ARFC

# Energy Systems Analysis for Microreactor Integration

***Samuel Dotson*[1], *Dr. Kathryn Huff*[1]**

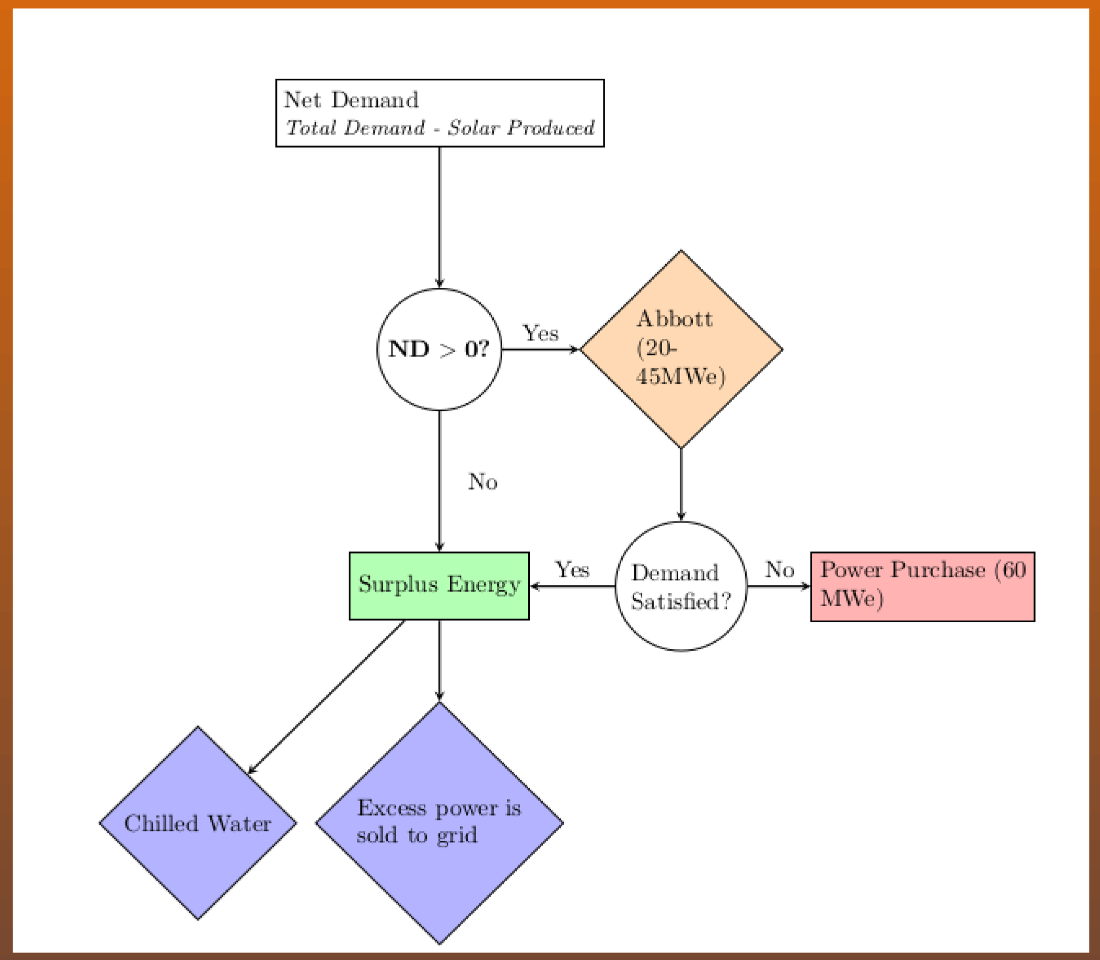
1. Advanced Reactors and Fuel Cycles ◆ Department of Nuclear, Plasma, and Radiological Engineering, University of Illinois at Urbana-Champaign, Urbana, IL 61801

