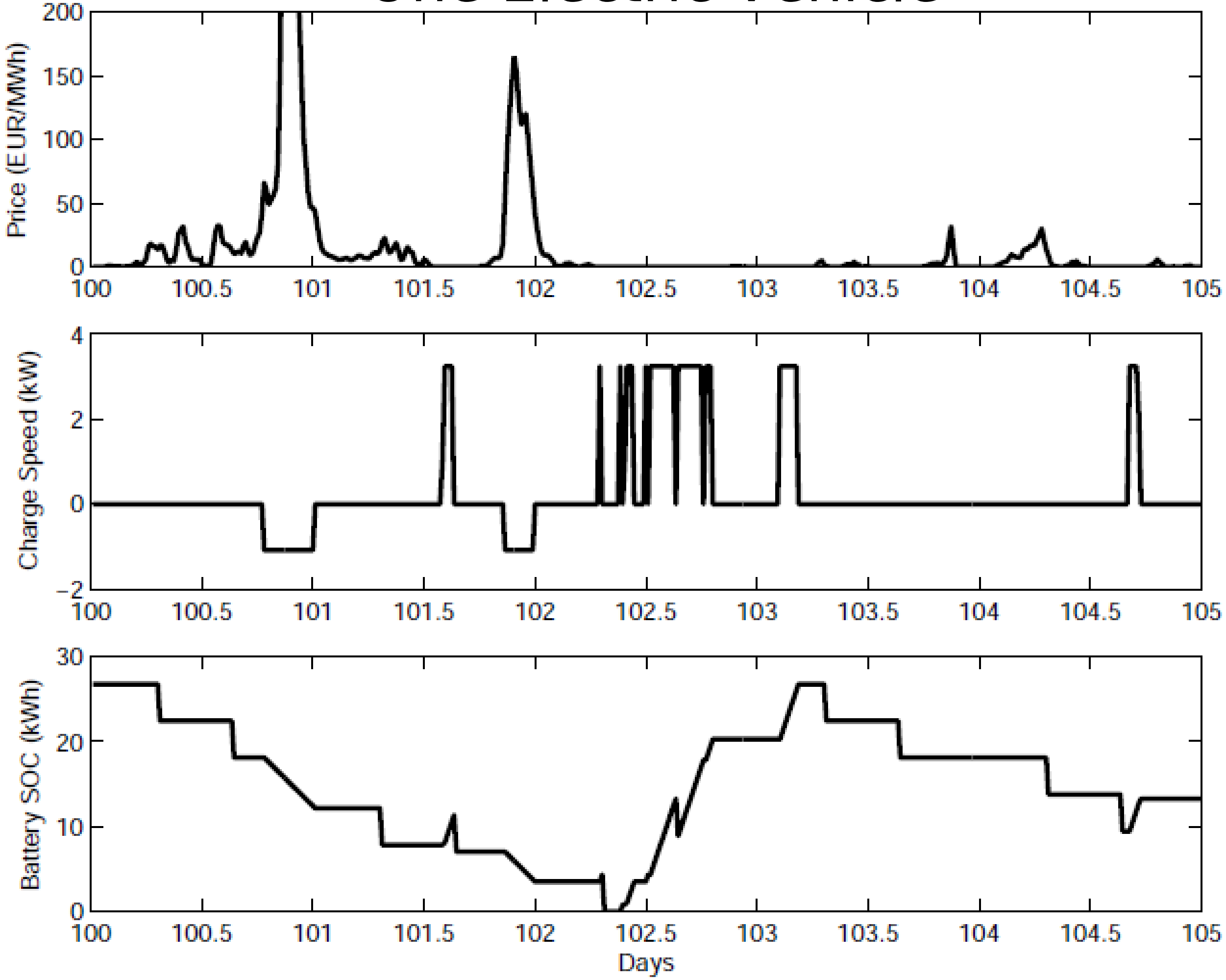
# New generation scenarios



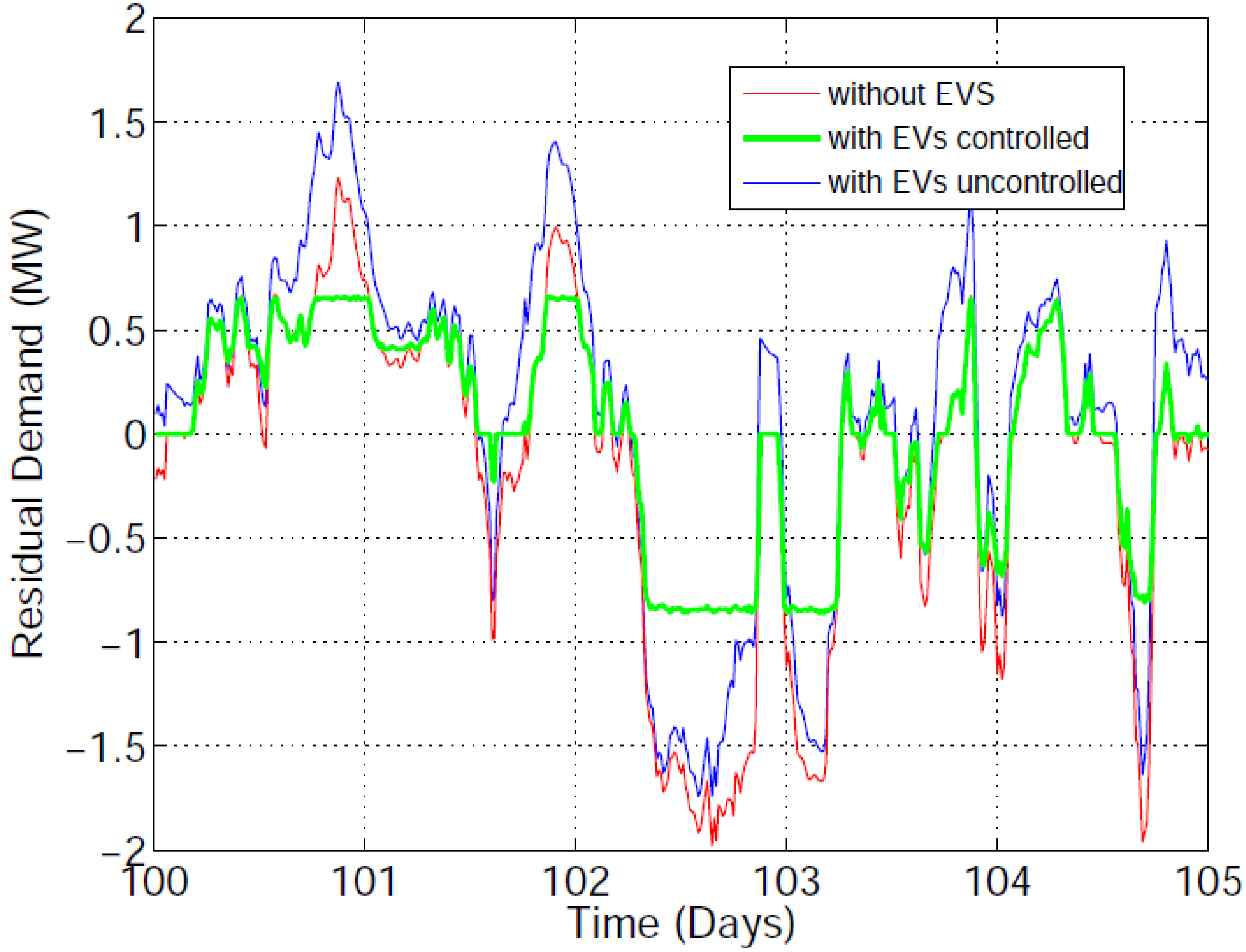

| Generation scenario | Wind | Solar | Hydro | Diesel |
|---|---|---|---|---|
| Current Generation Mix | 0.6 | 0 | 1.4 | 2.3 |
| Moderate Wind and Solar | 2.7 | 1.4 | 1.4 | 2.3 |
| Maximum Wind and Solar | 4.1 | 4.0 | 1.4 | 2.3 |

