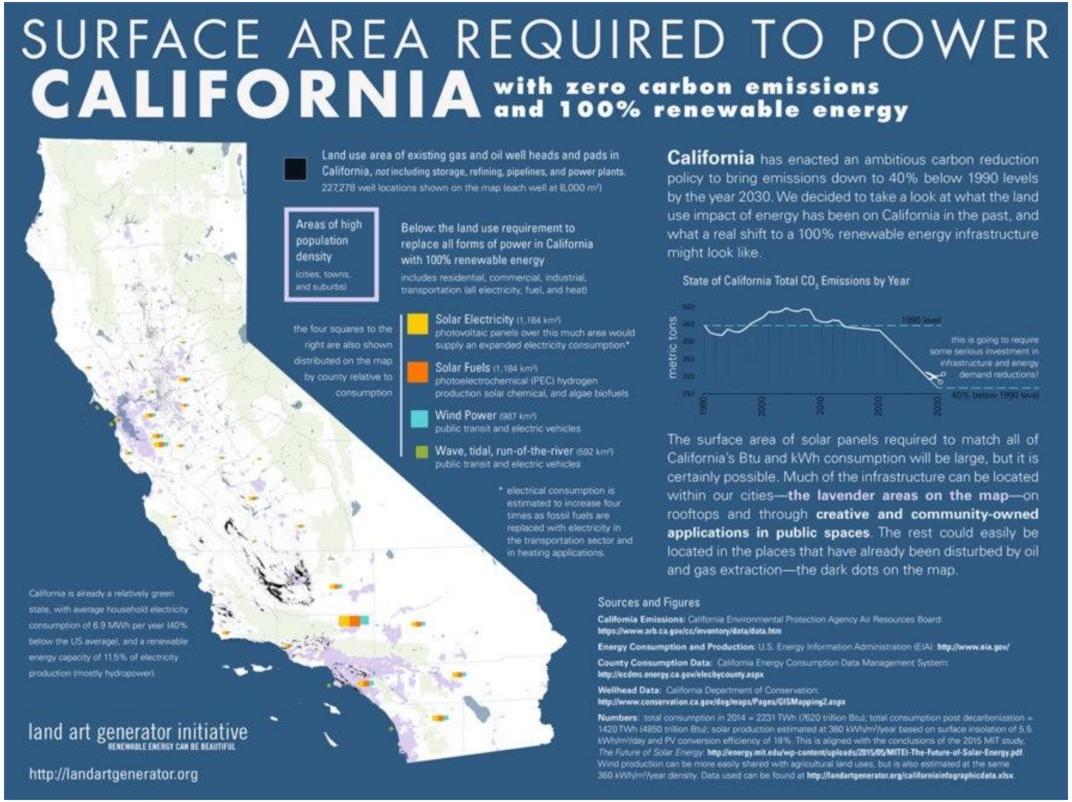
Go Go Green It

What's in your constraints?

Motivation: 50% by 2030



http://assets.inhabitat.com/wp-content/blogs.dir/1/files/2016/09/LAGI-graphic-California-renewable-energy-889x667.jpg

- California has ambitious goals for renewable growth and integration
- Opportunity to leverage DER assets to store and discharge electricity
- Focus on cost competitiveness and site-specific economic potential
- Reliability problems/extra costs
- **Risk and uncertainty in investing**

