

FUSION ENERGY

A Compelling Opportunity for Alberta

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Alberta/Canada Fusion Energy Program

Presentation to EEDC – November 2009

Our Objectives Today

- **Further your understanding of fusion energy**
- **Highlight fusion implications for economic development**
- **Ask for your engagement – Fusion Committee presence**
- **Ask for your support – as advocate and \$ sponsor of Alberta/Canada Fusion Energy Program**

Fusion Energy - Nature's Choice

Imagine

- An energy source – universal, abundant, clean
- Proof-of-principle laser experiments within 2 years
- Test demonstration of power production in 20 years
- Alberta a leader in clean fusion energy development & global supplier of fusion technology

Fusion – “star” energy



Energy Demand/Supply Challenge

To obtain energy equal to current oil used ANNUALLY (1 Unit):

- **If obtained from - requires**
 - **coal: 2 power plants/wk (for 50 years)**
 - **nuclear (fission): 1 power plant/wk (")**
 - **solar (thermal): 3 power plants/wk (")**
 - **solar (PV): 250,000 rooftop installs/day (")**
 - **wind: 1,200 turbines/wk (")**
 - **biodiesel: 85 times annual world soybean production (")**
 - **oilsands: 1.5 million barrels/day (")**
- **Conclusion - we need all future clean energy sources (cumulative energy demand to 2050: ~270 Unit)**

Energy/Environment Challenge

Electricity, Greenhouse Gases (GHG) & Climate Change

- Demand for clean electrical power generation: (>40TW by 2100)
- Climate Change Limits: CO₂ and other GHG limits
- Carbon Fuel Limits: projections of peak coal by ~2025
- World needs all “clean” energy alternatives to meet future demand:
limited options & long lead-times (20+ years)
- **Non-Carbon solutions (only 3):**
 - fission (sustainable only with fuel breeding)
 - fusion (sustainable, primary energy source, electricity/hydrogen)
 - renewables (sustainable, secondary energy source)

Fuel/Waste Processing Challenge

Daily fuel consumption & waste production for 1GWe

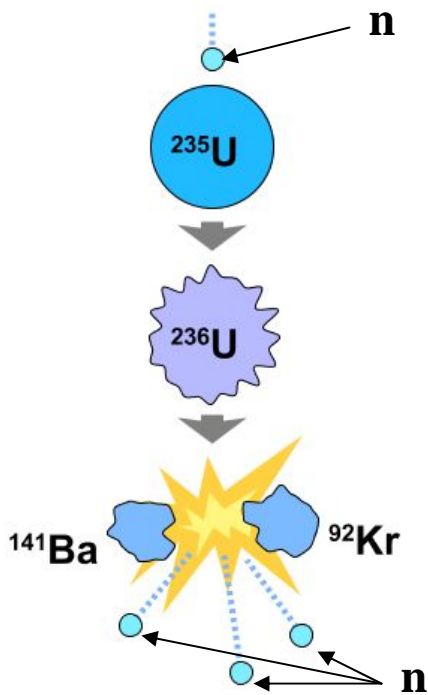
	<u>Coal plant</u>	<u>Fission plant (U)</u>	<u>Fusion plant (D,T)</u>
Fuel	~ 10,000T	~77kg	~ 0.27kg D ~ 0.82kg Li ⁶ (0.41kg T)
Waste	~ 30,000T CO ₂ ~ 600T SO ₂ ~ 40T NO _x ~ 600T fly ash	~77kg	~ 1.09kg He (“ash”) (advantage fusion)

Hopper filled with coal – 10-20 min fuel
Filled with fusion targets – 7 years fuel



