GEN IV International Forum
Expertise | Collaboration | Excellence

Evaluating Changing Paradigms Across the Nuclear Industry

Summary / Objectives:

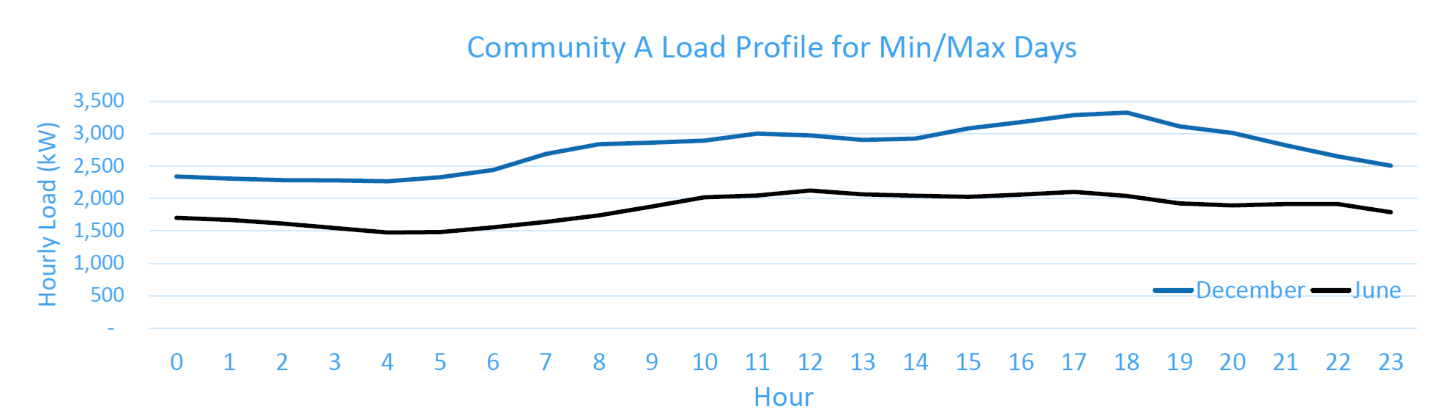
Dr. Lovering's recent work focuses on **microreactors (SMRs <10MWe),** trying to **understand the pathways to commercialization and economic competitiveness.**
To understand their potential, a techno-economic evaluation of microreactors for off-grid and community microgrid applications was first performed. The results indicate that microreactors **can be cheaper and more reliable compared with 100% renewables systems, and they can also be cost-competitive with diesel where fuel costs are greater than $1/liter and the microreactor capital cost is less than $15,000/kW**. However, the levelized cost of electricity (LCOE) for microreactors is most sensitive to the initial capital cost, and whether this technology will ever move beyond niche markets will depend on the learning effects accrued through factory fabrication.
Therefore, the **hypothetical trade-offs between economies of scale and economies of volume for potential factory-fabricated** microreactors are also examined. The breakeven volumes necessary for microreactors to become cost-competitive with large reactors and with fossil fuels, using parameters from historic nuclear builds and analogous energy technologies are calculated. Drawing from the literature on learning rates across energy technologies, potential learning rates for various sized microreactors based on historical relations are predicted.

Meet the Presenter:

Dr. Jessica Lovering is the co-founder of the Good Energy Collective, a new organization working on progressive nuclear policy. She recently completed her PhD in Engineering and Public Policy at Carnegie Mellon University. Her dissertation focused on how commercial nuclear trade affects international security standards and how very small nuclear reactors could be deployed at the community level.

She is a Fellow with the Energy for Growth Hub, looking at how advanced nuclear can be deployed in sub-Saharan Africa. She was formerly the Director of the Energy Program at the Breakthrough Institute, a pioneering research institute changing how people think about energy and the environment. Her work at Breakthrough sought policies to spur innovation in nuclear power technologies to drive down costs and accelerate deployment as part of a solution to climate change and economic development.