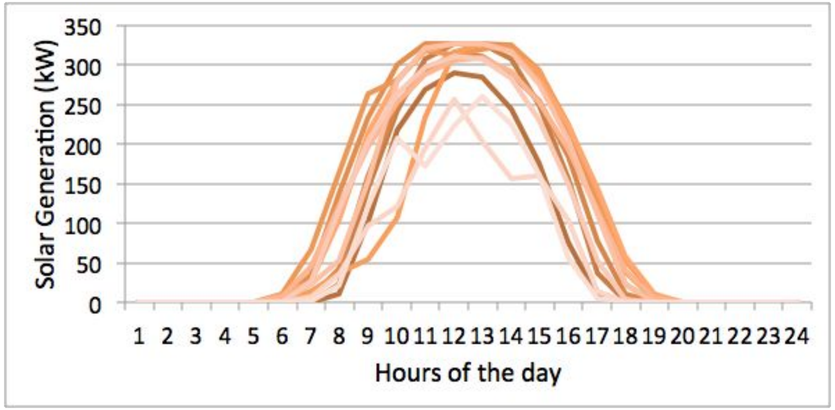
Problem: Uncertainty

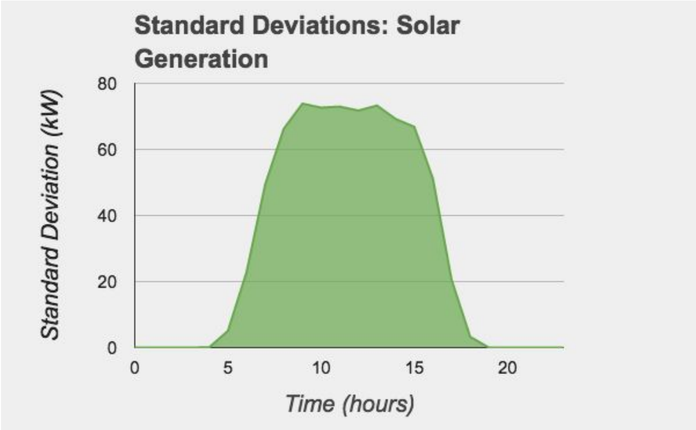
- Current practice assumes perfect knowledge of future loads and solar generation in order to manage energy storage controls and sizing.
- Realistically, solar energy generation is intermittent and uncertain.
- Inaccuracies in forecasting can result in significant economic losses and issues in power system reliability

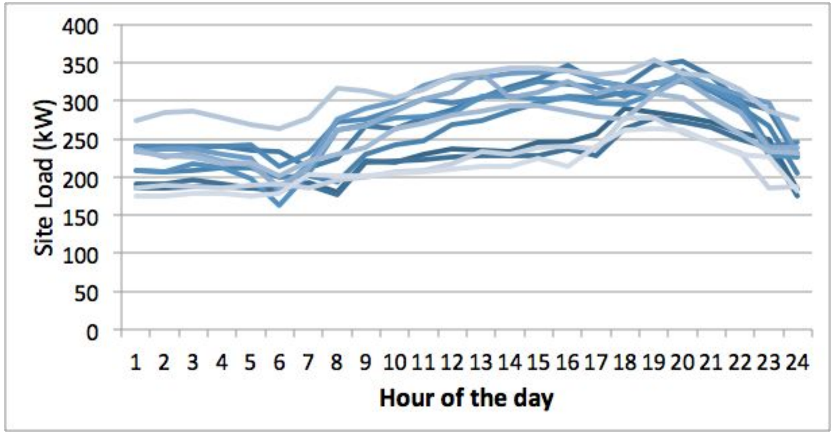
- *“NRG is the leading integrated power company in the U.S., built on the strength of the nation's largest and most diverse competitive electric generation portfolio and leading retail electricity platform.”*
- *“At Station A, our mission is to drive a clean, distributed energy future through analytics, engineering and commercial solutions.”*

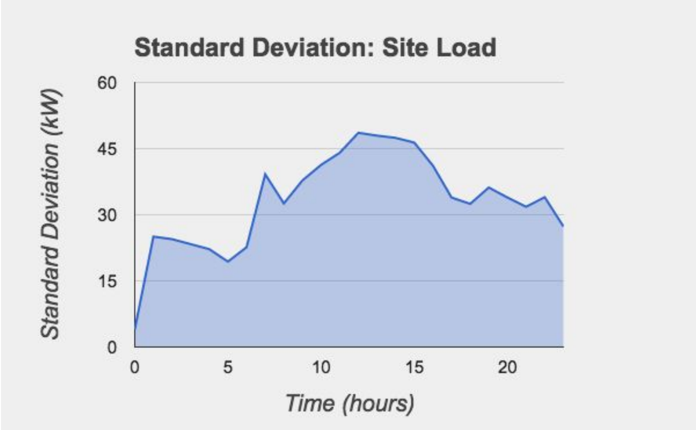
J. Zhang, B.-M. Hodge, A. Florita, S. Lu, H. F. Hamann, and V. Banunarayanan. Tmetrics for evaluating the accuracy of solar power forecasting. In Integration of Solar Power into Power Systems, pages 1–8 pp., 2013.

