Presentation to the Canadian Nuclear Society
Saskatoon
Agenda

1. Introductions
2. Generation mPower structure
3. Technical overview
   • mPower Plant layout
   • Nuclear Island overview
   • mPower reactor module
4. Post-Fukushima design robustness
5. Design and licensing maturity
6. Economic competitiveness
7. mPower value proposition
Generation mPower LLC

Formal alliance between B&W and Bechtel
- Joint Venture agreement executed July 14, 2010
- Substantial investment commitments by B&W and Bechtel

Recognized and established energy industry leaders
- B&W:
  - 60+ years of nuclear engineering and manufacturing experience
  - Exclusive B&W mPower™ reactor technology
- Bechtel Power:
  - 60+ years of nuclear power industry experience
  - Integrated engineering and project management leadership

Alliance objectives:
- Design, license and deploy first commercially viable Gen III++ SMR
- Improve cost and schedule certainty, with reasonable investment
- Increase accessibility to nuclear power across global energy industry

www.generationmpower.com

A “game changer” for the global energy industry
Current Market Landscape

Fundamental Issues:
- Energy Independence
- Long-Term Load Growth
- Environmental Concerns
- CO$_2$ Constraints
- Diversity of Fuels
- Gas Price Volatility

One size does not fit all…

Traditional large reactors
- 1000-1600 MWe

Small, GEN IV reactors
- 10-50 MWe
B&W mPower™ Integral Reactor

From This To This

Traditional 2 Loop PWR NSSS
Goal and Value Proposition

Develop and deploy, by 2020, an SMR that offers:

- Lower capital cost
- Schedule and cost certainty
- Competitive LCOE pricing

within the constraints of:

- **Proven**: GEN III+, established nuclear regulation
- **Safe**: Robust margins, passive safety
- **Practical**: Standard fuel, construction and O&M
- **Benign**: below grade, small footprint, public acceptance
“Twin Pack” mPower Plant Site Layout

- 2 x 180MWe* units
- Compact <40-acre site footprint*
- Low profile, separated NI and TI
- All safety-related SSCs below grade
- One-to-one reactor to T/G alignment
- Enhanced security posture
- Optimized for minimum staff and O&M
- Water- or air-cooled condenser option
- Conventional steam cycle components
- “Island Mode” operation
- 3-year construction schedule

*with water-cooled condenser

Security-informed plant design contains O&M costs
Nuclear Island Features

**Fully underground**
- Protected from external threats
- Enables security-informed architecture
- More efficient seismic design
- Steel containment, with space for O&M activity

**“Passive safety” design**
- No safety-related emergency AC power
- 72-hour safety-related control/monitoring battery
- No shared active safety systems between units
- 14-day “coping time” under station blackout
- No containment sprays, sumps, or recirculation
- Multi-layered defense-in-depth for ~10⁻⁸ CDF

**Enhanced spent fuel pool configuration**
- Underground, inside reactor building
- Large heat sink with 30-day “coping time”

“Simple and robust” architecture lowers cost and risk, enhances licensing
B&W mPower™ Reactor

Integral 530 MWt NSSS module
- Core, CRDMs, SG, Pressurizer and Coolant Pumps
- No penetrations below top of core
- 50 degree superheat in Secondary Loop
- 60 year design life, rail shippable

Passively safe design philosophy
- Core remains covered during all DBAs
- No active ECCS or safety-related AC power

4-Year fuel cycle with “standard” PWR fuel
- 69 fuel assemblies with <5% $^{235}$U enrichment
- ~Burnable poisons, no chemical boron shim in coolant

Modular ALWR with best of Generation III+ features … low risk, low cost and passively safe
Process Development / Planning

GmP is positioned for unprecedented coordination between:

- sub-tier component suppliers
- fabrication plants
- field construction

Maximizing the benefits of modularity

Utilize full corporate know how and experience in design and construction

- System Design in US
- Component Design in US and Canada

Outstanding execution of SMR modularity will be the technology “advantage” that leverages the North American nuclear industry into a leading role internationally
## 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**: Auxiliary Power Units inside reactor building 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 (11.5kW/m) and small core (500MWth) limit energy
- **Slow accidents**: Maximum break small compared to reactor inventory (4.7x10-5m²/m³)

### 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

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**Multi-layer defense ... mitigates extreme beyond-design basis challenges**
Design and Licensing Status

- Full-scale development ongoing since 2009 with substantial $$ invested
- NSSS is 50% design complete with robust core and safety margins
- Plant and Nuclear Island architecture defined, seismic analysis underway
- New, full-fidelity Integrated Systems Test (IST) facility operational
- Control room engineering simulator under construction

