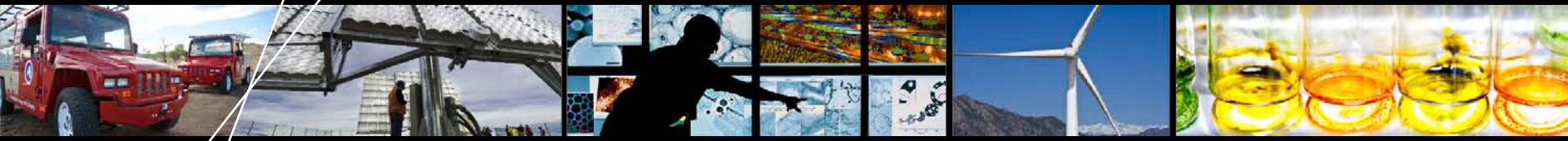
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Using SAM User Language (SAMUL)

Scripting Functionalities Utilized to Reduce SAM User Time-On-Task and Run-Time Simulations



Presenter: Nathan Clark

Date: June 20th 2012

SAM One Day Conference

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

Nathan Clark

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- **A part of NREL's Research Participant Program (RPP) for Solar Market Transformation in the Strategic Energy Analysis Center. Under direct supervision from Sean Ong within Energy Forecast & Modeling group, as well as, Barry Friedman within the Market Policy and Impact Analysis group.**

- **Currently Studying Electrical Engineering at University of Colorado Denver**

- **Five years experience as Commercial and Industrial Electrician in Colorado**

PV Break-Even Study Courtesy of Sean Ong
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Why SAMUL?

- **“The SAM User Language (SAMUL) is a built-in scripting language that allows a user to automate tasks and perform more complex analyses directly from within SAM.” – SAM Documentation**

- **Analysts performing more than “one” simulation**
- **Variable manipulation**
- **Data and File management**
- **Closed Loop I/O**
- **Multi-processing**

SAMUL Benefits

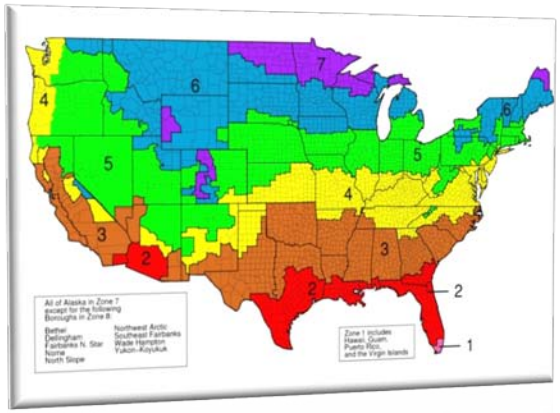
- **Is taking the time to write a script always worth it?**
  - Analyst creates own personal toolbox that can be used for future analyses
- **Can I change SAM variables on the fly in between simulations?**
  - Yes! In fact whole scenarios worth of variables can be manipulated on the fly
- **Ok. I have just created more data than I know what to do with. Now what?**
  - SAMUL can write results to files and perform simple file management
- **Is there a way to model an output variable's trend to constrain subsequent simulations?**
  - Yes. SAMUL can help solve complex non-linear problems through simple iterative methods
- **SAMUL is fast but running 100,000 simulations is going to take days. What can I do?**
  - Scripts can be easily transformed from their current state to include multiprocessing support

