generation mPower

Generation mPower Reactor Design Overview
Redacted

March 21, 2012

generation mPower

2012 mPower™ Reactor Design Overview
Workshop Agenda

Session	Date	Time	Topics
	3/21	1:00-1:15 p.m.	Opening/Introductions
1		1:15-2:15	Plant Overview
2		2:15-3:15	Site Layout & Building Details
		3:15-3:30	BREAK
3		3:30-4:30	Electrical Overview and Selected BOP Systems
		4:30-4:40	CLOSING

generation mPower

2012 mPower™ Reactor Design Overview Workshop Agenda (Cont.)

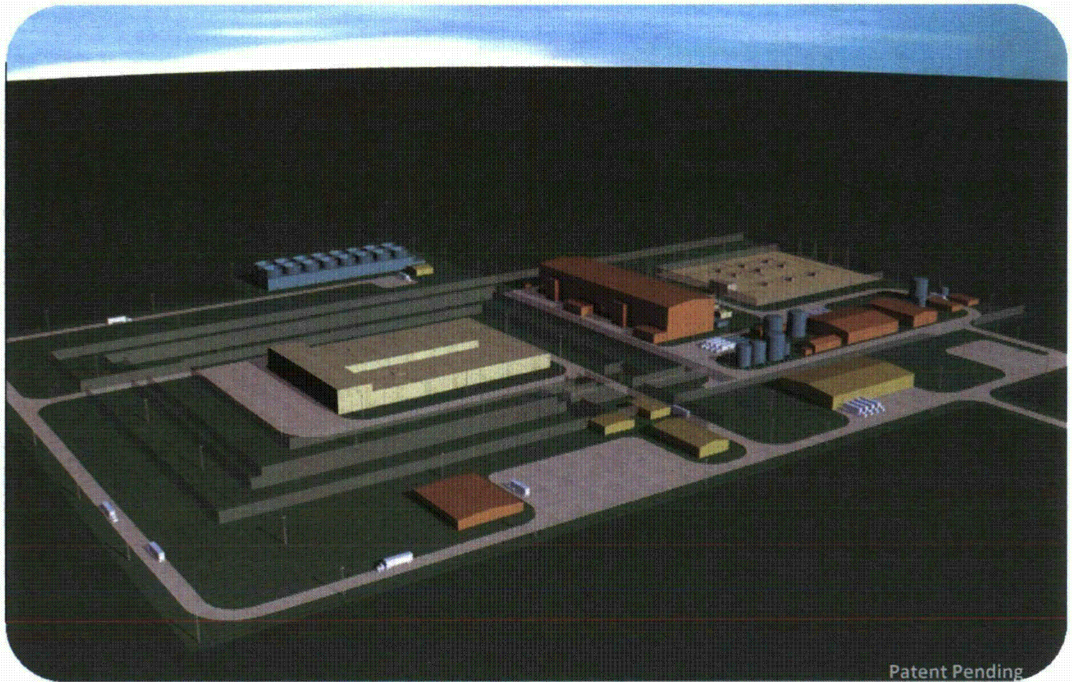
Session	Date	Time	Topics
4	3/22	8:15-9:15 a.m.	Containment & Containment Systems
5		9:15-10:15	Reactor Module (Vessel +)
		10:15-10:30	BREAK
6		10:30-11:30	Nuclear Steam Supply Systems
		11:30-12:30 p.m.	LUNCH
7		12:30-1:30	Fuel and Core Design
8		1:30-2:30	I&C Design & Control Room
		2:30-2:40	BREAK
9		2:40-3:40	Safety Analysis
10		3:40-4:40	Test Programs
		4:40-4:50	Closing

generation mPower

Plant Overview

generation

mPower



Innovative Design

- Integrated nuclear module
- Underground reactor and used fuel
- Water-cooled main condenser
- Passively safe

Breakthrough Performance

- 180 MWe increments with no "size-premium"
- 4-year operating cycle (2x standard)
- 7+ days "Station Blackout" capability

generation mPower

Goal and Value Proposition

Develop and deploy, by 2020, an SMR design that is:

- Proven: GEN III^{+}, established NRC regulation
- Safe: Robust margins, passive safety
- Practical: Standard fuel, construction and O&M
- Benign: underground, small footprint

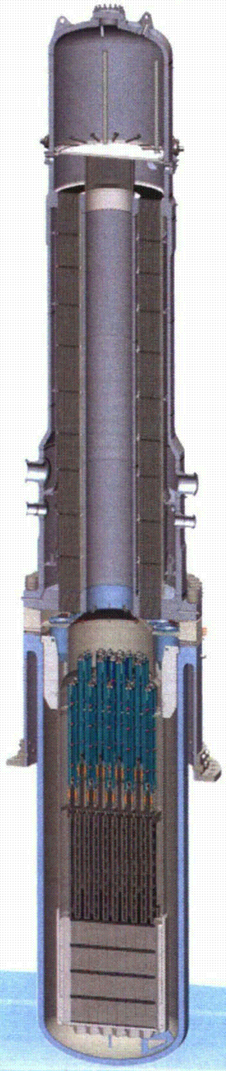
generation
mPower

Unique Approach

- Simplified – Integrated, Pressurized Water Reactor
- Internal control rod drives to minimize vessel penetrations
- Control rods versus boron shim
- [ ] **[CCI per Affidavit 4(a)-(d)]**
- Passive safety
  - No safety-related emergency diesel generators
  - No core uncovery during design basis accident (small break LOCA)
- Performance of critical functions by multiple systems for improved reliability and plant safety
- Multiple unit plants – safety systems not shared

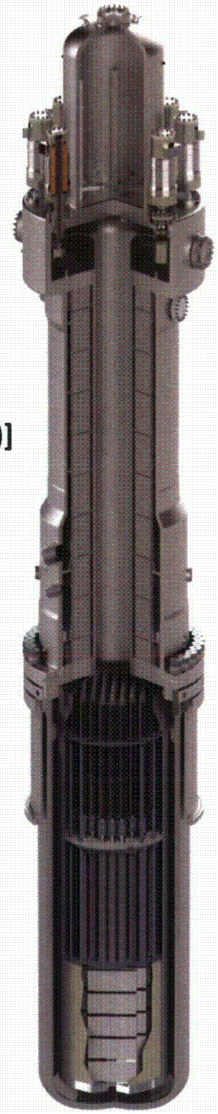
generation
mPower

Recent Design Changes



April 2011

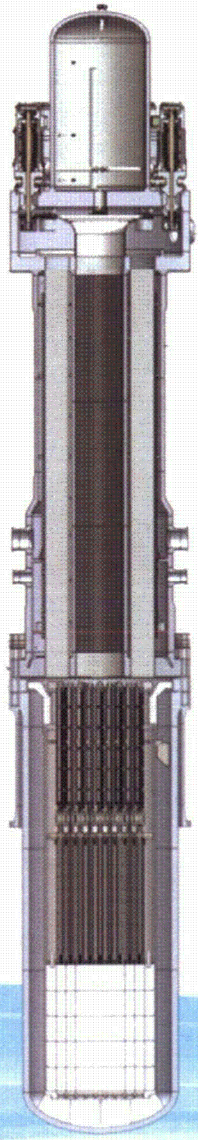
- Core thermal power increased from 425 MWth to 530 MWth
  - ➢Fuel assembly active length[ ] [CCI per Affidavit 4(a)-(d)]
  - ➢Number of CRDMs[ ] [CCI per Affidavit 4(a)-(d)]
  - ➢Steam generator tubes[ ] [CCI per Affidavit 4(a)-(d)]
  - ➢Operating conditions
- [ ] [CCI per Affidavit 4(a)-(d)] internal RCPs at midflange replaced with 8 canned motor RCPs above steam generator
- RCS purification components located inside containment
- Ultimate heat sink tank[ ] [CCI per Affidavit 4(a)-(d)]
- Plant layout modified



