DAT604 - Simulation & Modeling Techniques

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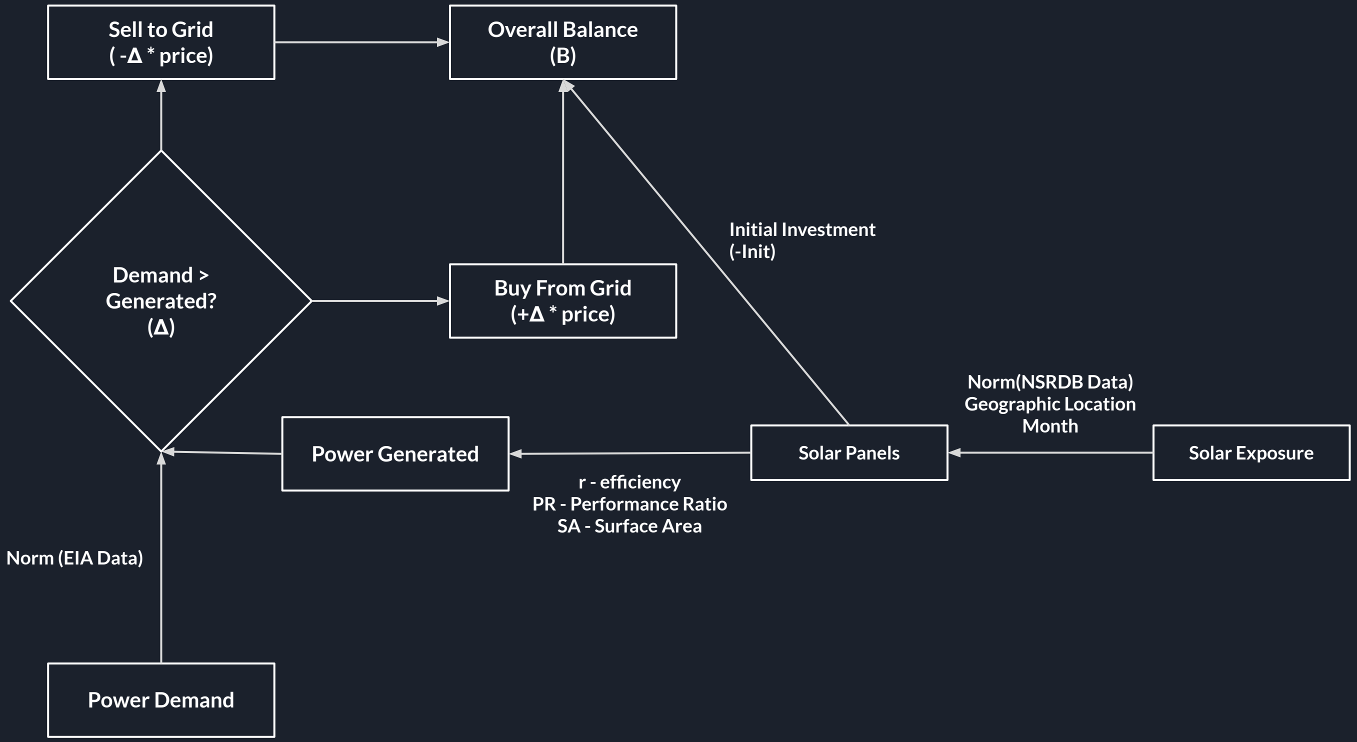
Problem

- Solar power is becoming more and more viable for homeowners
- Far too many factors come into play to evaluate the financial implications
  - Environmental variables
  - Size limitations
  - Power consumption
  - Initial investment

Goal

Create a simulation which can be used to investigate the viability of a solar panel system

Overview


Sell to Grid
(-Δ * price)
Overall Balance
(B)
Demand >
Generated?
(Δ)
Buy From Grid
(+Δ * price)
Initial Investment
(-Init)
Norm(NSRDB Data)
Geographic Location
Month
Power Generated
Solar Panels
Solar Exposure
r - efficiency
PR - Performance Ratio
SA - Surface Area
Norm (EIA Data)
Power Demand

Gather Data on Solar Exposure (NSRDB)

- Determine location (lat/long)
- Pull hourly GHI for location (NSRDB API)
- Calculate average daily exposure broken out by month
- Calculate st. dev of daily exposure broken out by month

Month	GHI	STD
1	3087.322581	1366.215244
2	2388.500000	1390.704285
3	4682.806452	1780.111746
4	5718.066667	2026.809093
5	6850.806452	1959.323513
6	6877.333333	1314.185321
7	7179.741935	1422.765663
8	6675.580645	1244.565085
9	4153.066667	1458.029514
10	3316.354839	1663.581128
11	2925.000000	1411.190278
12	2846.580645	1327.766465

Create System Defining Solar Panels

- Define the area, efficiency, PR of the solar panel array. Defaults based on average panel
- Determine state (to determine average price of power)
- Determine initial expenditure for panel install

```python
In [33]: def define_system3(A=80,r=0.175,PR=0.8,lat=lat,long=long,state='Texas',initial_cost=15000):
             '''Create a system object defining our solar panel system

             A -    surface area of the panels (in m^2)
             r -    solar panel efficiency (between 15 and 21%, default 17.5%)
             PR -   performance ratio (between 50 and 90%, default 75%
             lat -  latitude of the location
             long - longitude of the location

             returns: System object
             '''

             start = State(P=0, N=0, PB=0, MP = -initial_cost, C = 0)
             '''Create a state tracking the positive/negative months as well as the balance overall
             P -    number of months where more power was generated than used
             N -    number of months where less power was generated than used
             PB -   overall balance of power
             FB -   overall financial expenditure
             '''
             t0 = 0
             '''13 years worth of operation'''
             t_end = 13*12

             return System(start=start, t0=t0, t_end=t_end, A=A, r=r, PR=PR, state = state, lat=lat, long=long)
```