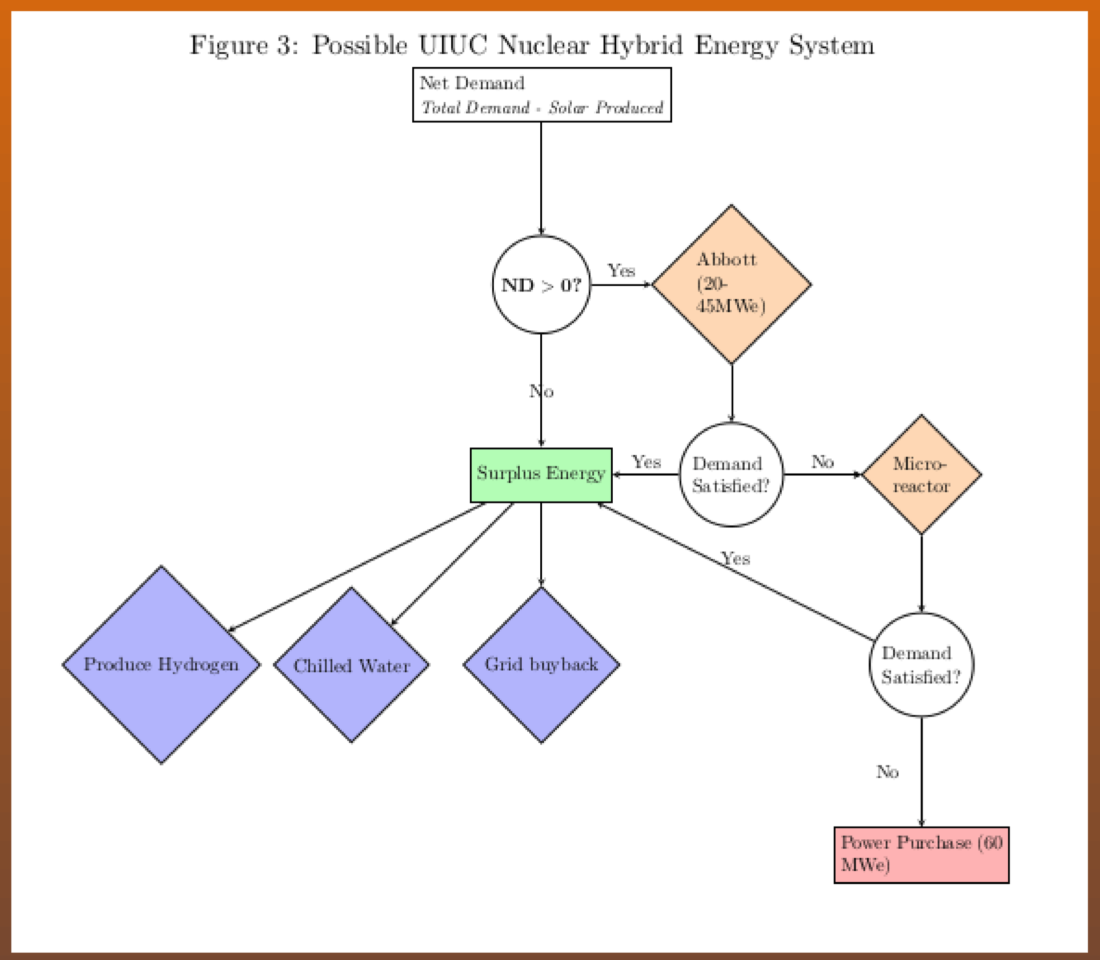
ILLINOIS
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

## Introduction

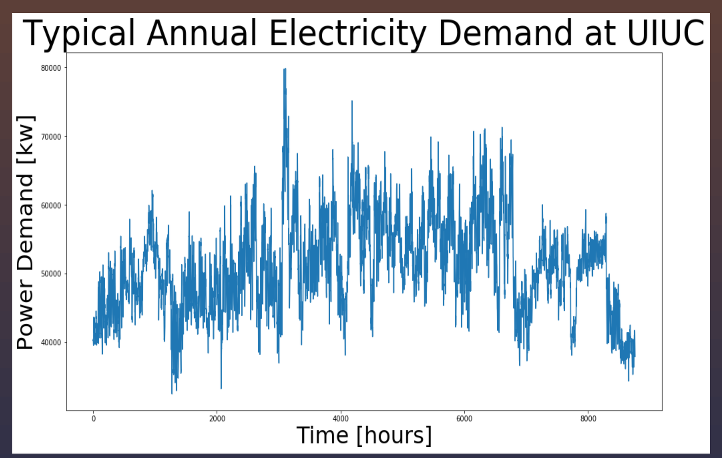
The purpose of this study was to characterize the energy grid at the University of Illinois in order to understand how a micro-reactor could be integrated into the existing energy infrastructure at UIUC. We were specifically interested in examining the best applications for a reactor on the UIUC campus.