March 2012

generation mPower

High-Level Requirements

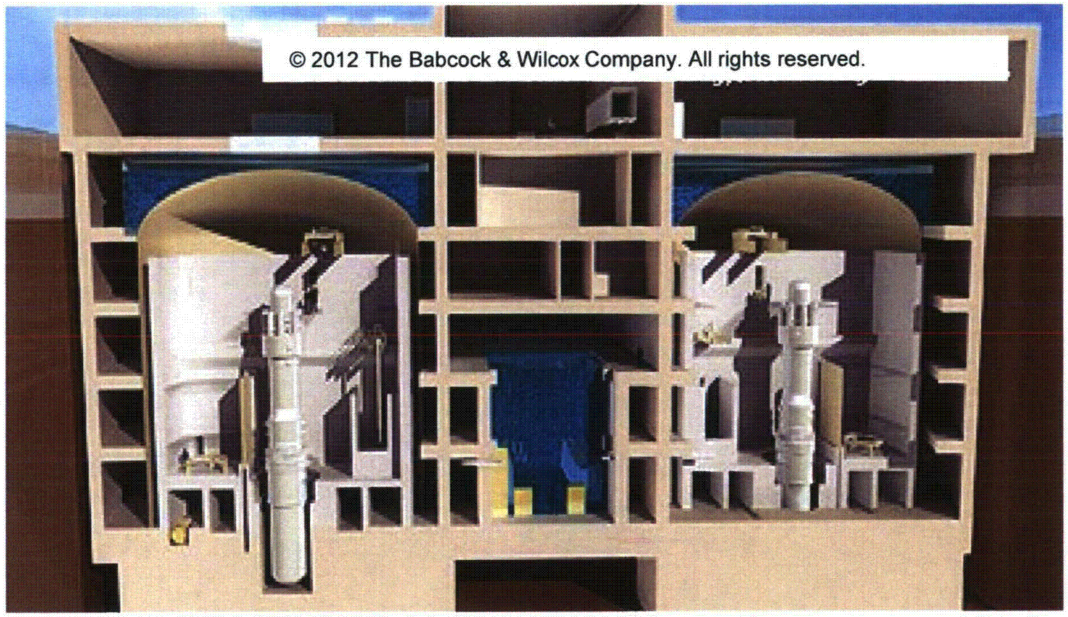


- 180 MWe per unit and 60-year plant life
- NSSS forging diameter allows domestic forgings and rail shipment
- Standard fuel (less than 5% U^{235})
- Long fuel cycle, 4+ year core life
- No soluble boron in primary system for normal reactivity control
- Spent fuel storage on site
- Conventional/off-the-shelf balance of plant systems and components
- Accommodate air-cooled condensers as well as water-cooled condensers
- Flexible grid interface (50 Hz or 60 Hz)
- Digital instrumentation and controls compliant with NRC regulations

generation mPower

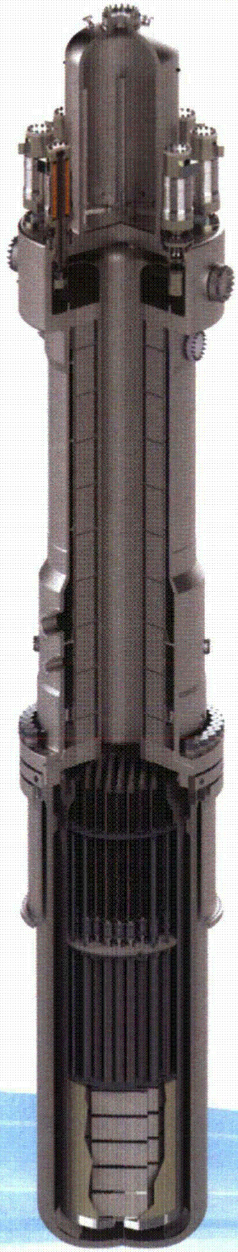
Containment Requirements

- Underground containment and fuel storage buildings
  - Favorable seismic response
  - Missile protection
- Environment suitable for human occupancy during normal operation
- Simultaneous refueling and NSSS equipment inspections
- Leak tight
- Volume sufficient to limit internal pressure for all design basis accidents