# Results

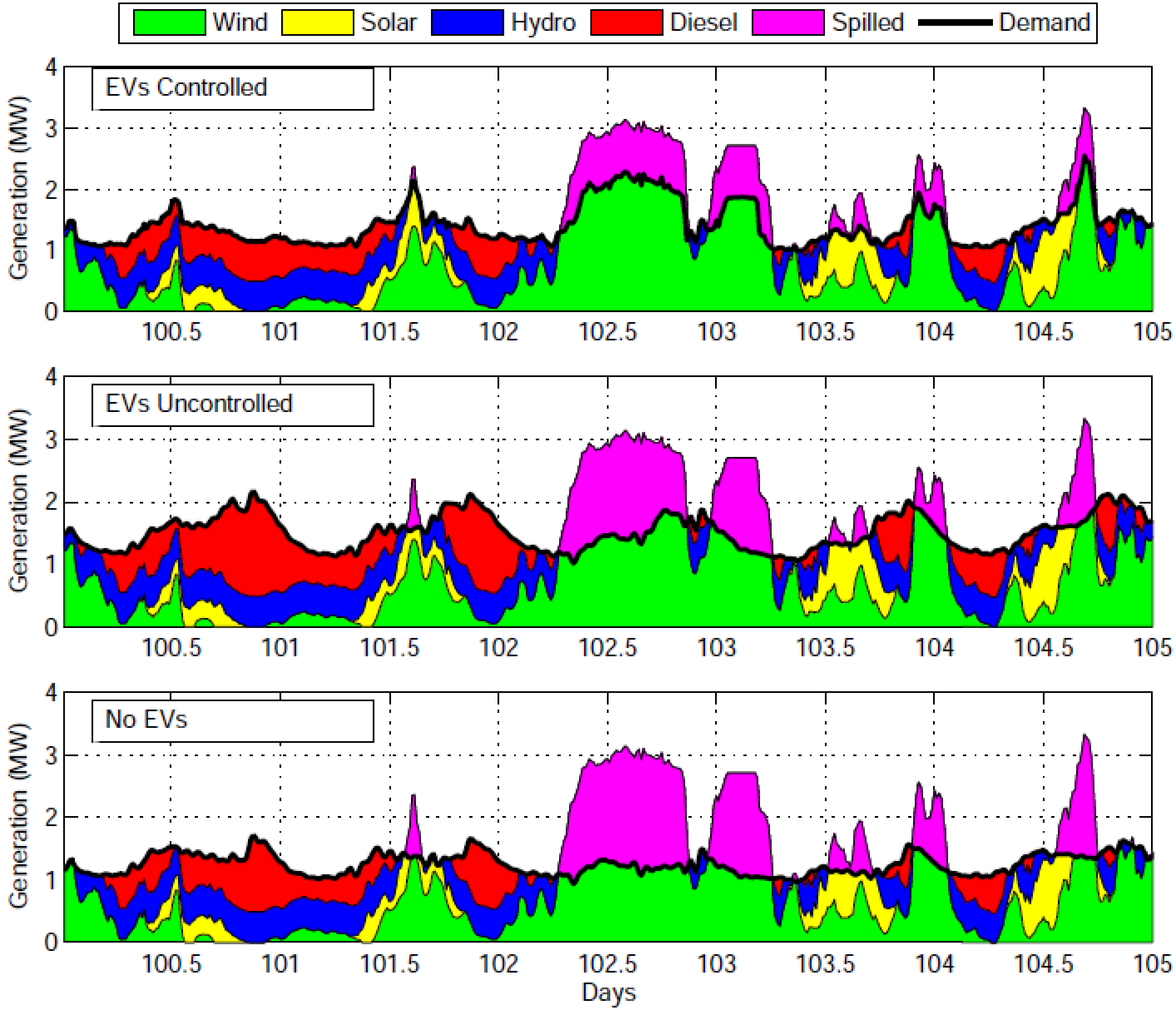
One Electric Vehicle



# Results: a fleet of 1000 EVs



# Dispatch

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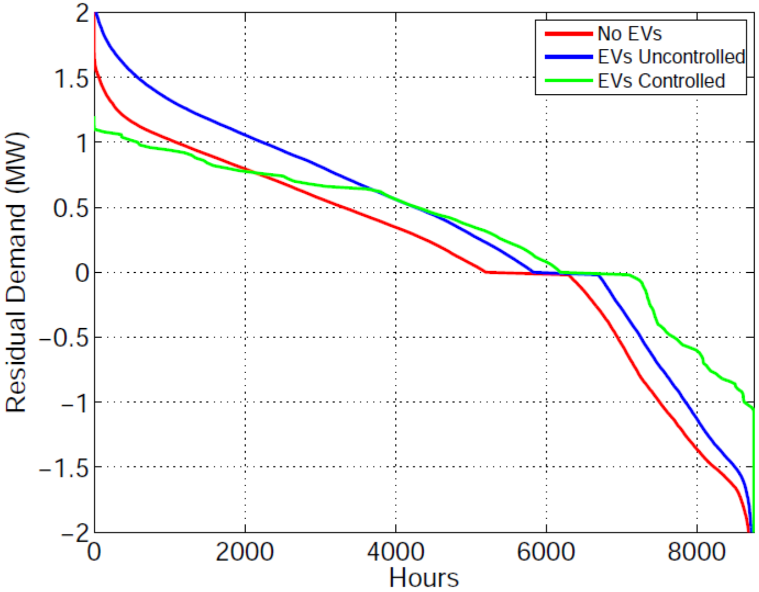
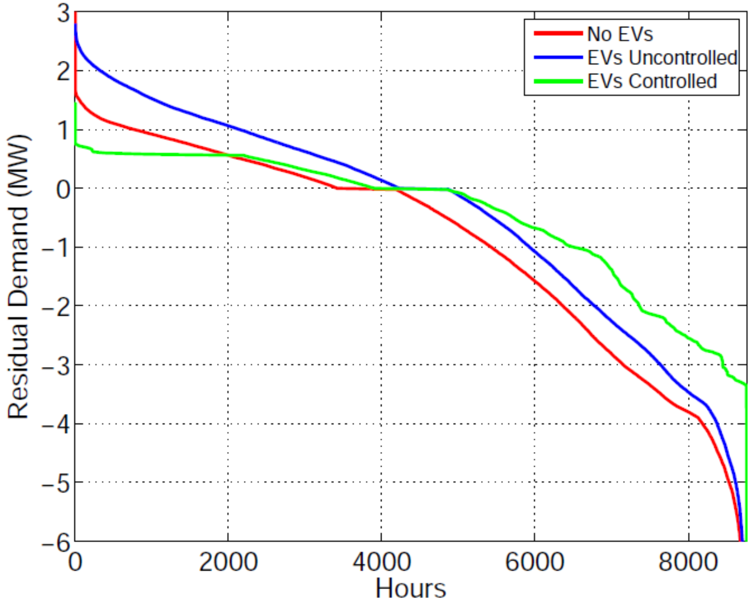
# Load duration curves of residual demand

Medium wind + solar, 1000 EVs




Maximum wind + solar, 2000 EVs

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# CO2 Emissions

| Electricity Scenario | Vehicle Scenario | | | | |
|---|---|---|---|---|---|
| | All Diesel ICE | 50%EVs Uncontr. | 50%EVs Contr. | 100%EVs Uncontr. | 100%EVs Cont. |
| Current generation mix | 8.38 | 8.08 | 8.06 | 7.80 | 7.76 |
| Moderate Wind and Solar | 6.18 | 5.37 | 4.65 | 4.26 | 3.05 |
| Aggressive Wind and Solar | 5.52 | 4.42 | 3.29 | 3.13 | 1.29 |

**85%**

# Cost effectiveness

## Spilled renewables

| Electricity Scenario | Vehicle Scenario | | | | |
|---|---|---|---|---|---|
| | No EVs | 50%EVs Uncontr. | 50%EVs Contr. | 100%EVs Uncontr. | 100%EVs Cont. |
| Current generation mix | 0 | 0 | 0 | 0 | 0 |
| Moderate Wind and Solar | 28 % | 21% | 10% | 23% | 8% |
| Aggressive Wind and Solar | 49 % | 42% | 30% | 45% | 29% |

Remember: Diesel ~ 300 \$/MWh
Wind ~ 100 \$/MWh
Solar ~ 210 \$/MWh

# Conclusions

- EVs have huge potential
- Right price incentives critical
- Reduction up to 85% possible
- Lots of things to research (AGC, uncertainty, grid)

Thank You!