SAMUL Applied to Break-Even Study

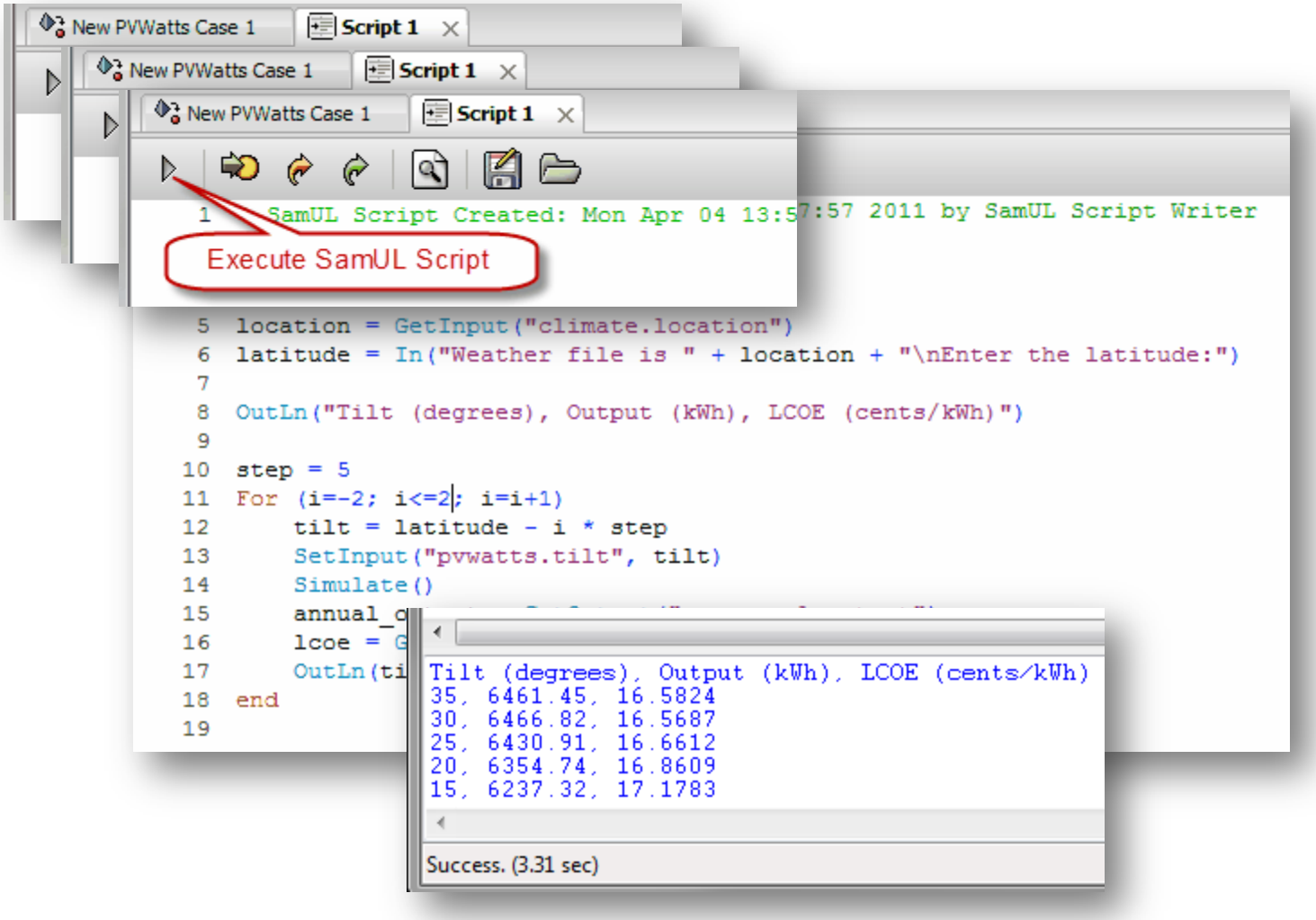
- **At what price point does PV make “economic sense”?**
- **How SAMUL can utilize aforementioned scripting techniques to answer the “does PV make economic sense” question.**
- **Break-Even study leverages SAMUL and analysis is completed with ease and significant reduction in analyst error**

Break-Even Study Details

- 1020 U.S. TMY3 Weather Locations
- 16 different commercial building load profiles generated through E+
- 16 different ASHRAE locations specified
- DSIRE data used for state PV incentives
- Break-Even cost is defined as: total installed cost of PV in which NPV = zero (or NPB = NPC)



Setting up simple SAMUL scripts



SAMUL I/O Variables For Break-Even

Load Inputs:

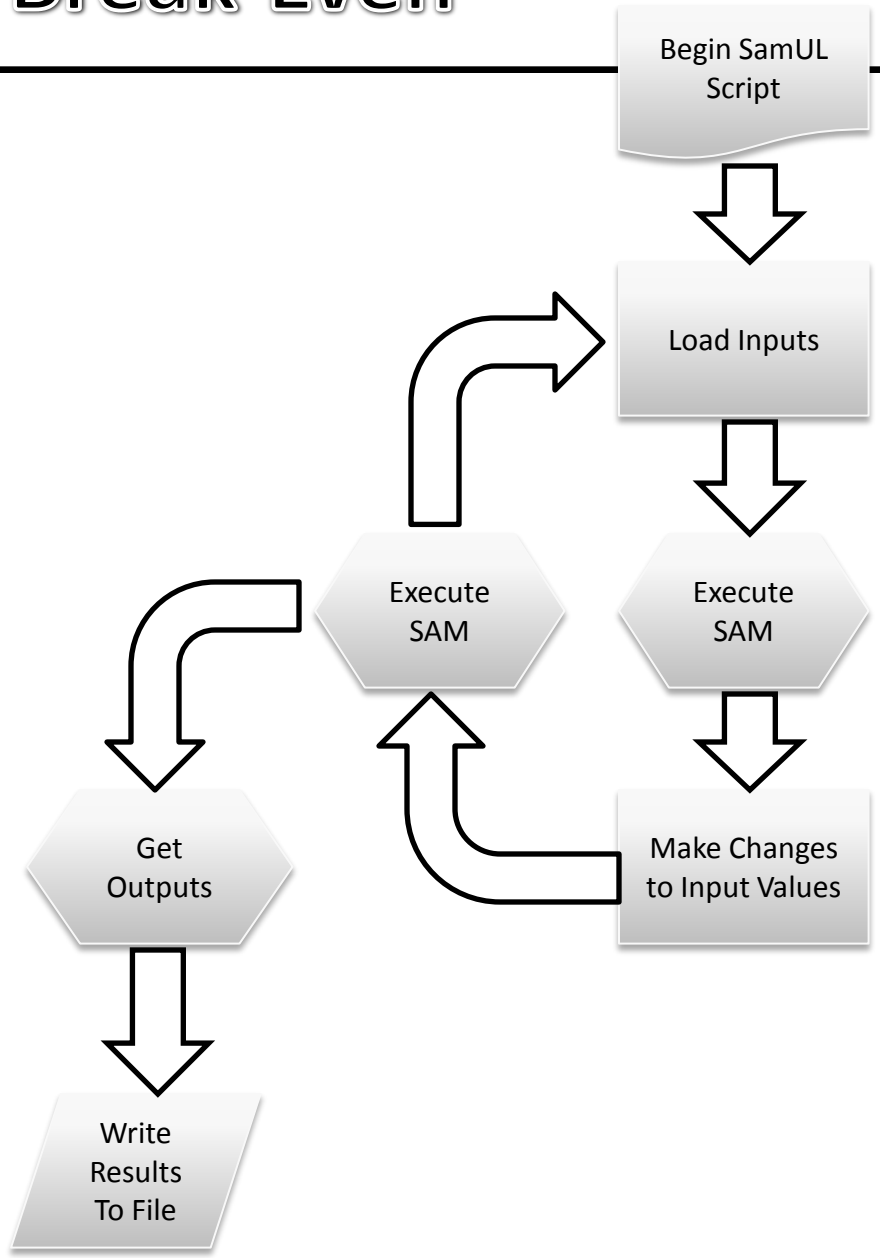
```
setinput ( "elecload.user_data", load )
setinput("climate.location", file_list[count] )
setinput ( "txc.itc.state.percentage.value", 20 )
```

Read Variables/Make Changes:

```
setinput ( "pv.cost.per_module", Cost - 0.001 )
getoutput ( "sv.installed_cost_per_capacity" )
getoutput( "sv.npv" )
```

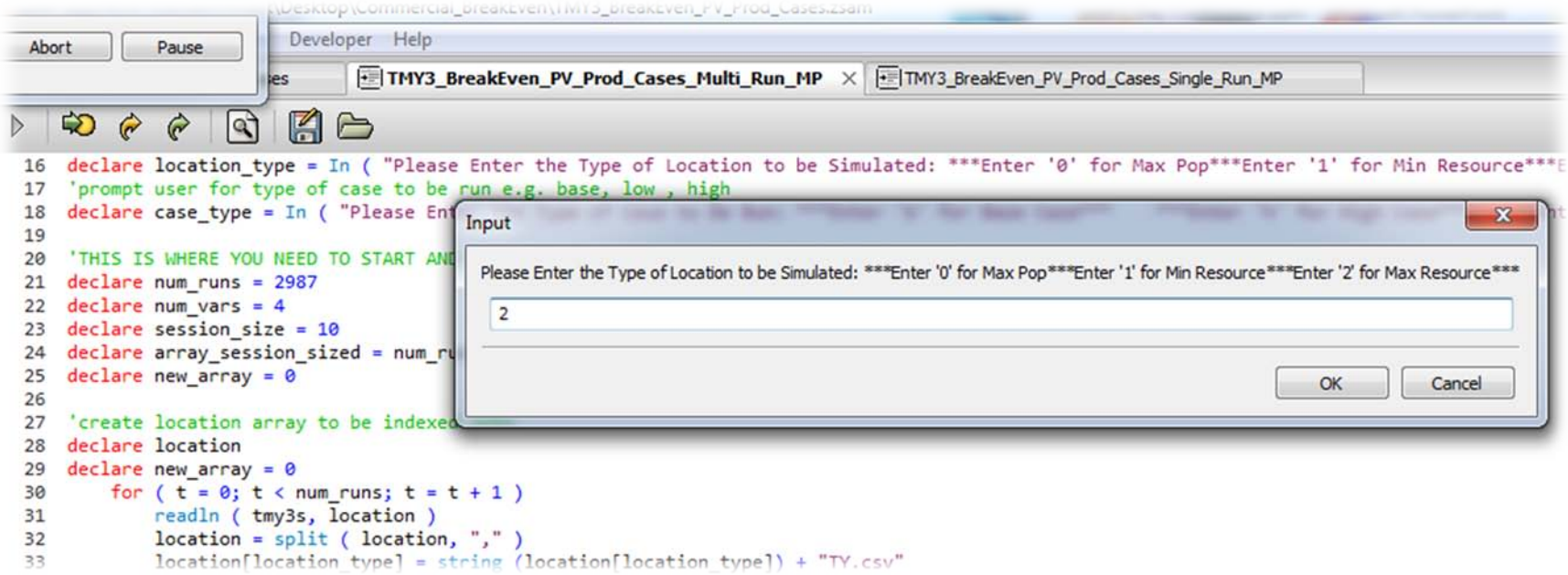
Dump Results:

```
getoutput ( "firstyear.ur.monthly.revenue_w_sys" )
getoutput ( "system.annual.e_net" )
writeln ( output_file, results )
```