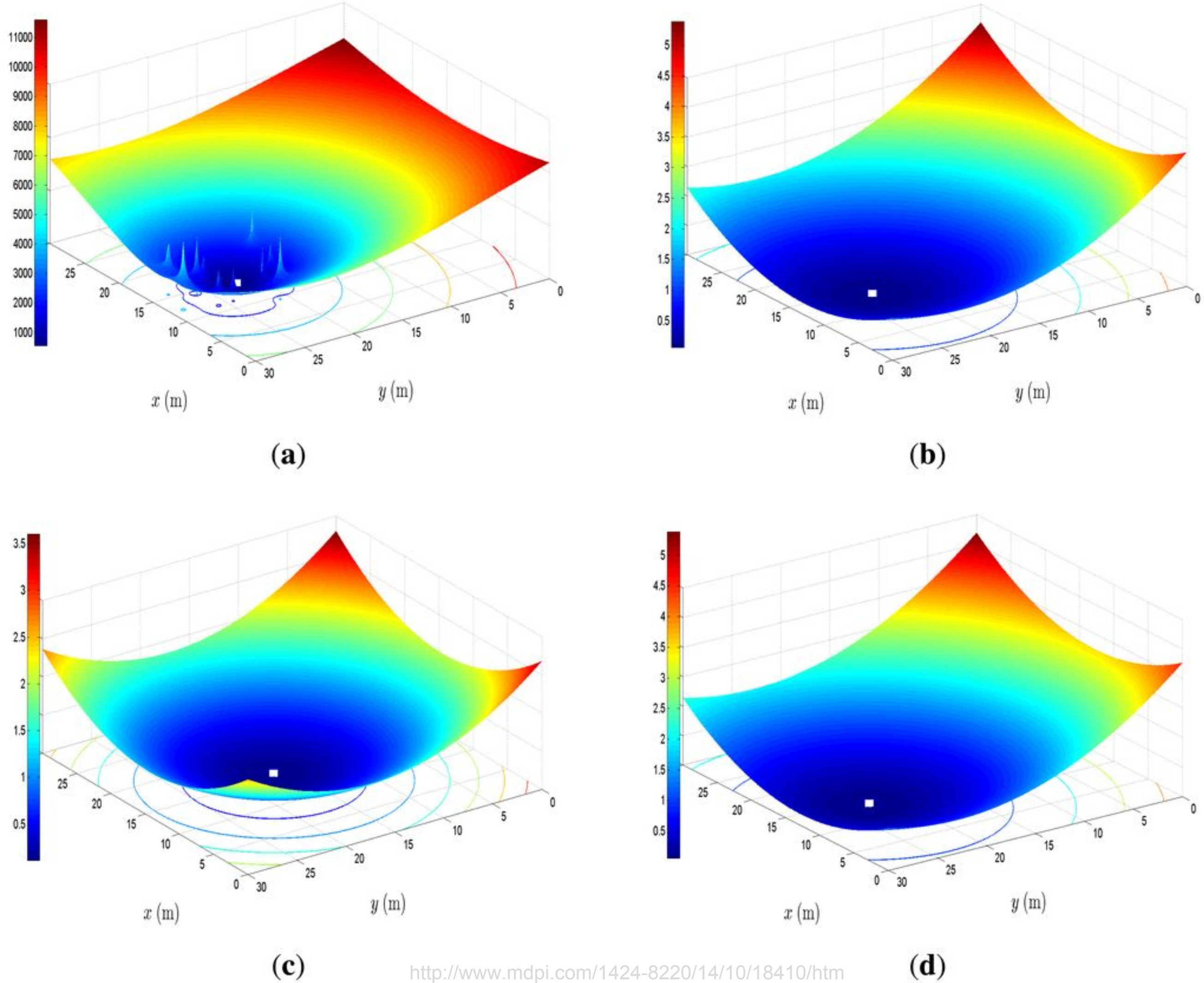
Data for Irvine, CA Site