generation mPower

Inherent Safety Features



- Low Core Linear Heat Rate
  - Low power density reduces fuel and clad temperatures during accidents
  - Low power density allows lower flow velocities that minimize flow induced vibration effects
- Large Reactor Coolant System Volume
  - Large RCS volume allows more time for safety system response in the event of an accident
  - More coolant is available during a small break LOCA providing continuous cooling to protect the core
- Small Penetrations at High Elevation
  - High penetration locations increase the amount of coolant left in the vessel after a small break LOCA
  - Small penetrations reduce rate of energy release to containment resulting in lower containment pressures

generation

mPower

Key Features of the Integral RCS

Feature	B&W 177	Typical Gen 3 PWR	B&W mPower
Rated Core power (MW_{th})	2568	3415	530
Core average linear heat rate (kW_t/m)	18.7	18.7	[
Average flow velocity through the core (m/s)	4.8	4.8	
RCS volume (m^3)	325	272	
RCS volume to power ratio (m^3/MW_t)	0.14	0.08	
Maximum LOCA area (m^2) *	1.3	1.0	
RCS volume/LOCA area ratio (m^3 /m^2)	250	270	]

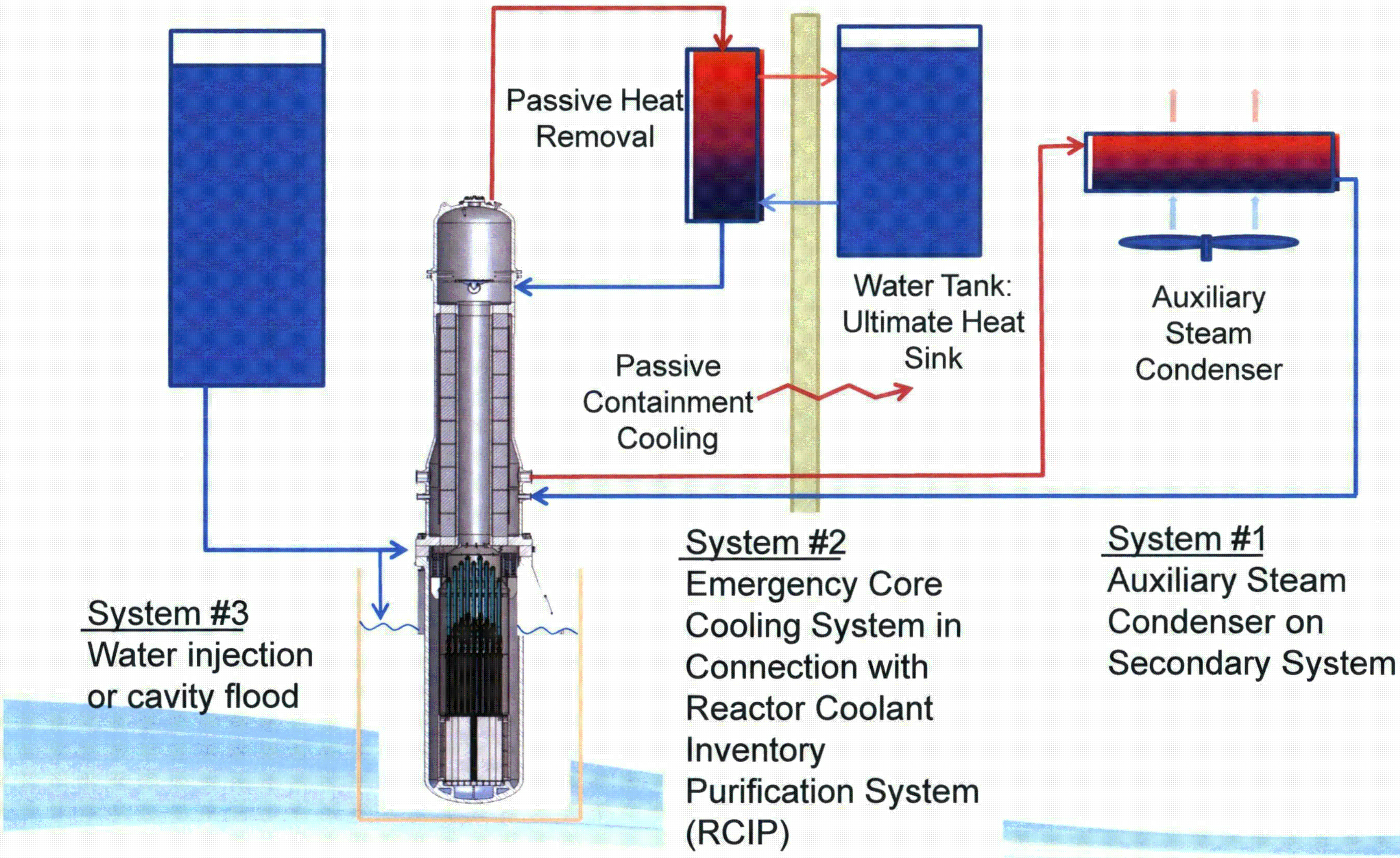
[CCI per Affidavit 4(a)-(d)]