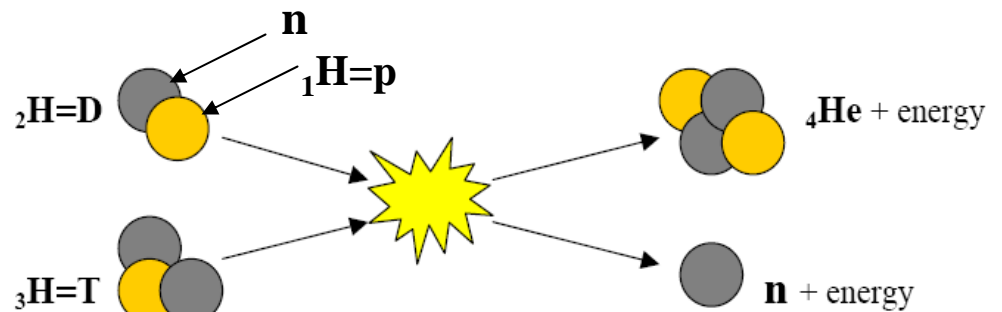
Fusion Differs From Fission

Fission of heavy elements



Energy + radioactive daughter nuclei

Fusion of light elements

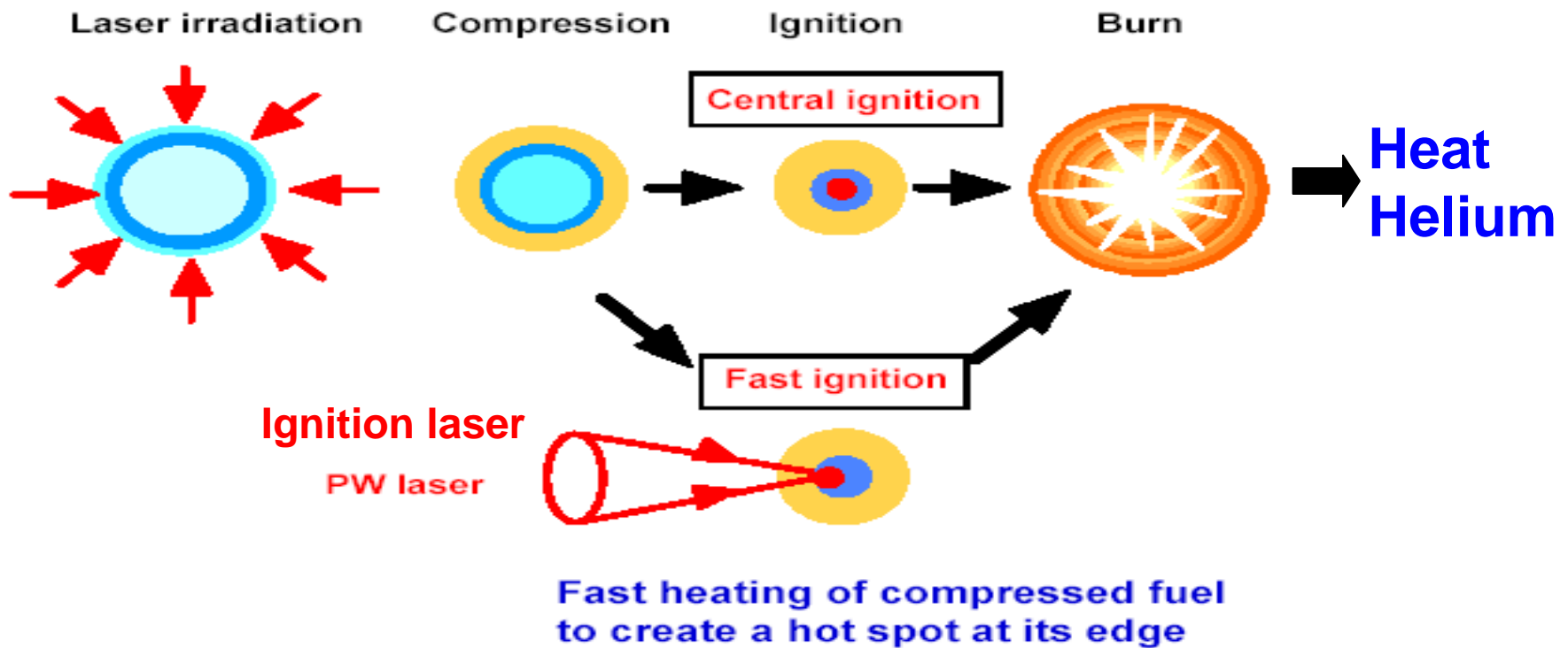


Energy + non-radioactive daughter nuclei

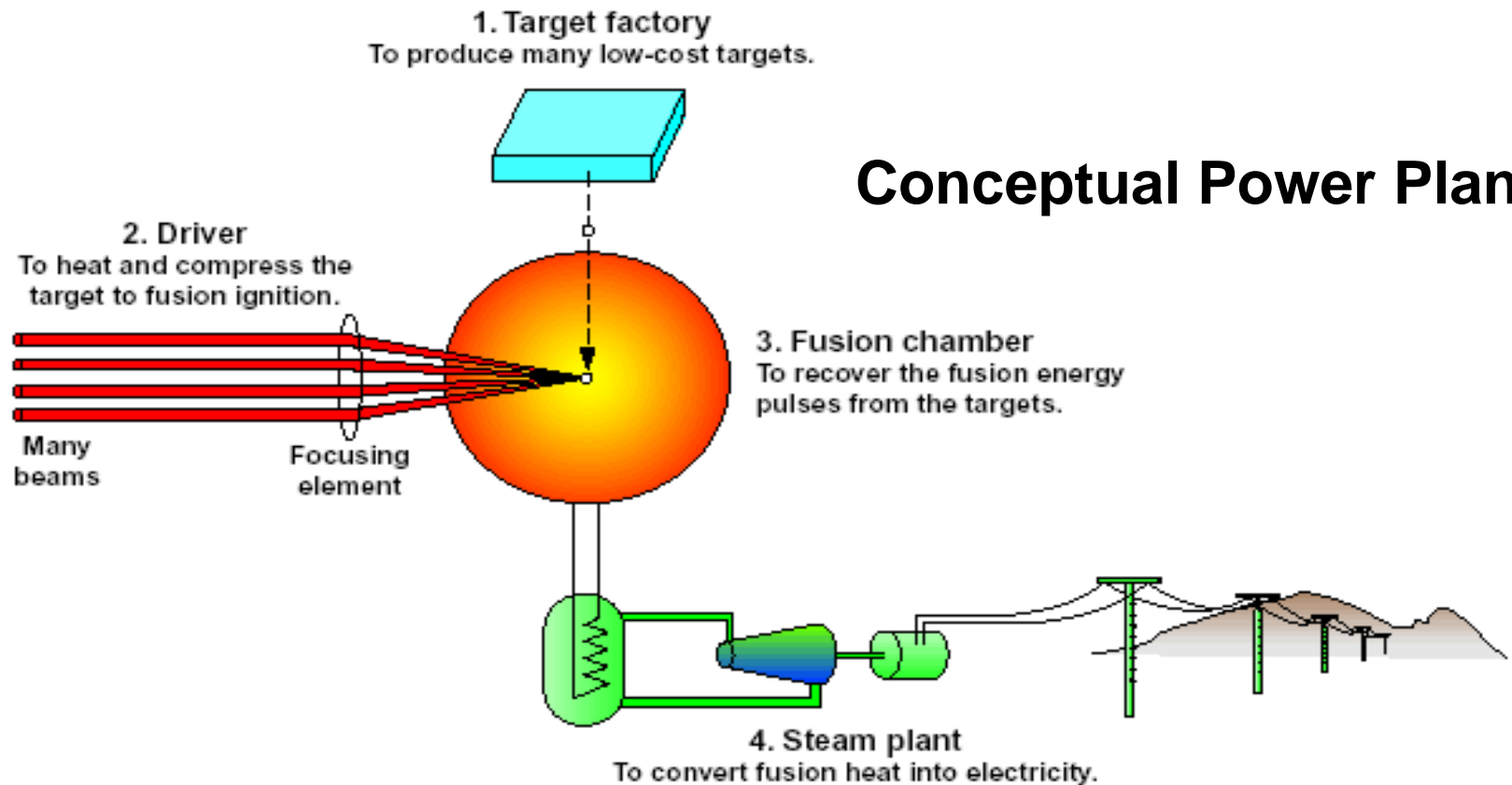
Requires high temperature

Lasers - Compress/Heat Fuel (Ignition)

