The Case for Micro Reactors as On-site Generators at Government Installations

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Background

- Commercial nuclear plants are currently large: ~ 1,000 MWe.
  - Capital costs becoming larger than utilities can afford.
  - Overall costs have difficulty competing with gas-fired units.
- DoE has programs to help introduce SMR's: ~ 50-300 MWe
  - Attempting to bring capital costs down by a number of technical advances.
  - Objective is for SMR's to be able to compete with natural gas.
- DOE announced a program to explore the use of micro-reactors. ~1-10MWe
  - Aug. 2018: Congressional request to develop plan for micro-reactors at DoD sites by 2019
  - Jan. 2019: UW began two-year project on case for on-site generators at federal facilities.

Our Study

- To determine whether micro-reactors can satisfy a need for resilient power at U.S. Government sites.
- To determine whether it would be practical to try to site micro-reactors at federal agency installations.
- To make recommendations to Department of Energy:
  - If DOE goes down this path, how might DOE proceed?

Study Goal

Determine if there is a case for federal government to act as guaranteed first consumer of microreactors.

Can Micro-reactors be a way to increase the Resilience of the electric supply at federal agency installations?

Resilient power has certain attributes:

- *Power adequate to supply the critical power load*
- *Availability of fuel supply for extended period (weeks)*
- *Redundancy of power source to protect against single failure*

Study Tasks

Short-term: Assist DoE in developing program plan for micro-reactors at DoD sites.

(Task was completed in early 2019 and Draft report submitted)

Long-term:

1. Estimate size of market for new on-site secure power at federal agency installations.
2. Survey potential vendors of micro-reactors to elucidate their respective technologies.
3. Perform economic analysis: Under what conditions can micro-reactors compete with other technologies to provide on-site power (Diesels are baseline for on-site power)?
4. Regulatory issues: What are licensing options and issues that need to be addressed?
5. Decision whether to go forward: What are the acquisition options for micro-reactors?

How can this program be a bridge to commercial introduction of micro-reactors

Task 1: Estimate the Market

- FEMP provided an extensive range of energy use data.
- UW team surveyed the largest energy users in each civilian agency as well as their specific federal agency facilities (>200 facilities with >4MW energy usage).
- UW received detailed energy use data for selected facilities
- For these larger energy users:
  - All federal installations are connected to the grid;
  - 40-60% of energy is in form of electrical power;
  - Critical loads have many small local backups (buildings).
- Micro-grids will be a natural evolution for facility resilience with larger backups
- We estimate there are over 200 potential sites, assuming that it is reasonable to site at least a single micro-reactor with backup for redundancy.

No Large Federal Facilities are Off-the-Grid

AGENCY	Number of facilities with average power exceeding ...				Comments on Facilities > 5MW (150 billion BTU/yr)
	1 MW	3MW	5MW	5MW (off-grid)	
Homeland Security	34	10	6	0	Coast Guard Bases
Commerce	9	5	3	0	NIST is major on-grid facility
Energy	29	23	19	0	DOE national labs on-grid
Interior	18	4	1	0	HQ in Washington, DC
Justice	79	38	18	0	No official response on any data
Transportation	23	3	2	0	Bldg in Washington, DC
GSA	90	15	8	0	HQ and major city bldgs
Health & Human Services	38	19	14	0	NIH
NASA	12	11	8	0	
NRC	2	0	0	0	HQ in Washington, DC
Social Security Administration	6	2	1	0	HQ in Washington, DC
Treasury	15	7	3	0	Printing in Washington, DC
Agriculture	20	5	2	0	HQ and research center in DC
Labor	9	1	0	0	HQ in Washington, DC
EPA	6	2	1	0	CEnters in RTP/Cincinnati/U. Michigan
FDIC	2	0	0	0	none
HUD	1	0	0	0	none
Archives	3	2	1	0	HQ in College Park, MD
Personnel Management	1	0	0	0	none
Railroad Retirement Board	1	0	0	0	none
Smithsonian	10	7	1	0	HQ in Washington, DC
TVA	9	1	0	0	fossil fuel plants
Corp of Engineers	5	1	1	0	Research center in Vicksburg, MS
Postal Service	94	7	1	0	Facilities in Major Cities
Veterans Administration	164	127	81	0	Hospitals*
	680	**290**	**171**	**0**	