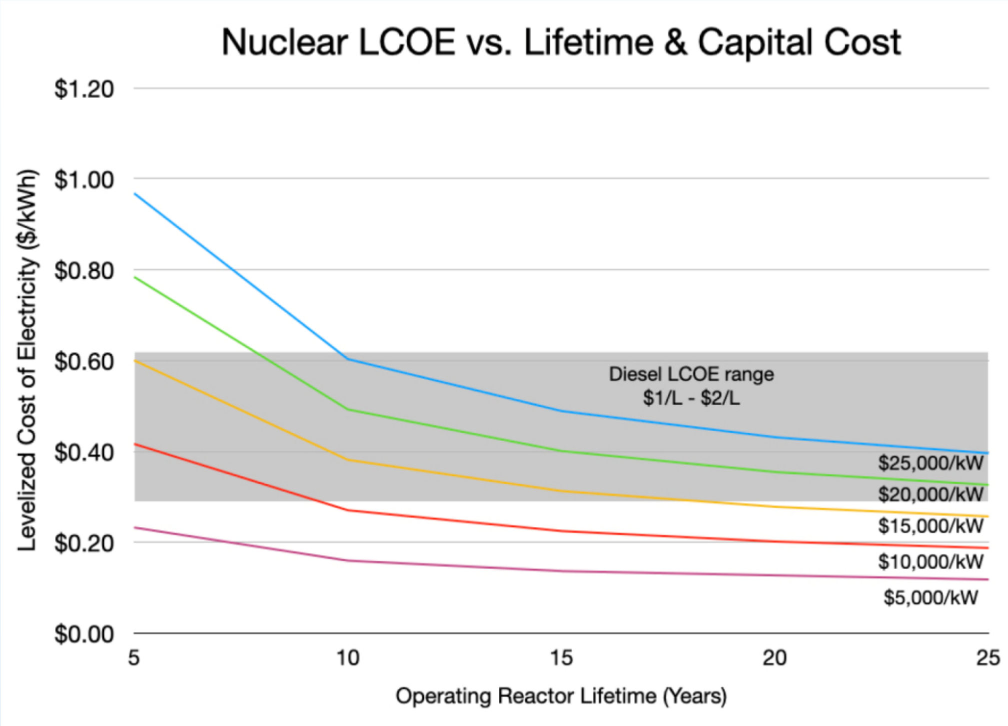
Market research



	Load	Average Load (MW)	Peak Load (MW)	Load factor	Peak Month	Day-to-Day Variance	Timestamp Variance
Comm. A	Elec.	2.41	3.66	0.66	Feb.	3.96%	2.70%
Comm. B	Elec.	1.18	1.77	0.67	Feb.	4.47%	3.65%
Fairbanks Hospital	Elec.	1.49	2.35	0.64	May	13.16%	8.58%
	Therm	1.47	4.47	0.33	Dec.	16.79%	9.19%
UW Madison	Elec.	208	329	0.63	Jul.	7.47%	3.86%
	Therm	107	229	0.47	Jan.	16.13%	6.72%

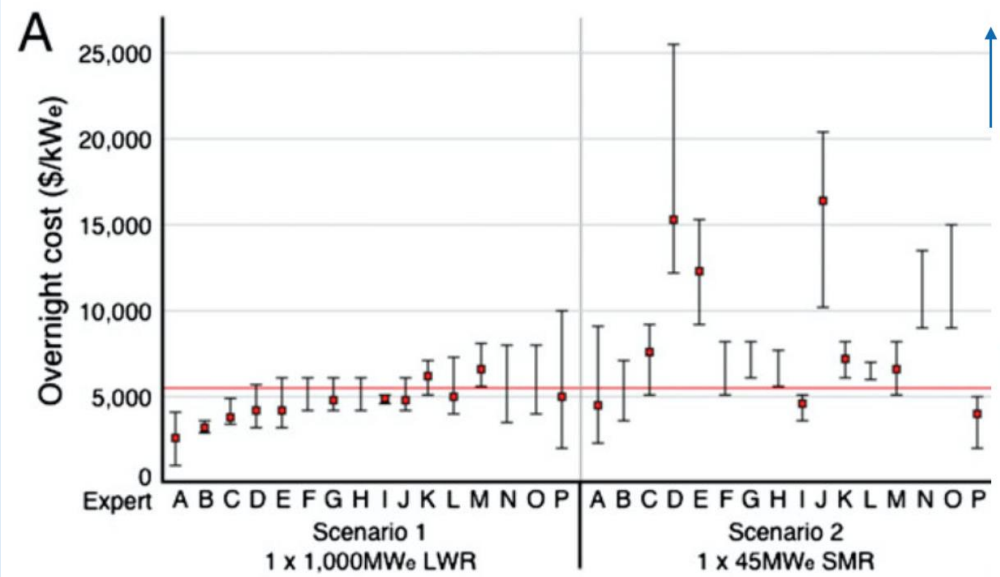
	Lowest Cost	Lowest Cost, Zero-Carbon
Including Nuclear	3MW Nuclear + 3.3MWh Battery LCOE = $0.16/kWh	3MW Nuclear + 3.3MWh Battery LCOE = $0.16/kWh
Excluding Nuclear	4.1MW Diesel + 6MW Wind LCOE = $0.29/kWh	54MW PV + 21MW Wind + 325 MWh Battery LCOE = $1.0/kWh

When community load profile is considered, 3MW nuclear + 3.3 MWh Battery is cheaper than 4.1MW Diesel + 6MW Wind or 54MW PV (Solar) + 21MW Wind + 325 MWh Battery.