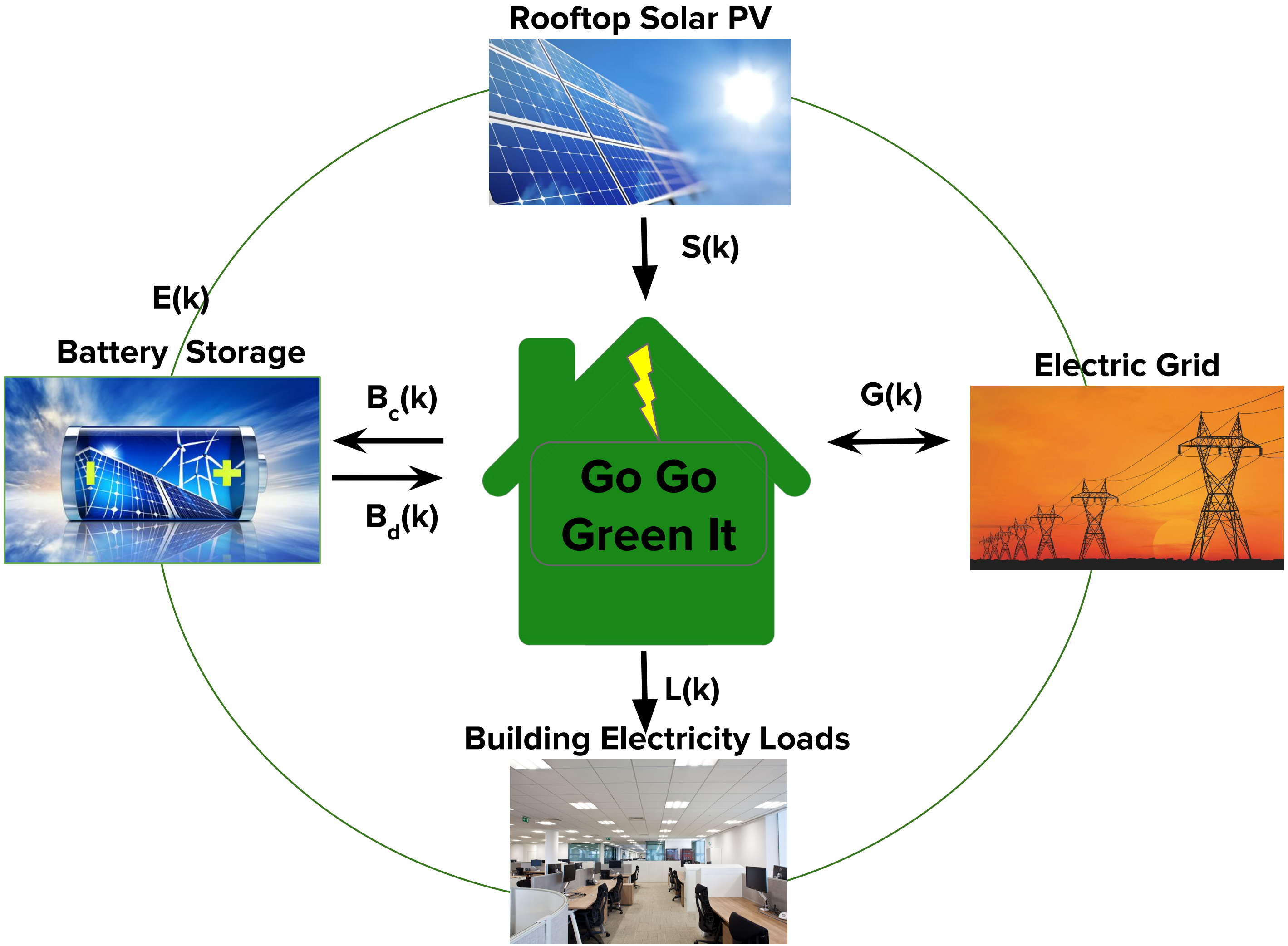




http://www.mdpi.com/1424-8220/14/10/18410/htm

Solution:

Statistically Relax Constraints



Rooftop Solar PV
S(k)
E(k)
Battery Storage
$B_c(k)$
$B_d(k)$
Go Go
Green It
G(k)
Electric Grid
L(k)
Building Electricity Loads

Second Order Cone Program

Objective: size solar and battery storage capacities to minimize costs from capital and use phase monetary costs and optimize for an ideal dispatch profile

A second order cone program was utilized to incorporate uncertainty in solar output and system load [KW].

$$\text{minimize} \quad c_b \cdot b + c_s \cdot s + \sum_{k=0}^{N} c_G(k) \cdot [\overline{L}(k) - s \cdot \overline{S}(k) - B_d(k) + B_c(k)]$$

$$\text{subject to:} \quad E(k+1) = E(k) + \left[\eta_c B_c(k) - \frac{1}{\eta_d} B_d(k)\right] \Delta t$$

$$0 \leq E(k) \leq b \cdot E_{\max}$$

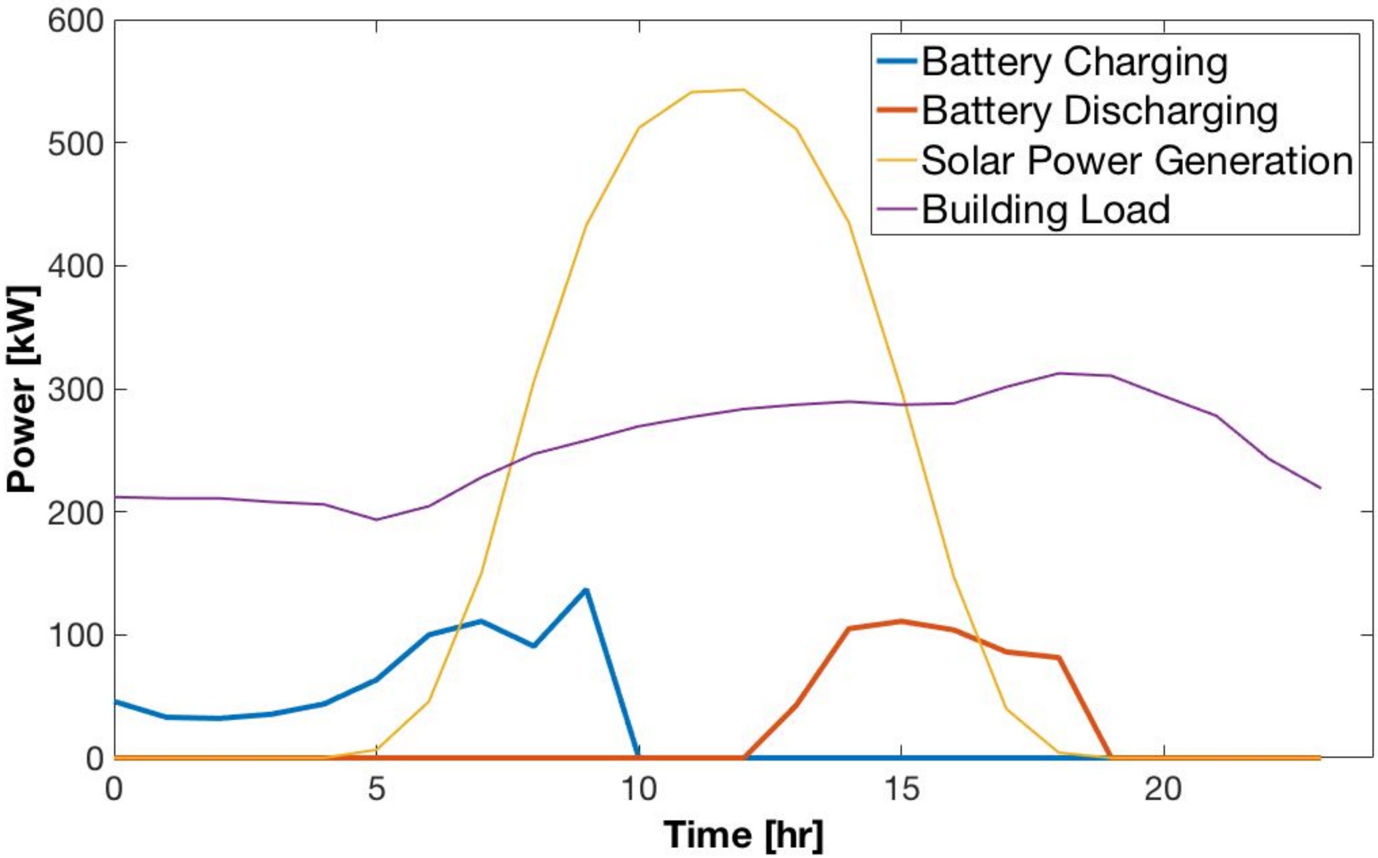
$$0 \leq B_c(k) \leq b \cdot B_{\max}, \quad 0 \leq B_d(k) \leq b \cdot B_{\max}$$