* ARRA funds and to a small extend ESPC and UESC funds used to have on-site renewables and CHP at some facilities

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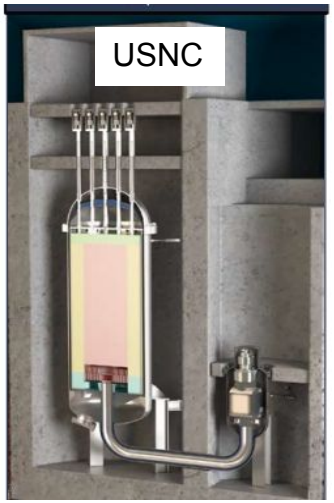
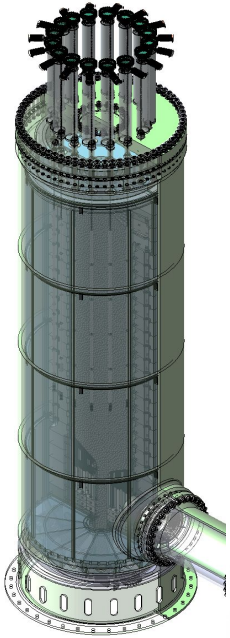
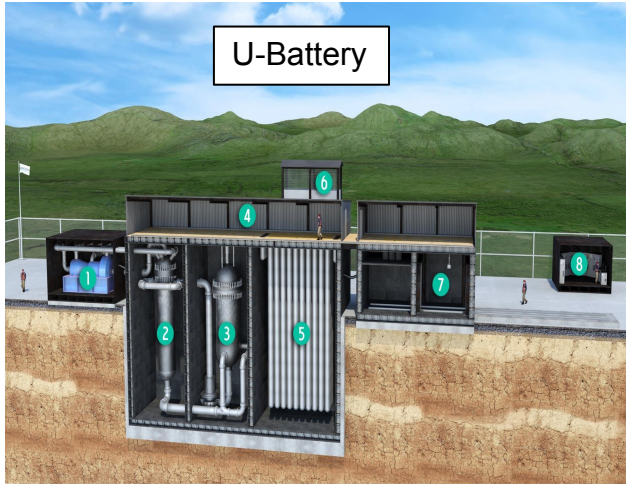
Task 2: Micro-reactor potential vendors

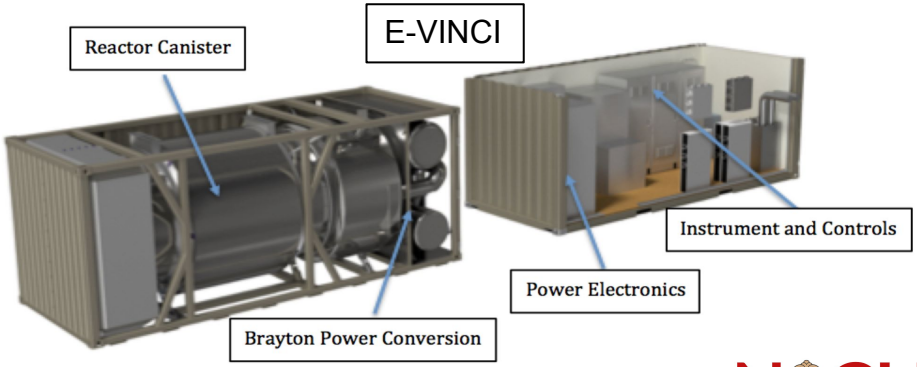
- There is a wide range micro-reactor design concepts available.
- Conceptual technical designs have details to be determined.
- Cost estimates exist only as proprietary data; i.e., FOAK estimates as well as required R&D development costs.
- UW contact with individual vendors did not provide any firm basis for stated cost estimates. A detailed methodology to estimate costs will be necessary to gain confidence in future.