RCS volume and small break sizes allow simplification of RCS safety systems

* Assumes double ended break

generation mPower

Robust Defense-in-Depth Strategy



generation mPower

Probabilistic Risk Assessment

- Internal Events Initiators – Due to the design simplicity, several PWR typical initiators have been eliminated:
  - RCP seal LOCA
  - Rod ejection
  - Startup of inactive loop (reactor coolant pump)
- The target at power internal events CDF is [ ]

[CCI per Affidavit 4(a)-(d)]

- PRA risk insights guiding design to maximize reliability
  - RCP cooling arrangement
  - Feedwater arrangement
  - ECCS condenser arrangement
  - Condensate polisher arrangement
  - Auxiliary steam to feedwater heater arrangement
  - Auxiliary power arrangement

generation mPower

Instrumentation and Controls

[

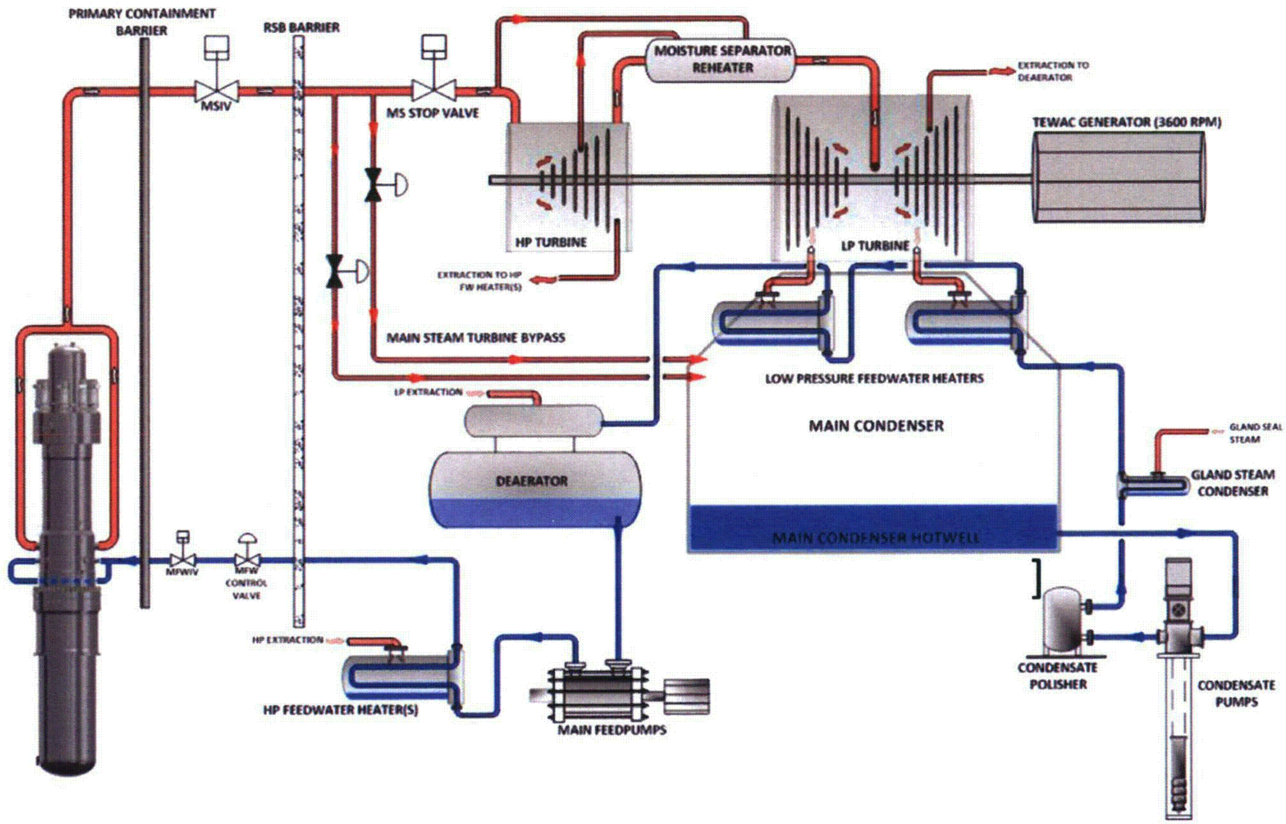
]