Determine The Demand on System

- Look at average household consumption in the US
- Decided to skew towards the high end of the table to be conservative
- Normally distributed demand

State	Number of Customers	Average Monthly Consumption (kWh)
Montana	509,526	850
Nevada	1,183,660	947
New Mexico	889,841	639
Utah	1,091,162	742
Wyoming	272,427	841
Pacific Contiguous	**18,418,260**	**649**
California	13,591,152	546
Oregon	1,750,240	901
Washington	3,076,868	957
Pacific Noncontiguous	**723,792**	**539**
Alaska	287,526	572
Hawaii	436,266	518
U.S. Total	**133,893,321**	**914**

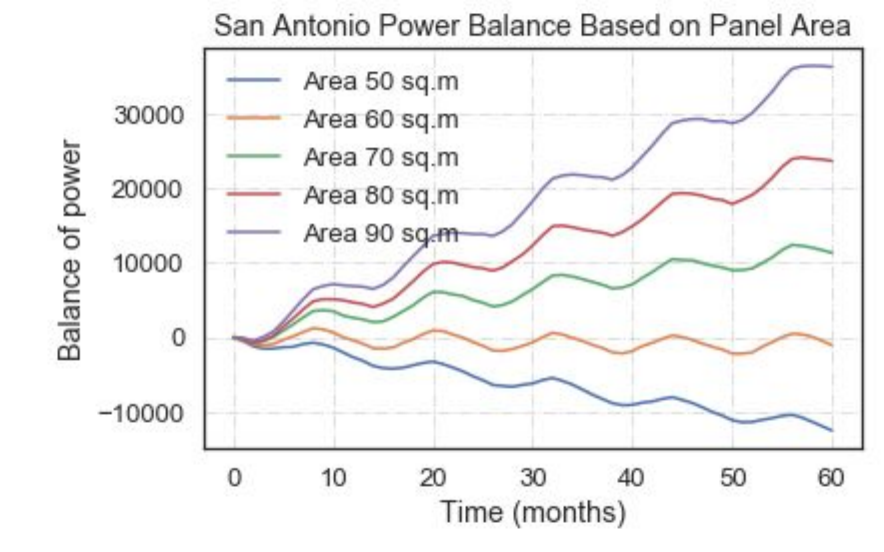
```
In [8]: ####   Function generating a value for the demand on our system in a day.
        def days_demand_norm(mean = 40, std = 6):
            demand_day = np.random.normal(mean,std)
            if demand_day < 0:
                demand_day = 0
            return demand_day

        days_demand_norm()

Out[8]: 35.27083922041013
```

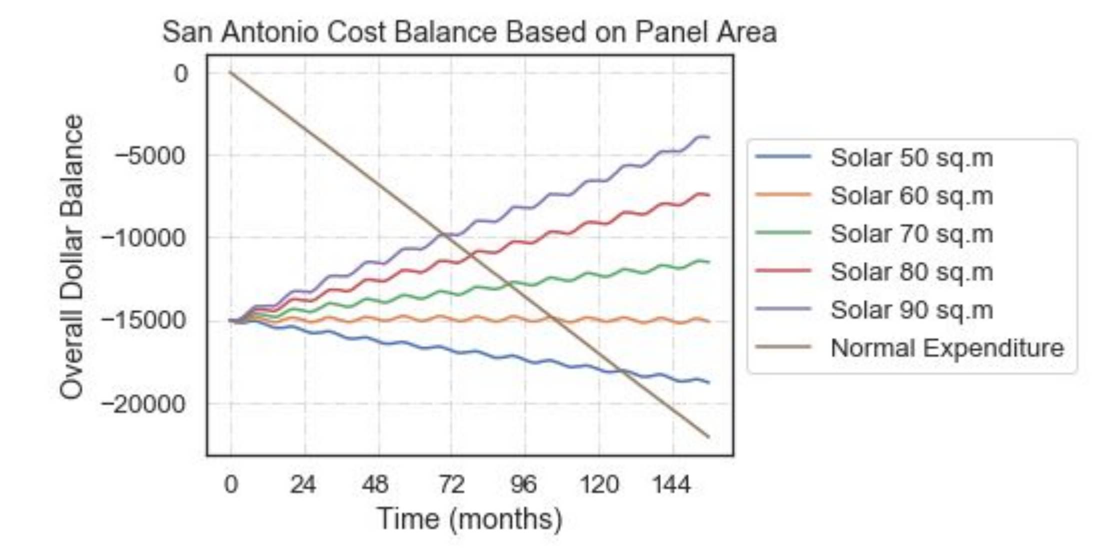
Run Simulation

- Run for 13 years (Median length of homeownership)
- Assume standard efficiency & Performance Ratio
- Look at Different Surface Areas
- Calculate Delta of Power Generated to Consumed



Refine Simulation

- Start accounting for price/kWh
- Account for initial cost of installation
- Account for what would have been spent on power without Solar



Re-run to See Efficiency Effect

- Simulate multiple panel systems with different efficiencies
- Assume an area of 80 sq m (half of an average US roof)