SAMUL User Prompts

- **User Prompts: Making the Script User Friendly and Portable to other Users and Analysts**



SAMUL I/O Closed Loop Analysis

While (the Net-Present-Value of PV is Less Than Zero)

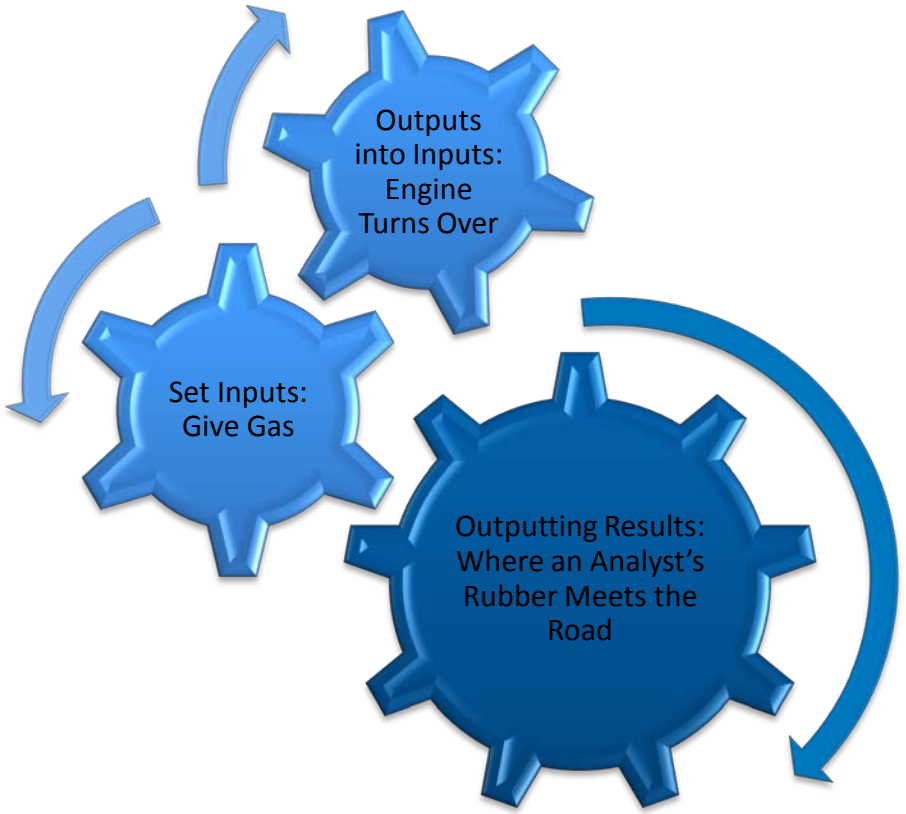
- Cost = 10
- **simulate()**

- price_x[0] = getoutput ("sv.installed_cost_per_capacity")
- npv_y[0] = getoutput("sv.npv")
- **simulate()**

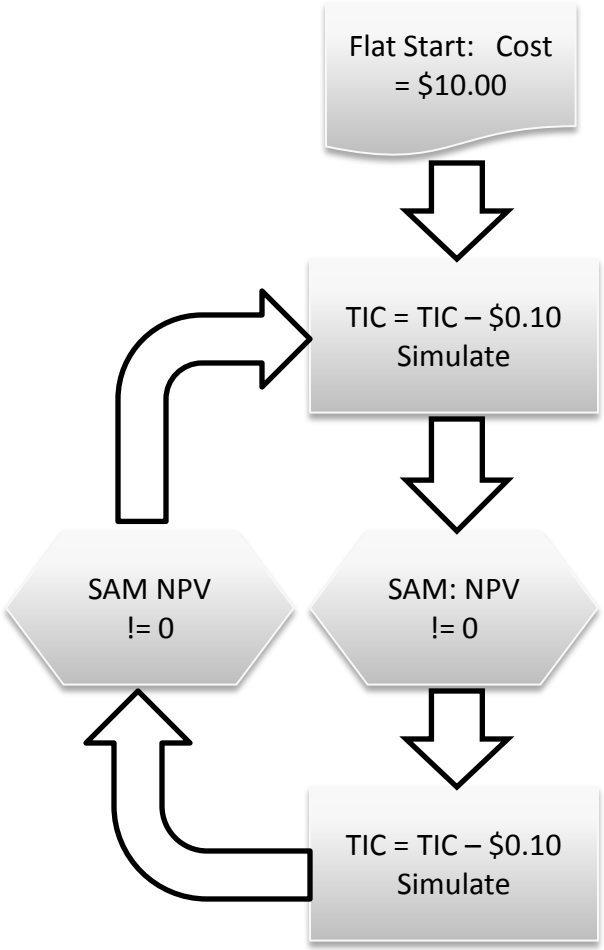
- setinput ("pv.cost.per_module", Cost - 0.1

