Final Application Portfolio

Community Level Solar Energy System

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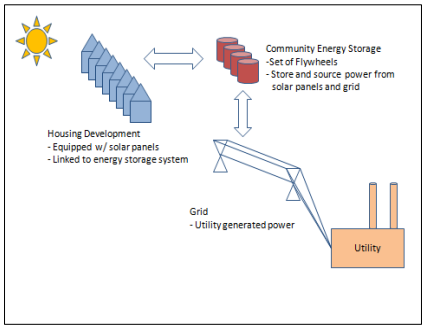
Agenda

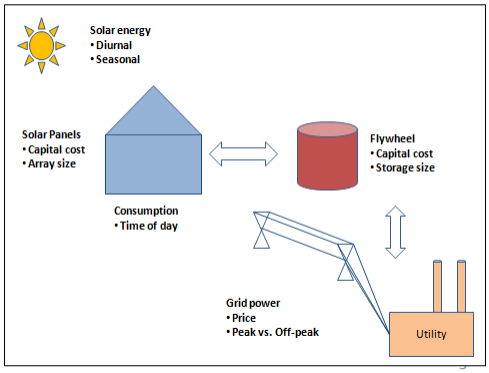
- System Definition
- Model Structure
- Deterministic design results
- Flexible design results
- Conclusions and Reflections
- Next Steps

System Definition



The Vision

- Community level system
- Linked solar panels
- Central energy storage
- Negotiated off-peak rate



Exercise scope

- Single home in Tucson AZ
- Historic hourly solar data
- 20-year timeframe

System Definition

Solar panels

- Initial install (5.52 kWh DC) [$17,000]
- Additional increments are 0.92 kWh [~$2,500]

Flywheel energy storage

- 5 kWh unit [$60,000]
- Production systems from 5-25 kWh available [$60K-$120K]

Grid power

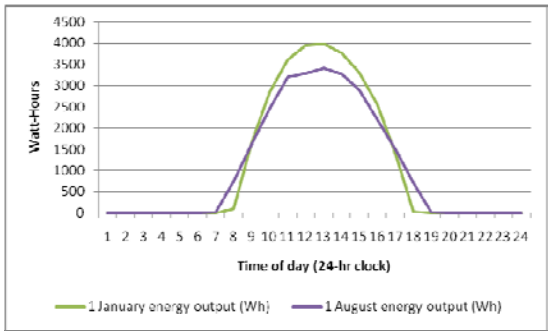
- Peak and off-peak rates

"Green Power" Subsidy

- $2.70/W DC
- Reduced initial CAPEX by ~$15,000

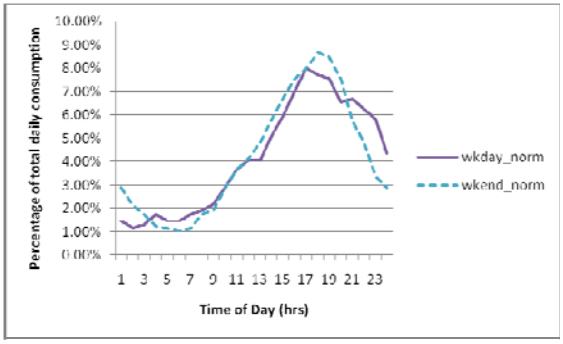
Model Structure

- Solar Panels
  - Output dependent on three factors
    - Size of the array: 24 panels
    - Solar insolation: Tucson AZ (representative hourly data)
    - Efficiency of conversion: 77% (system chosen for model)



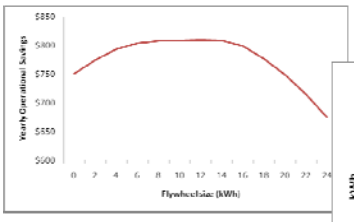
Model Structure

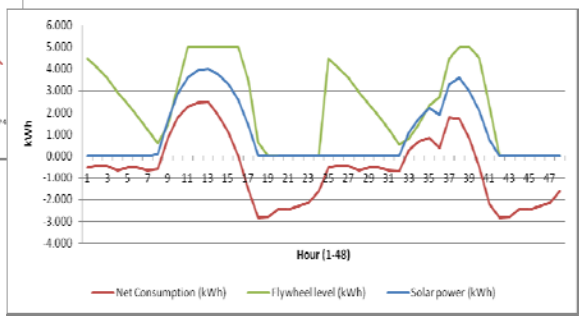
- Home Power Consumption Profile
  - Energy consumption consists of two components
    - Variable load tied to amount of heating or cooling required
    - Base load that includes other usage (appliances, lighting, etc)
    - Used standard curves scaled to capture heating/cooling use



Model Structure

- Energy Storage (Flywheel storage system)
  - 20-year + lifetime (Not cycle limited)
    - Size based on static case (discharge cycle vs ops savings)
    - 5 kWh chosen to limit cost but get to flat peak in the curve