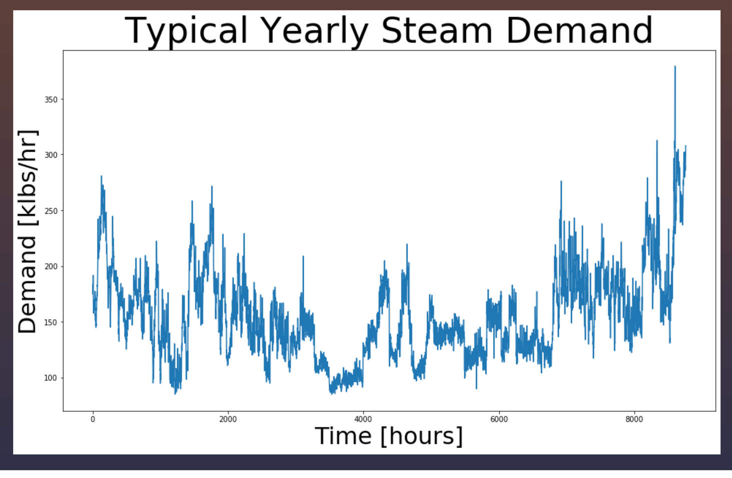
This study was motivated by the 2015 Illinois Climate Action Plan[6] (ICAP) that set a goal for UIUC to be carbon neutral by 2050. The ICAP report indicated a potential role for nuclear power in achieving that goal.

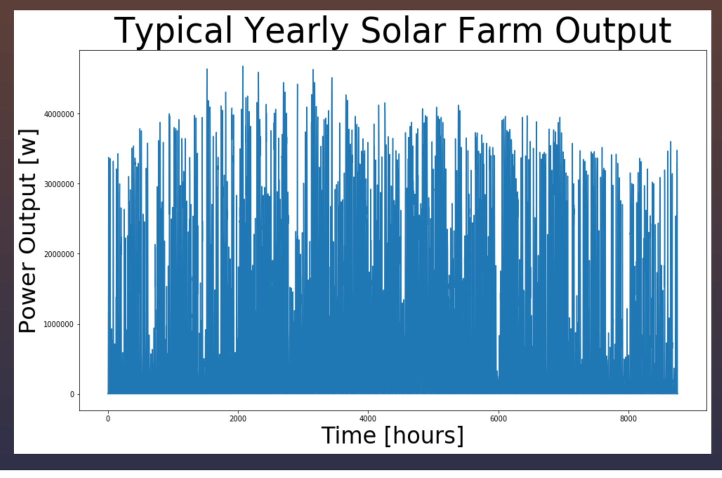


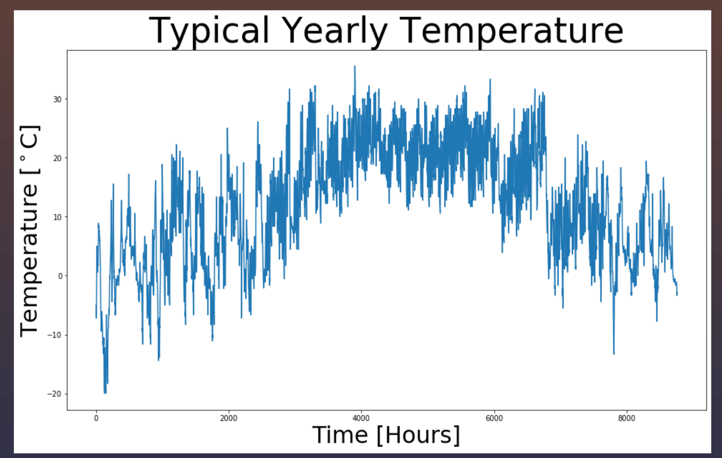




Left: A flow chart describing the current energy grid at UIUC; Right: A flow chart describing a potential energy mix with a micro-reactor on campus.