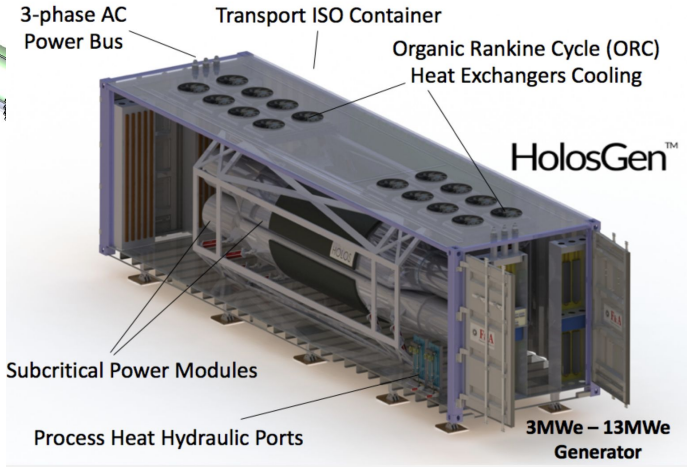
Micro-Rx Systems











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Task 3: Economic Analysis

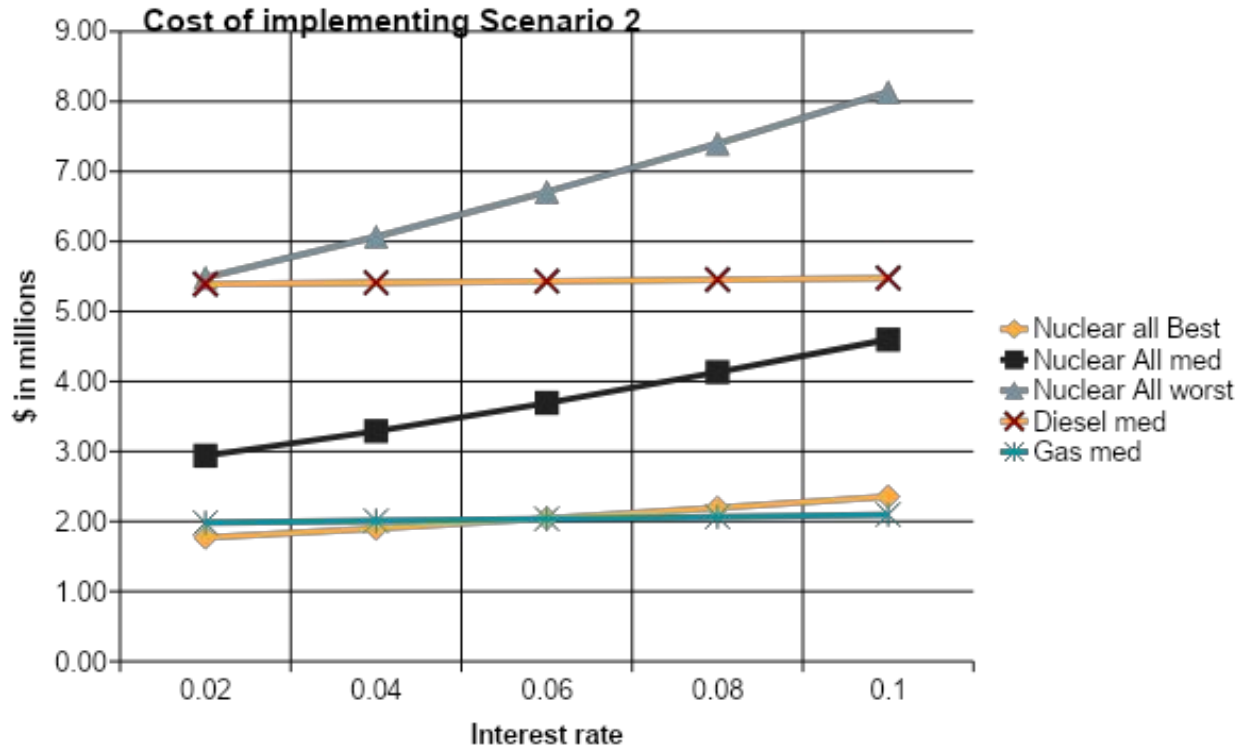
- Developed a set of cases to consider for analysis
  - Status quo
  - On-site generators for critical load with backup
  - On-site generators for whole facility load with backup
- Considered all energy technologies to supply power
  - (Diesel, Natural Gas, Micro-reactor, Renewables + Storage)
- Gathered cost inputs from variety sources (e.g., ATB, EIA)
- Analysis using simple tool and optimization tool (Homer)

