SASOR Canada Ltd

Tetra Tech Inc.

4S reactor applications -
Economic case studies

May 2009
Agenda

- Roles of Tetra Tech and SASOR Canada

- Why the 4S Reactor and not others
  - Size
  - Production and Cost
  - Environmental benefits

- Provide Business Plans for Deployment
  - Cost comparisons
  - Time Phased Milestones
  - What SASOR Canada seeks from an oil sands producer

- Discussion
Tetra Tech Inc

- $2 billion (US) licensing, engineering and construction provider with 10,000 employees
- Has business interest in support of small and large nuclear power
- Staff very familiar with all types of small, advanced and large reactor technologies
- Tetra Tech - Wardrop Engineering
- Offices in Canada and in the US
SASOR Canada

- Formed by group of experts in energy markets, Canadian natural resource extraction, nuclear power and business development in 2004
- Foresaw the business interest in nuclear power for cost reasons, social interest for GHG reduction and economic and environmental reasons
- Offices in Calgary and in the US
- Funded for development, siting and licensing a small reactor in oil sands service
- SASOR Canada will BOO (build, own, operate) under contract and sell “over the fence” energy assets to oil sands producer
4S Reactor

- 50 MWe -135 MWth LMR (sodium moderated and cooled)
- Modular construction
- 15-30 year core – No refueling
- No used fuel on site
- Passive safety systems
- Low pressure reactor system
- In US NRC pre licensing process
- Expeditious manufacturing and deployment
- High reliability
- Proliferation resistant
- Included in DOE GNEP proposals
Deployment Readiness

Deployment Potential of Innovative SMRs

- **2030**
  - Fast Reactors (Na; Pb; Pb-Bi):
    - RBEC-M
    - BREST-300
    - KALIMER
  - VHTR: AHTR
  - LWRs with TRISO Fuel:
    - AFPR
    - VKR-MT
    - PFPWR 50
  - Longer-term Na & Pb/Pb-Bi Cooled:
    - STAR-LM
    - LSPR
    - ENHS
    - SSTAR
    - BN GT-300

- **2020**
  - Integral Design
    - PWRs:
      - SCOR
      - SMART
      - IRIS
      - CAREM
  - Advanced LWRs, PHWRs:
    - IMR
    - AHWR
    - CCR
  - HTGRs:
    - GTHTR300
    - GT-MHR
    - HTR-PM
    - PBMR
  - Nearer-term Na Cooled Reactors:
    - 4S
  - Submarine Derivatives:
    - SVBR-10
    - SVBR-75/100

- **2010**
  - Conventional Refuelling Schemes
  - Small Reactors without On-site Refuelling
Advantages of the 4S Design

- **Simple design- factory constructible**
  - Easy to construct – Atmospheric operating pressures
  - Small modules – Easy to transport
  - Based on proven design and historic operations

- **Small components**
  - Easy to fabricate
  - Many sources in supply chain

- **Technical licensing documents being completed**
  - USNRC licensing process ongoing
  - Inherent safety proven by testing
  - Small reactor with 15-30 year core and refueling cycle
  - Japanese interests have spent over $300 Million over 20-years on 4S development
Oil Sands Applications

- Steam distribution limited to 10-15 km
- Dedicated steam distribution for 4S over approximately 300-700 square km if located at the center of the production area
- If formation becomes depleted 4S reactor can be remissioned to serve other needs including hydrogen production, water treatment, upgrading, chemical production, etc.
- 15 years before refueling
- The 4S is air cooled
- Air and water emissions virtually nil
4S in oil sands production

- 270 MW thermal
- 2x 135MW 4S facility
  - Configured for surface and SAGD
- Steam Cost:
  - Significant discount off avoided cost or fixed price steam purchase agreement
- Steam cycle will be tailored to specific applications during Feasibility Study
4S in oil sands production

- 4S will be deployed in 2 reactor unit configuration
  - Capable of 40,000 bbl/day in SAGD
  - 270 MWth for surface and upgrading applications
- 4S units are base load steam production capability
  - Supplemented by fossil fuel steam production

![Diagram showing steam load and 4S nuclear baseload with fossil steam generation](image-url)
Deployment Strategy

- **Developers Risk**
  - Takes several years and large expenditure to develop and license a new reactor design and start generating a revenue stream

- **Risk Mitigation**
  - Time phased costs to achieve these milestones
  - Exit ramps at each milestone
  - As milestones are achieved, oil sands customer commitment deepens

- **Oil sands operator risk** – limited so that only if successful and other means (i.e., CCS) are less expensive

- **Oil sands operator benefits** – energy supply diversity, no GHG emissions
Approximate Breakdown Cost per MMBTU

Total $/ MMBTU

- Toshiba 4S Nuclear Reactor
- Natural Gas
- Diesel

Resource Used

- Capital
- O&M
- Fuel
Cost over Time with 2% inflation and 4% yearly fuel cost increase

- 4S
- Natural Gas
- Diesel

Years

$0.00 $10.00 $20.00 $30.00 $40.00 $50.00 $60.00 $70.00

Total $ / BTU
Program Schedule

- Design Certification Preparation (50 MWe)
- CSNC DC discussions
- Additional reactor deployments
- Oil sands Pre-Application Studies
- CSNS License Preparation
- CSNC and other agency review
- Environmental Report and Site Design
- Construction
- Facility Startup operations

Path Forward

- Identification of a specific site and operations of interest
- Mutual Nondisclosure Agreement
- Joint Phase I Initial Feasibility Study of 4S application to Company facilities
- Memorandum of Understanding
- Phase II Final Feasibility Study
- Letter of Intent
- Submittal of licensing application to the CNSC and other federal and provincial entities
Thank you for your time and interest

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