 [CCI per Affidavit 4(a)-(d)]

generation mPower

Balance of Plant Design

- Plant designed to produce 180 MWe
  - Water-cooled condenser
  - Air-cooled condenser
- Conventional steam cycle equipment (small, easy to maintain and replace)
- BOP operation not credited for design basis accidents



generation
mPower

Protection against "Fukushima-type" Events

Events and Threats	B&W mPower Design Features
Earthquakes And Floods	• **Seismic attenuation**: Deeply embedded reactor building dissipates energy, limits motion • **"Water-tight"** : Separated, waterproof reactor compartments address unexpected events
Loss of Offsite Power	• **Passively safe**: AC power, offsite or onsite, not required for design basis safety functions • **Defense-in-depth**: 2 back-up 2.50MWe diesel generators for grid-independent AC power
Station Blackout	• **3-day batteries**: Safety-related DC power supports all accident mitigation for 72 hours • **APU back-up capability**: Auxiliary Power Unit recharge battery system • **Long-duration "station keeping"**: Space allocated for 7+ day battery supply for plant monitoring/control
Emergency Core Cooling	• **Gravity, not pumps**: Natural circulation decay heat removal; water source in containment • **Robust margins**: Core heat rate (13.1 kW/m) and small core (530MWth) limit energy • **Slow accidents**: Maximum break small compared to reactor inventory (8900 m^3/m^2)
Containment Integrity and Ultimate Heat Sink	• **Passive hydrogen recombiners**: Prevention of explosions without need for power supply • **Internal cooling source**: Ultimate heat sink inside underground shielded reactor building • **Extended performance window**: Up to 14 days without need for external intervention
Spent Fuel Pool Integrity and Cooling	• **Protected structure**: Underground, inside reactor service building, located on basemat • **Large heat sink**: 30 days before boiling and uncovering of fuel with 20 years of spent fuel

Multi-layer defense … mitigates extreme beyond-design basis challenges

generation mPower

Actions Re Fukushima Lessons Learned

- Monitoring regulatory and industry actions with regard to lessons learned

- Following industry actions by informing design with FLEX, the applicable content of the recent Fukushima Orders and intent of the 50.54(f) RFI letter regarding NTTF Recommendations 2.1, 2.3 and 9.3 to determine:
    - What other features and responses need to be evaluated
    - What design changes may be needed for the DCA

- Addressing the design features for beyond design basis events as per the guidance in the pending SRP Section 19.4 (LOLA)

generation mPower

Summary of Unique Design Features

- Integral NSSS with No Large Primary System Penetrations
  - Internal steam generator and pressurizer, with conventional core design
  - Innovative reactor coolant pumps and internal control rod drive mechanisms
- Simplified Reactor Operations
  - 4+ year fuel cycle with complete core replacement
  - No soluble boron system for reactivity control
- Improved Reliability and Plant Safety
  - Performance of critical functions by multiple systems (e.g., decay heat removal via steam generator, RCIPS, ECCS); defense-in-depth
  - Use of a passive safety system with large coolant inventory
  - No core uncovery during design basis accident (small break LOCA)
  - Use of PRA risk insights throughout the design process