Scenarios considered in Economic Analysis

1. Status quo: A utility is primary supplier of power. Backup generators are left in stand-by.
2. Critical power supplied by on-site generators running continuously, with utility supplying remaining power: Utility and on-site generators each serve as backup to the other.
3. Critical power supplied by on-site generators running continuously, with utility supplying remaining power: Enhanced resilience is achieved by on-site secondary back-up.
4. All power supplied on-site, with no power supplied by the utility: This basically takes an installation off-grid. This approach is completely under the control of the installation.

In each case we use a nominal site with 4 MWe required and 2 MWe critical load for the first on-site generator. Total levelized annual costs are used as the metric for comparison.

Effect of Different Micro-Rx Total Costs



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Task 4: Regulatory Issues

- Micro-reactor licensing likely to use NRC regulations
  - 10CFR 50 (CP + OL) or 10CFR 52 (DC + COL) could be used
- NEIMA required new license approach (Part 53) ongoing
  - Provide licensing flexibility: Traditional, Risk-informed, MCA bound
- There are current policy issues under consideration
  - Staffing requirements for operations/monitoring on-site or remote
  - External man-made hazards that need to be considered
  - Physical security requirements for the micro-reactor
  - Siting requirements near population centers
- Prototypes can demonstrate operability and safety

Task 5: Program Development

- Execute an R&D program that can demonstrate technical feasibility as well as reduce capital cost to be competitive
- Micro-reactor demonstrations at DOE lab sites (e.g., NRIC)
- Micro-reactor demonstration options under consideration
  - Single agency ownership (DoE) and manage micro-reactors at sites
  - Commercial ownership with milestones & payments (NASA-COTS)
- Provide credit for low-carbon attributes
- Examine the opportunity for commercial deployment
  - Industrial and community sites with community acceptance

Questions?

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BACKUP SLIDES

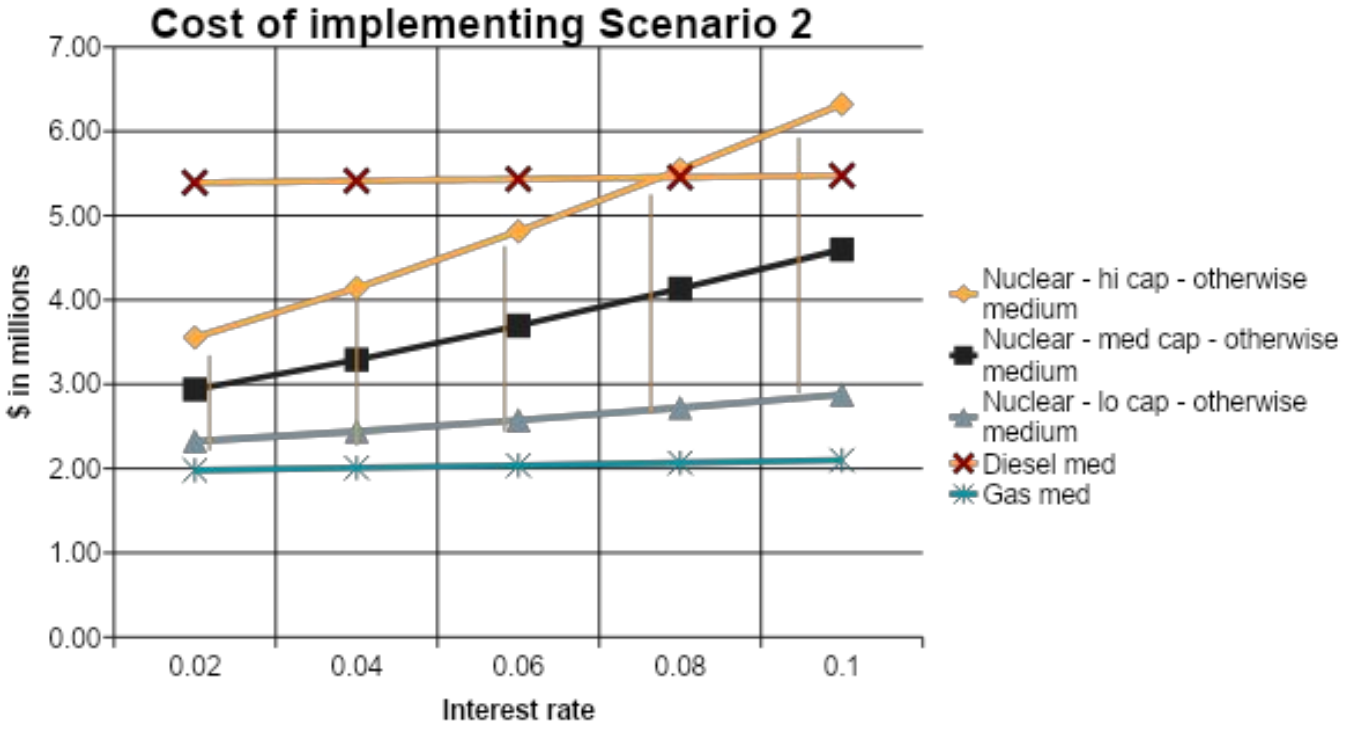
FEMP Task Members and Facility Managers Contacted