- **simulate ()**

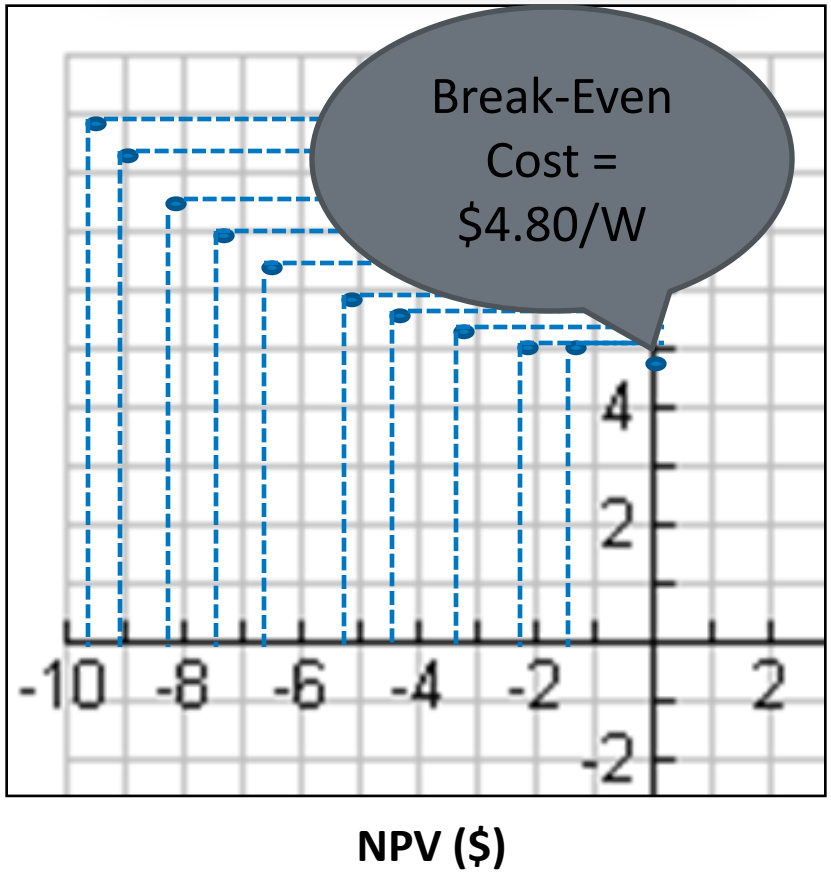
- price_x[1] = getoutput ("sv.installed_cost_per_capacity")
- npv_y[1] = getoutput("sv.npv")