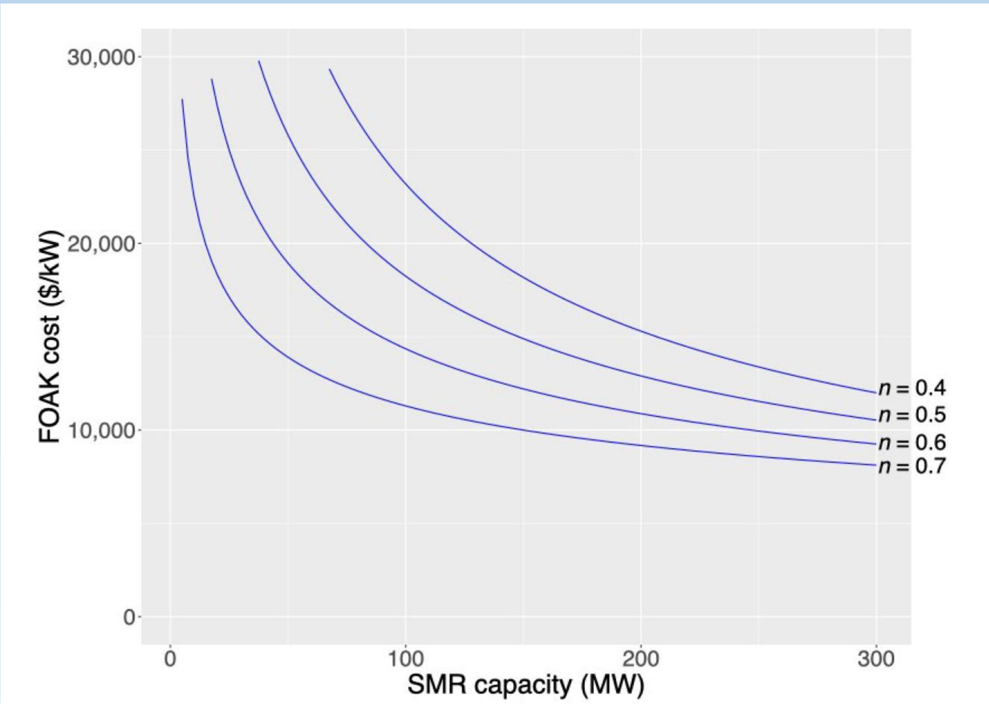
Cost potential exists for Nuclear, even no consensus on cost of future SMRs or microreactors.

Microreactors will be too expensive if traditional scaling relations apply. Need to obtain high Learning Rate (LR).



Froese et al. (2020): $130,000/kW. 3MW
Moore (2016): $35,000/kW. 10MW

Oklo: $6,700/kW. 1.5 MW
NuScale: $4,400/kW. 12x 60MW



$$Cost_{SMR} = Cost_{NPP} \times \left(\frac{SMR\,MW_e}{NPP\,MW_e}\right)^{n-1}$$

The standard scaling relation for a base plant of OCC= $5500/$kW$ and $Capacity$= 1100MW.

microreactors (<10MWe)