AGENCY	Response
DHS - Homeland Security	FEMP information at facility level
DOC - Commerce	Details provided at facility level
DOE - Energy	Data calls for NNSA & Science Labs
DOI - Interior	FEMP information at facility level
DOJ - Justice	No formal response provided
DOT - Transportation	Provided information as requested
EPA - Environ. Protection Agency	FEMP information at facility level
GSA - General Services Admin.	Some details provided at facility level
HHS - Health Human Services	Details provided at facility level
NASA - Space Agency	Details provided at facility level
NRC - Nuclear Reg. Commission	Details provided at facility level
SSA - Social Security Admin.	Provided information as requested
TRSY - Treasury (Bureau Engraving	Details provided at facility level
USDA - Agriculture	Some details provided at facility level
USCAE - Corps of Engineers	FEMP information at facility level
USPS - Postal Service	FEMP information at facility level
VA - Veterans Administration	FEMP information at facility level

Fraction of Energy Consumed in the form of Electricity is about 50% on average

Agency	Facilities		Fraction of Electricity (without transportation)
	Electricity	Facilities Subtotal	
Postal Service	15,213.7	**22,196.1**	**0.685**
Veterans Affairs	11,347.3	**28,361.4**	**0.400**
Energy	15,235.5	**25,893.4**	**0.588**
DHS	2,683.6	**4,595.7**	**0.584**
Justice	4,896.3	**12,184.5**	**0.402**
GSA	7,440.1	**15,329.8**	**0.485**
HHS	2,811.1	**9,714.8**	**0.289**
NASA	4,338.0	**7,705.0**	**0.563**
Interior	1,960.5	**3,778.5**	**0.519**
Agriculture	1,624.5	**3,117.8**	**0.521**
Transportation	3,172.5	**4,249.4**	**0.747**
Commerce	1,726.4	**2,817.6**	**0.613**
USACE	1,086.0	**1,635.9**	**0.664**
Labor	877.8	**1,854.3**	**0.473**
TVA	1,314.3	**1,428.2**	**0.920**
Treasury	897.1	**1,523.7**	**0.589**
Smithsonian	628.6	**1,361.7**	**0.462**
State	263.6	**509.5**	**0.517**
EPA	354.7	**957.5**	**0.370**
SSA	508.6	**745.1**	**0.683**
Archives	215.3	**458.0**	**0.470**
OPM	46.8	**72.2**	**0.648**
HUD	53.4	**88.1**	**0.606**
Education	0.0	**0.0**	
Other*	471.8	**677.7**	**0.696**
Civilian Agencies Subtotal	79,167.7	**151,256.0**	**0.523**
Defense	100,603.0	**202,831.9**	**0.496**
Government Total	179,770.8	**354,087.9**	**0.508**