Closed Loop Analysis of Break-Even Study



$$y - y_1 = m(x - x_1)$$

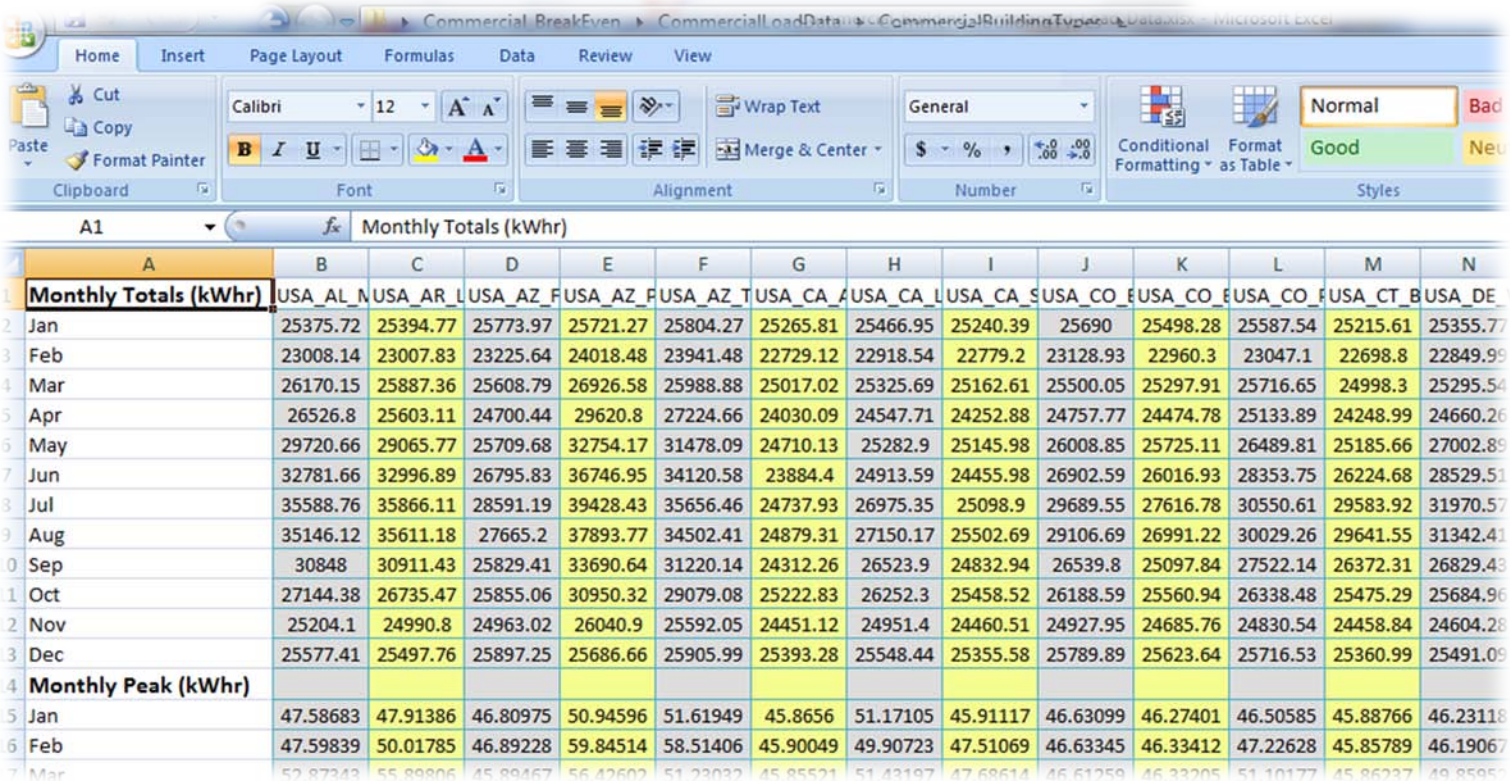


Managing Large Data and File Sets

workdir = "C:/Documents and Settings/nclark/Desktop/Commercial_BreakEven/“

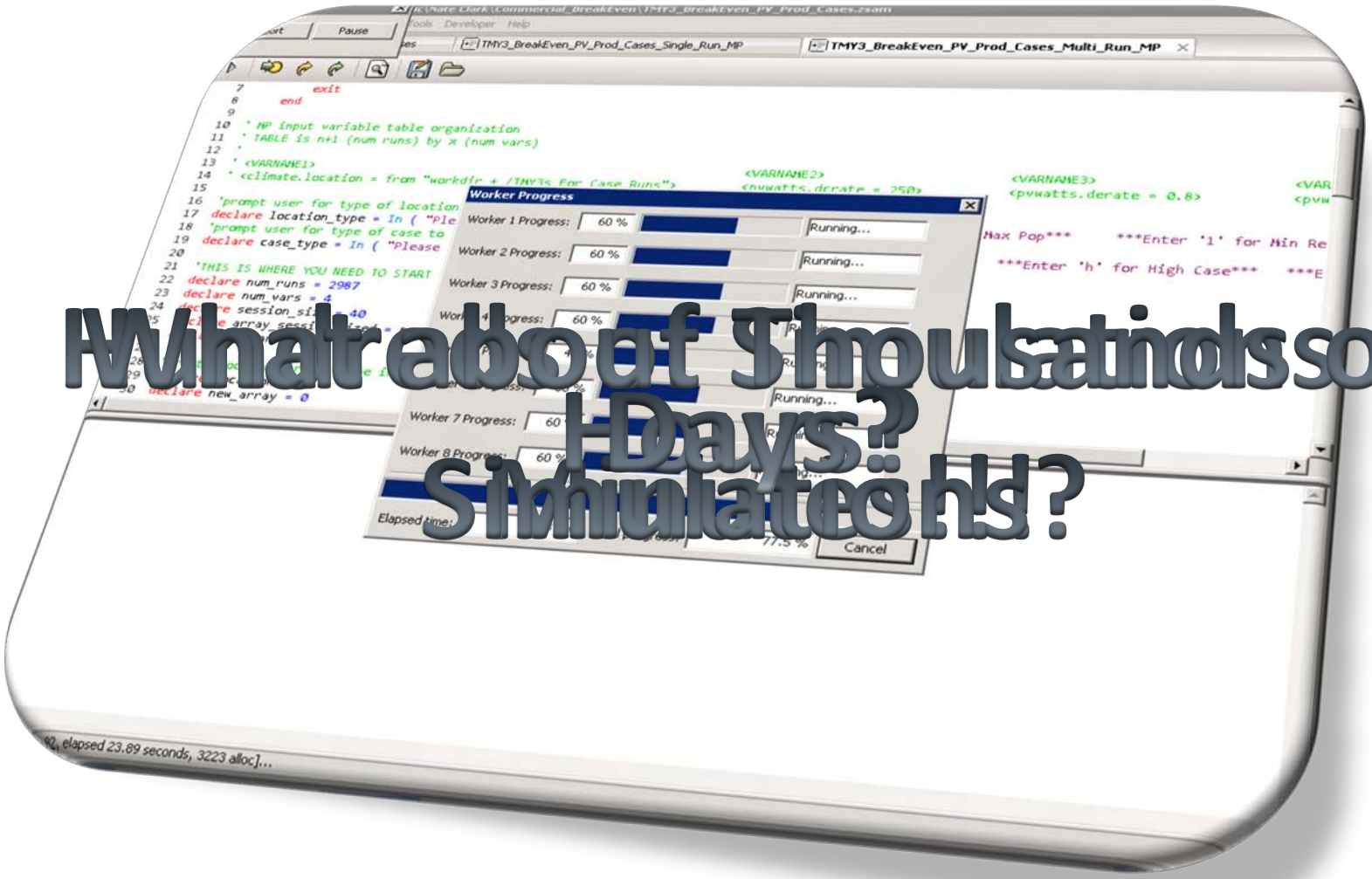
Opening/Creating Files for Writing To:

strlen(file_name) strsplit(“replace_this”, “with_that”) copyfile("c:/test.txt", "c:/test2.txt")



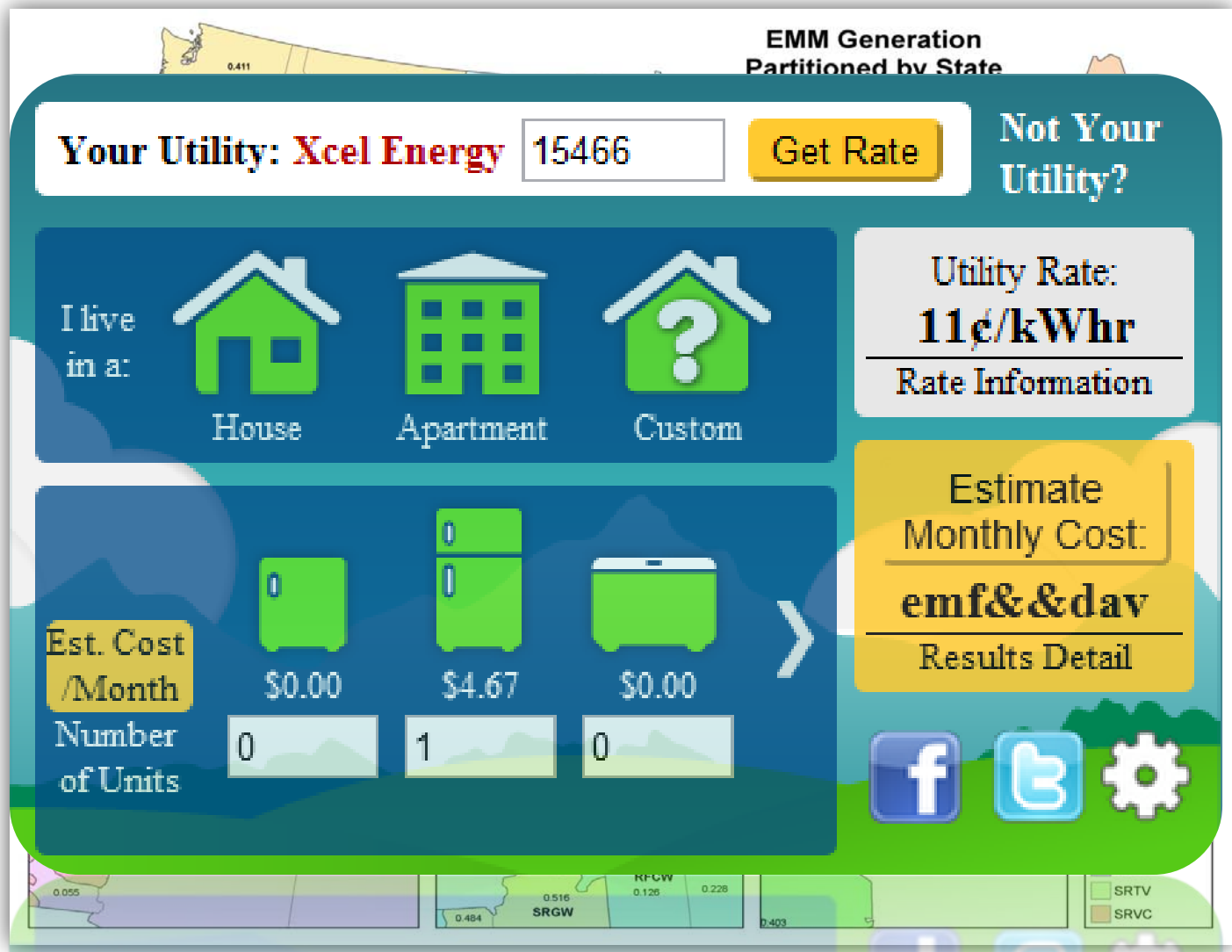
	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	**Monthly Totals (kWhr)**	USA_AL_N	USA_AR_L	USA_AZ_F	USA_AZ_F	USA_AZ_T	USA_CA_A	USA_CA_L	USA_CA_S	USA_CO_E	USA_CO_E	USA_CO_F	USA_CT_B	USA_DE_
2	Jan	25375.72	25394.77	25773.97	25721.27	25804.27	25265.81	25466.95	25240.39	25690	25498.28	25587.54	25215.61	25355.77
3	Feb	23008.14	23007.83	23225.64	24018.48	23941.48	22729.12	22918.54	22779.2	23128.93	22960.3	23047.1	22698.8	22849.99
4	Mar	26170.15	25887.36	25608.79	26926.58	25988.88	25017.02	25325.69	25162.61	25500.05	25297.91	25716.65	24998.3	25295.54
5	Apr	26526.8	25603.11	24700.44	29620.8	27224.66	24030.09	24547.71	24252.88	24757.77	24474.78	25133.89	24248.99	24660.26
6	May	29720.66	29065.77	25709.68	32754.17	31478.09	24710.13	25282.9	25145.98	26008.85	25725.11	26489.81	25185.66	27002.89
7	Jun	32781.66	32996.89	26795.83	36746.95	34120.58	23884.4	24913.59	24455.98	26902.59	26016.93	28353.75	26224.68	28529.51
8	Jul	35588.76	35866.11	28591.19	39428.43	35656.46	24737.93	26975.35	25098.9	29689.55	27616.78	30550.61	29583.92	31970.57
9	Aug	35146.12	35611.18	27665.2	37893.77	34502.41	24879.31	27150.17	25502.69	29106.69	26991.22	30029.26	29641.55	31342.41
10	Sep	30848	30911.43	25829.41	33690.64	31220.14	24312.26	26523.9	24832.94	26539.8	25097.84	27522.14	26372.31	26829.43