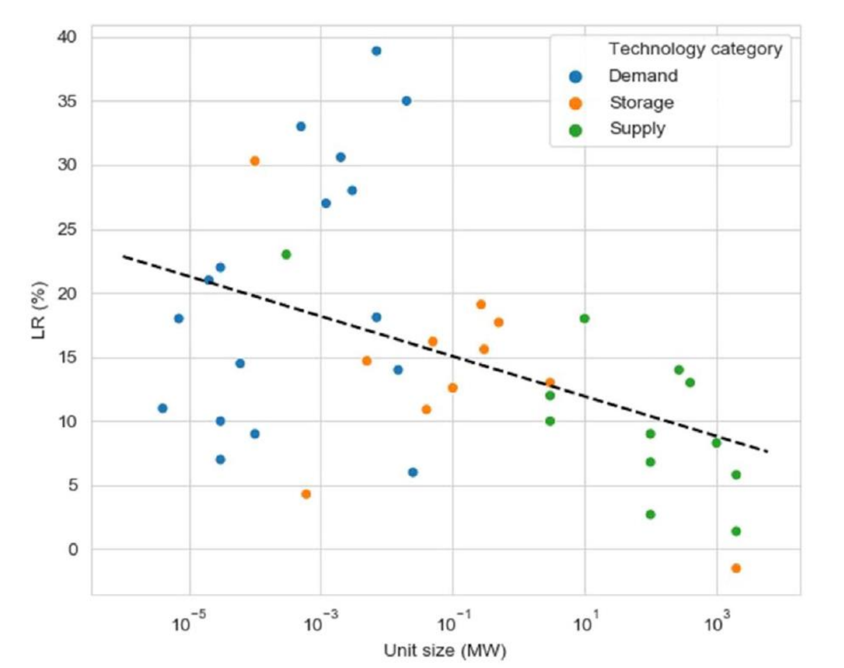
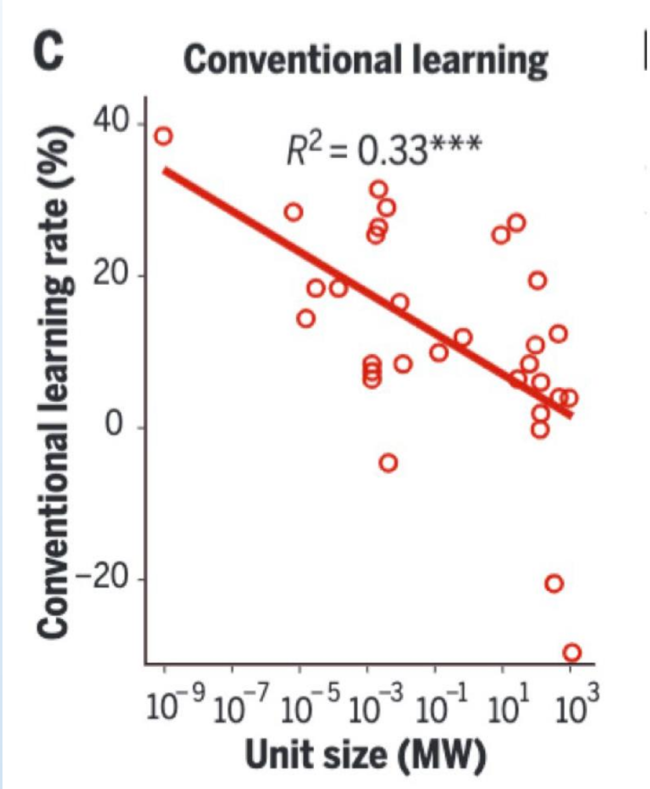
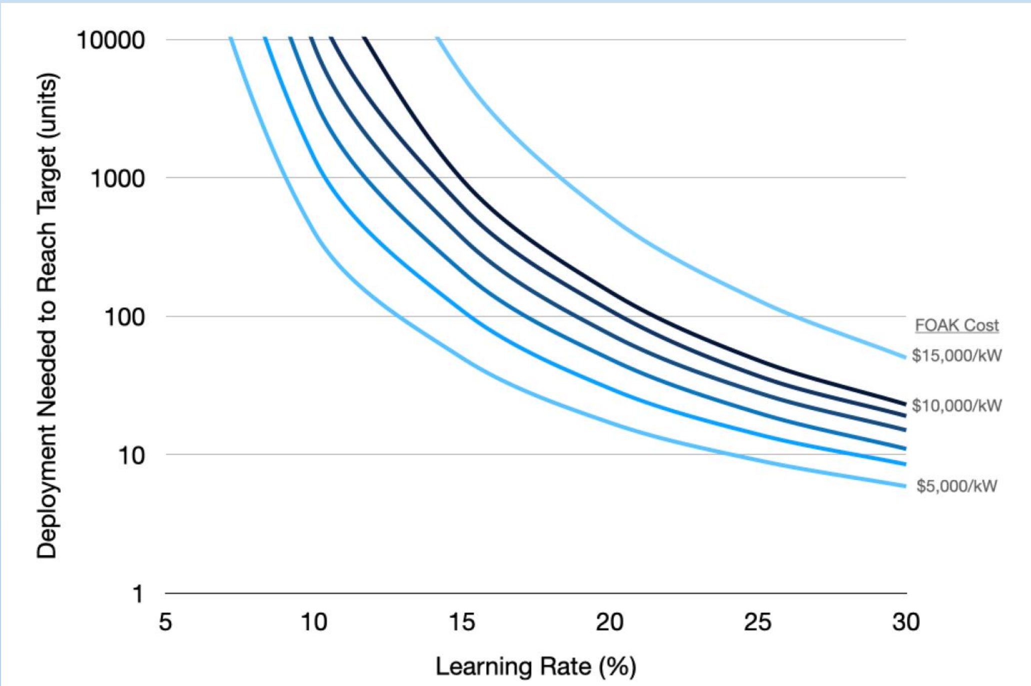


Figure 1. LRs for 41 Energy Technologies
The logarithmic fit shows a negative relation between unit size and observed LR. The logarithmic parameter (a = −0.68, R^2 = 0.22) translates into a 1.5% decrease in LR for each order of magnitude increase in unit size.



Learning Rate may be more dependent on size than on technology category.
High learning rate realizes low target units (Break-even deployment).



- **Microreactors could offer security benefits and an attractive export product for nuclear newcomer countries, if they can be made cost-competitive**
- **Microreactor concepts could be competitive with diesel for off-grid applications.**
- **However, to scale up and be cost-competitive with grid electricity, costs will need to decline significantly.**
- **Such cost declines are possible if economies of scale don't apply to novel designs, and if learning rates are above 20%.**