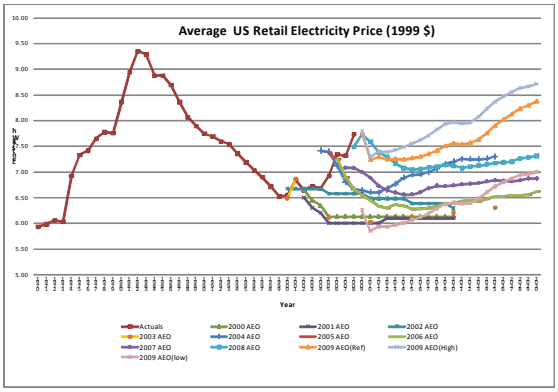




175,200 Total data points
- Hourly over 20 years

Model Structure

- Grid Power
  - Price/kWh is source of uncertainty
  - Modeled as a random walk
  - Starting price of 10.3 cents/kWh



Simulation Decision Rule

If the current year's grid provided electricity price is 10% or more above last year's price, add an additional 4 panels to each home's array.

- Reduce reliance on grid power as price increases
- Justifies additional solar panel installation
- Implemented using two different thresholds
  - 10% and 5% growth in electricity price year-to-year
- Discount rate of 10%

Deterministic Design Results

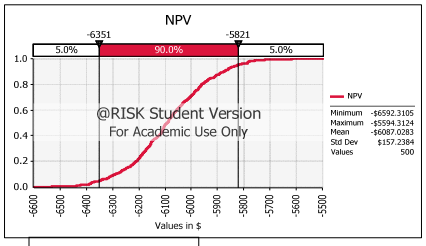
- $700-$1,500 saved in electricity costs per year
- Savings are insufficient to overcome large CAPEX
  - Despite CAPEX subsidy of $2.70/W DC expense

Summary of Results	
CAPEX	$14,235.00
Project NPV	($6,086.38) Loss

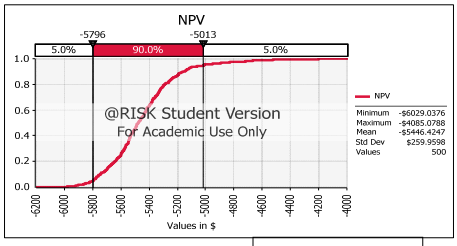
Year	0	1	2	3	4	5	6	
Peak power ($/KWh)	$0.10	$0.10	$0.11	$0.11	$0.11	$0.11	$0.11	
Off-peak power ($/KWh)	$0.07	$0.07	$0.07	$0.07	$0.07	$0.07	$0.07	
Expand?		0	0	0	0	0	0	
Capital Expense	-$14,235.00							
Ops Savings	$799.92	$807.92	$816.00	$824.16	$832.40	$840.72	$849.13	• • •
Expansion Costs			$0.00	$0.00	$0.00	$0.00	$0.00	
Cash Flow	-$13,435.08	$807.92	$816.00	$824.16	$832.40	$840.72	$849.13	
DCF	-$13,435.08	$734.47	$674.38	$619.20	$568.54	$522.02	$479.31	
NPV	-$6,086.38							

Results (Uncertainty Included)

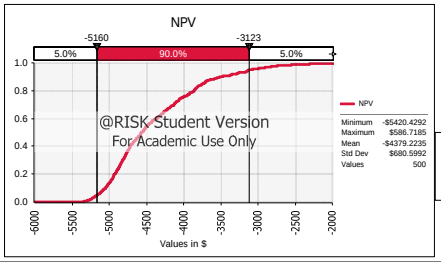
Threshold	Mean	P90	P05	Std Dev
10% w/ 1% trend	($6,087)	($5,821)	($6,351)	$157
5% w/ 2% trend	($5,446)	($5,013)	($5,796)	$260
5% w/ 3% trend	($4,379)	($3,123)	($5,160)	$681



10% DR
1% growth rate



5% DR
2% growth rate



5% DR
3% growth rate

Conclusions

- Large CAPEX makes system a financial loss
  - Large expense of flywheel
  - Historical growth rate of electricity price is small
    - Uncertaintly was too small to drive large change in outcome
- Potential game changers
  - Rapid increase in price of electricity
  - Incorporation of economy of scale (Demand response)
    - Scheduled energy use across multiple homes
  - Carbon credits (system avoids ~6.8 metric tons/year)
  - Reduction in the cost of flyweel / other storage option

Reflections

- Assumptions are a key aspect of any model
  - Consumption profiles, uncertainty modeling, etc
- Screening models are valuable
  - Allows for more iterations and analysis
- Never stop looking for coding errors!

Next Step

- Model that incorporates sharing across homes
  - Sharing of generating resources
  - Scheduling/deconfliction of energy consumption