$$\sqrt{\sigma_S^2(k) \cdot s^2 + \sigma_L^2(k)} \leq \frac{1}{\Phi^{-1}(\alpha)} [s \cdot \overline{S}(k) + B_d(k) - B_c(k) - \overline{L}(k) + G_{\max}]$$

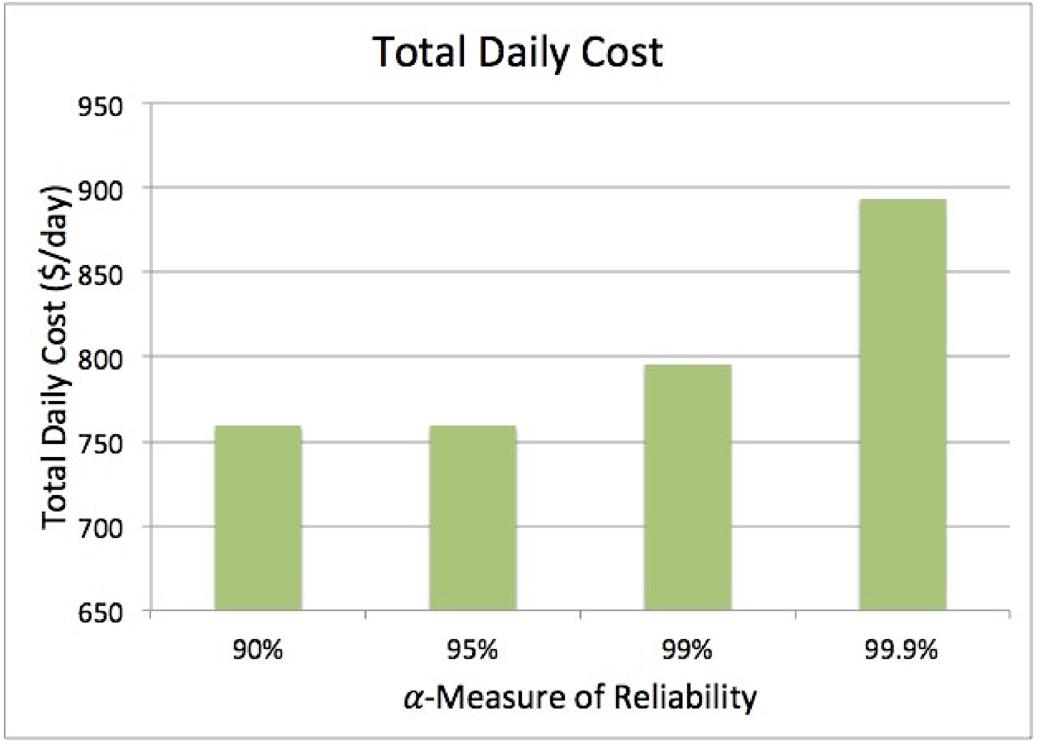
$$\sqrt{\sigma_S^2(k) \cdot s^2 + \sigma_L^2(k)} \leq \frac{1}{\Phi^{-1}(\alpha)} [-s \cdot \overline{S}(k) - B_d(k) + B_c(k) + \overline{L}(k) + G_{\max}]$$