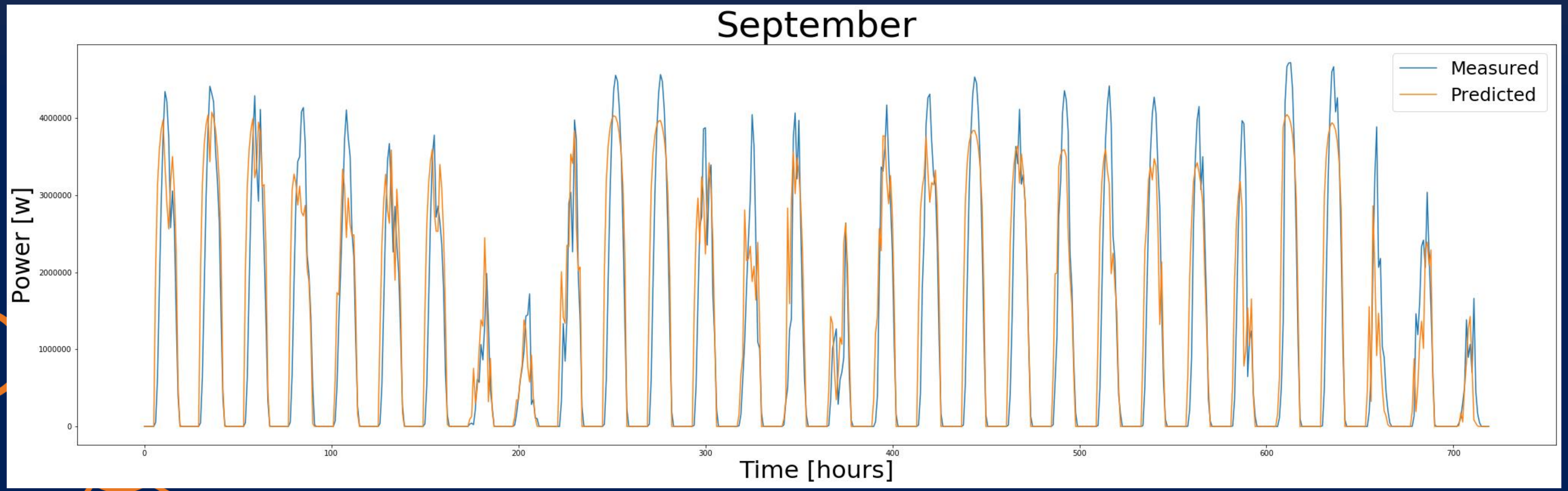



These are typical years of ***X*** quantity generated by the RAVEN framework. Each year has hourly data resolution.
Left: Typical Grid Load [kw]; Middle Left: Typical Steam Load [klbs/hr]; Middle Right: Typical Solar Farm Output [w]; Right: Typical Yearly Temperature [C]




A comparison of the real output from the UIUC solar farm vs. the output predicted from solar irradiance for the month of September.

## Methods

Modeling Solar Farm Output:

$$\delta = 23.44\sin(\frac{\pi}{180}\frac{360}{365}(N+284))$$
$$G_T = DNI\cos(\beta+\delta-lat) + DHI\frac{180-\beta}{180}$$
$$P = G_T\tau_{pv}\eta_{ref}A[1-\gamma(T-25)]$$

Generating a Typical Yearly History[2],[4]:

1. Gathered data for each quantity of interest
2. Clean it (no missing data points, no unreliable data)
3. Export cleaned data to csv files
4. Pass datasets to RAVEN which generates a typical time series.

## Conclusions

There are three broad applications for a nuclear reactor on the UIUC campus. Each of them can be investigated further in future work.

1. Replace coal and natural gas boilers with a microreactor, producing 100% of the University's steam needs.
2. Cogenerate Steam and Electricity*
3. Use the heat from the reactor to produce Hydrogen or other industrial processes.

*The power plant at UIUC is a cogeneration plant, thus it would be inefficient for the reactor to generate electricity only.

## Future Work

This work marks the first step towards establishing the technical requirements for a microreactor, such as the optimal size of the reactor.

1. Determine the optimal reactor size by following the method from Baker et. al[4]
2. Quantitatively outline the best applications for a micro-reactor.
3. Develop projections about future energy needs on campus that could be fulfilled by nuclear.

## References

[1] Affiliated Engineers, Inc, "Utilities Production and Distribution Master Plan," University of Illinois at Urbana-Champaign, Urbana, IL, Full Report UIUC Project No. U11045, October 2015.

[2] A. Alfonsi *et al.*, "RAVEN Theory Manual," Idaho National Lab. (INL), Idaho Falls, ID (United States), INL/EXT-16-38178, Jun. 2016.

[3] AlsoEnergy, "University of Illinois Solar Farm Dashboard," AlsoEnergy, Urbana, IL, Web Dashboard 2019-07–04, Jul. 2019.

[4] T. E. Baker, A. S. Epiney, C. Rabiti, and E. Shittu, "Optimal sizing of flexible nuclear hybrid energy system components considering wind volatility," *Applied energy*, vol. 212, pp. 498–508, 2018.

[5] H. E. Garcia *et al.*, "Nuclear Hybrid Energy Systems Regional Studies: West Texas & Northeastern Arizona," Idaho National Lab. (INL), Idaho Falls, ID (United States), INL/EXT-15-34503, Apr. 2015.

[6] iSEE, "Illinois Climate Action Plan (iCAP)," University of Illinois at Urbana-Champaign, Urbana, IL, Full Report 2015, Ocober 2015.

[7] M. White, "Solar Farm Fact Sheet." University of Illinois Facilities and Services, 04-Oct-2017.

## Acknowledgements

This work was made possible with data provided by UIUC Facilities and Services, in particular, Morgan White, Mike Marquissee, and Mike Larson. Additionally, this work is funded by the NRC Fellowship Program.