11	Oct	27144.38	26735.47	25855.06	30950.32	29079.08	25222.83	26252.3	25458.52	26188.59	25560.94	26338.48	25475.29	25684.96
12	Nov	25204.1	24990.8	24963.02	26040.9	25592.05	24451.12	24951.4	24460.51	24927.95	24685.76	24830.54	24458.84	24604.28
13	Dec	25577.41	25497.76	25897.25	25686.66	25905.99	25393.28	25548.44	25355.58	25789.89	25623.64	25716.53	25360.99	25491.09
14	**Monthly Peak (kWhr)**													
15	Jan	47.58683	47.91386	46.80975	50.94596	51.61949	45.8656	51.17105	45.91117	46.63099	46.27401	46.50585	45.88766	46.23118
16	Feb	47.59839	50.01785	46.89228	59.84514	58.51406	45.90049	49.90723	47.51069	46.63345	46.33412	47.22628	45.85789	46.19067
17	Mar	52.87343	55.89806	45.89467	56.42602	51.23032	45.85521	51.43197	47.69614	46.61259	46.33205	51.10177	45.86237	49.85952

SAMUL Multi-Processing



…The "Anything" Part

- Residential Projected Electricity Generator
- State Projected Electricity Generator



Closing Comments

- SamUL arms the Sam user with a powerful toolset for running numerous simulations sequentially
- Variable manipulation through dynamic user prompts creates a portable platform that is user friendly for others
- Scripting Sam Results can be extended beyond to file and data management
- Simple closed loop I/O routines can be created for to find solutions to otherwise unsolvable problems
- High Performance Computing through Parallel processing is the future

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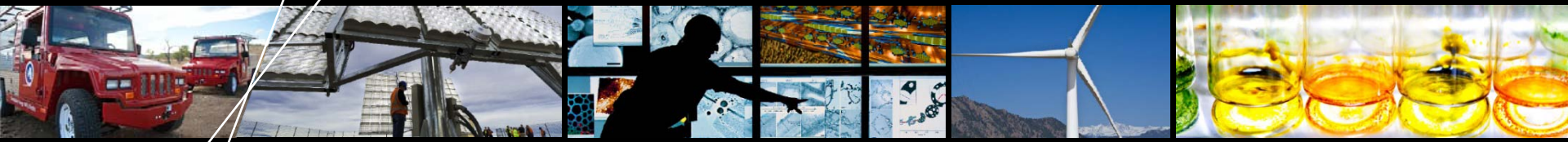
Thank You