Effect of Different Micro-Rx Capital Costs



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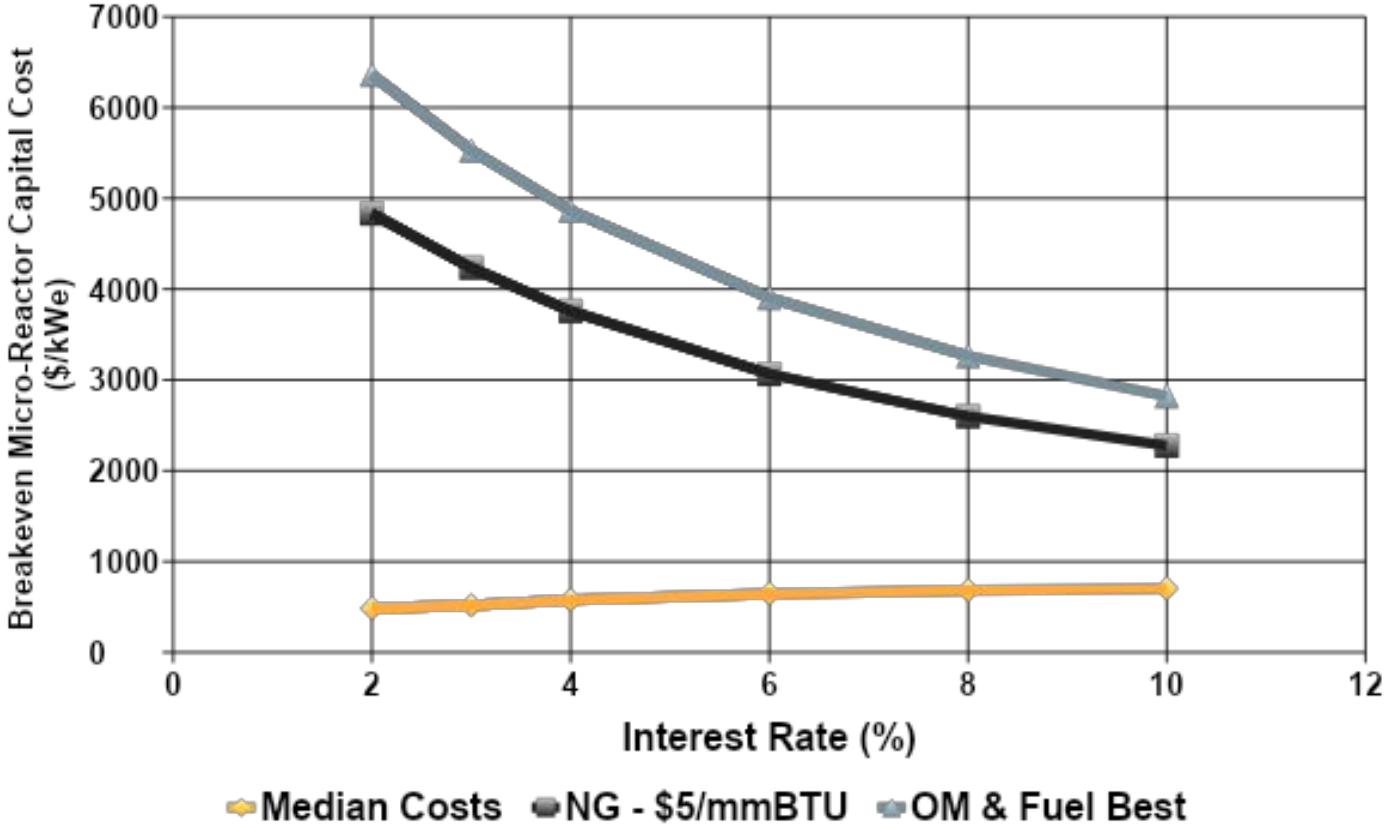
Breakeven Micro-Rx Capital Costs



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