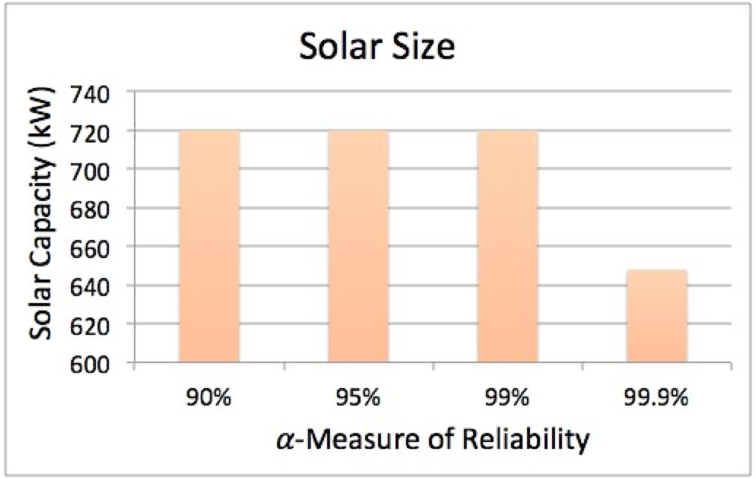
Chance Constraint

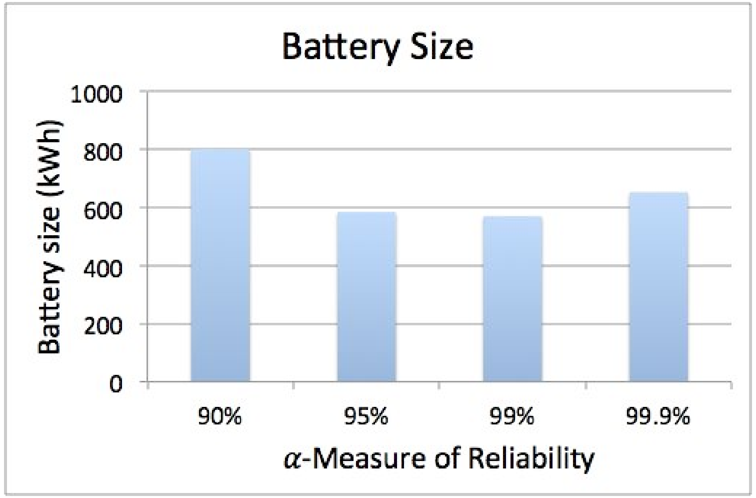
Results Visualization



Effect of Chance Constraints







$1.9M

Saved when investing in Solar & Battery over baseline

$3.1M

Saved from baseline scenario when deploying GGGI tool

63%

Savings from current practice

Conclusion: Robust Sizing Tool

Scalable and efficient.

Incorporating statistics and data analytics provides more accurate, efficient, and profitable methods for sizing distributed energy resource (DER) assets

Questions?

Liam Weaver

Dirk MacDonald

Sara Mitchell

Kan Ito

Appendix: Sensitivity to System Life

Varying Battery Life, solar life = 12 y, α = 99.9%

Battery Life (y)	Cost ($/day)	Battery Size	Solar Size
10	913	0.48	1.8
12	899	0.48	1.8
14	880	0.75	2
20	840	1	1.8

Varying Solar Life, battery life = 12.3 y, α = 99.9%

Solar Life (y)	Cost ($/day)	Battery Size	Solar Size
10	957	0.48	1.8
12	894	0.48	1.8
14	845	0.75	2
20	756	0.75	2

Constants

B_{max}	0.8*Peak Load
E_{max}	B_{max}*4
G_{max}	600 kW
η-discharge	0.9
η-charge	0.85