- Critical components status:
  - Steam Generator – detailed design based on proven B&W OTSG technology
  - CRDM – operational “in vessel” prototype built, separate effects testing underway
  - RCP – conceptual design complete for canned-motor solution, vendor engaged
  - Fuel – full-scale dummy fuel assembly fabricated, CHF testing 50% complete

- NRC and CNSC engaged on pre-application activities
  - 17 Licensing Topical Reports and Papers submitted to date
  - Regulatory Framework Documents for Clinch River completed and reviewed with NRC
  - Phase 1 Pre-licensing review under way with CNSC

On-target for Design Certification Application in 4Q13 ... No changes to NRC regulations needed
Testing Program

Component Prototyping
• Reactor Coolant Pump
• Control Rod Drive Mechanisms
• Fuel Mechanical Testing
• CRDM/Fuel Integrated Test
• Fuel Critical Heat Flux
• Emergency Condenser

Integrated Systems Testing
• Heat Transfer Phenomena
• Steam Generator Performance
• LOCA Response
• Pressurizer Performance
• Reactor Control

Dedicated mPower facility ... backbone of $100M testing program
Licensing Strategy - USA

Lead Plant (TVA Clinch River): 10CFR50
- First U.S. site-specific SMR license application
- 10CFR50 license approach lowers FOAK risk
  - Targeting late 2013 CPA submittal by TVA
  - Enables design changes in construction
- CP is opportunity to identify NRC issues early
- Manage regulatory risk with early engagement

Subsequent Plants: 10CFR52 with DC/COLA
- Gain DCD efficiency by leveraging PSAR work
- Submit DCA during 4Q13
- Target Design Certification by NRC in 2017
- Resolve all known FOAK issues before filing DCA
  - 24 topical & technical reports planned pre-DCA
  - Continue aggressive pre-DCA NRC engagement

Milestones:
- Design / Testing & DCD Preparation
- Prepare CPA
- Prepare OL / FSAR
- Submit DCA
- DC Issued
- NRC Review
- Hearing
- CPA
- CP
- OL
# Licensing Strategy - Canada

## Prelicensing
- Vendor Design Review (VDR) Phase 1
- VDR Phase 2 (If needed)
- VDR Phase 3 (If needed)

## Site Selection and Public Consultation
- Site Evaluation Activities (Bore holes etc)
- GmP Canada Establishment & Contract Negotiation

## Environmental Impact Assessment (EIA) Preparation
- EIA Review
- Site Preparation

## Construction Permit Application (CPA) Prepartion
- CPA Review
- Unit Construction

## Operating Permit Application (OPA) Preparation
- OPA Review
- Fuel Load and Final Commissioning

## Commercial Operation

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- Critical Path Activity
- GmP Controlled Activity
- CNSC Controlled Activity
- Utility Controlled Activity
Achieving Competitive Levelized Cost of Electricity (LCOE)

Minimize Overnight Cost
- Optimum power output (180 MWe)
- Simple standard plant layout and design
- Competitive global supply chain
- Innovative modularization
- Short construction schedule (3 years)
- Competitive Overnight costs for 360 MWe greenfield plant

Optimize Operating Costs
- “Plug and Play” design levers existing infrastructure
- 80%* reduction in security staff with normal DBTs
- 3 licensed operators/shift for “two-pack”
- Fleet O&M support enabled by standardization
- DCWG approach with IAC for utility-centric design

**Competitive LCOE range: $82-97/MWh**

*Key Assumptions:*
- Fuel range = $4.00 - $10.0/MMBtu (NG); $3.50-4.500/MMBtu (Coal)
- CO₂ price range = $0 - $30/ton
- Capacity factor = 92% (Large Nuclear); 95% (SMR); 60-90% (Coal)
- CCGT: 50-70% (FL); 30-60% (NC)
- CAPEX range = $4600 - $6000/kW (Large Nuclear)
mPower Value Proposition

• **Near-term (2020) regulatory response option**
  - Addresses tightening environmental constraints (CSAPR, MACT)
  - Hedges against mid-term GHG “carbon tax” uncertainty

• **Portfolio “balancing” opposite natural gas build-out**
  - Environmentally clean, stable fuel cost, dispatchable generation

• **Competitive “utility scale” power plant economics**
  - $5000/kW ONC equivalent or better than GW-class options
  - Competitive LUEC from low security and plant staffing

• **Reasonable (<$1.8B) investment and project risk**
  - Incremental investment for incremental generation (360 MWe)
  - ~70% factory and off-site construction supporting 3-year schedule

• **Low-risk technology and infrastructure for ~2020 COD**
  - NSSS 50% complete, DCA pre-application licensing underway
  - Existing North American reactor manufacturing capability