Two pathways – central and fast ignition



Fusion - Energy Source for Power Plant

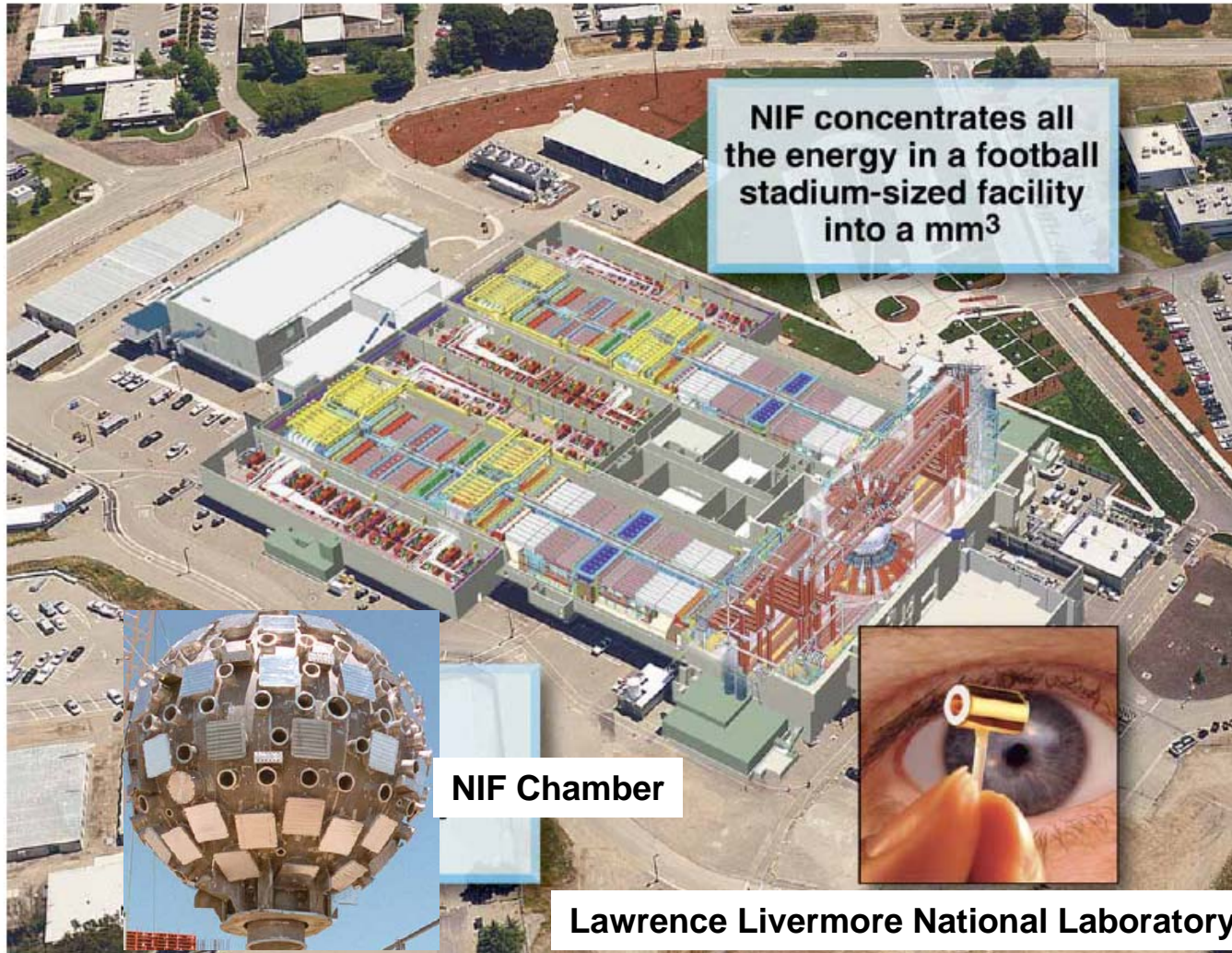


Fusion Energy - Clean & Sustainable

Fusion Impact (Compared to Other Sources)

- **Land** – less than any other energy source (mining & transporting)
- **Water** – less than most other energy sources (technical choices)
- **Air** – no GHG, no pollution
- **Fuel Availability** – virtually unlimited
- **Fuel Deliverability** – small quantity/annum (high energy yield)
- **Climate Change** – major positive impact (high efficiency)
- **Public Perception** – generally favorable (more education helpful)
- **Nuclear Accident** – no risk of public evacuation in vicinity of plant
- **Radioactive Hazards** – dependent on materials (technical choices)
- **Geo-political** – major positive impact (universally available fuel)

National Ignition Facility - USA



Inertial Fusion - Status of NIF/LMJ

National Ignition Facility (USA):

- 192 laser beam facility operational March 2009 – Lawrence Livermore National Laboratory (cost ~\$4 billion)
- National Ignition Campaign (NIC) – inertial fusion “proof-of-principle” experiments planned for ~2010-11 (“central ignition”)
- international confidence level high for successful fusion ignition (basic science is established) – will have major impact
- invitation for Alberta program to participate in NIC (needs funding)

Laser MegaJoule (France):

- independent program & facility with the same capabilities as NIF



HiPER

IAEA roadmap to Inertial Fusion Energy

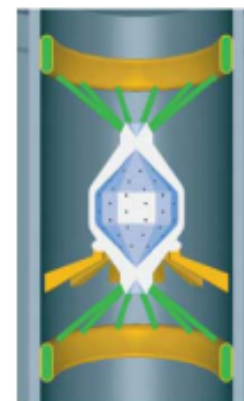
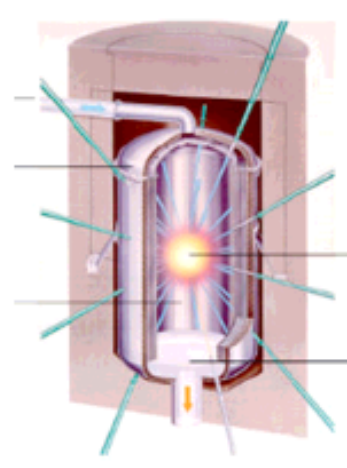
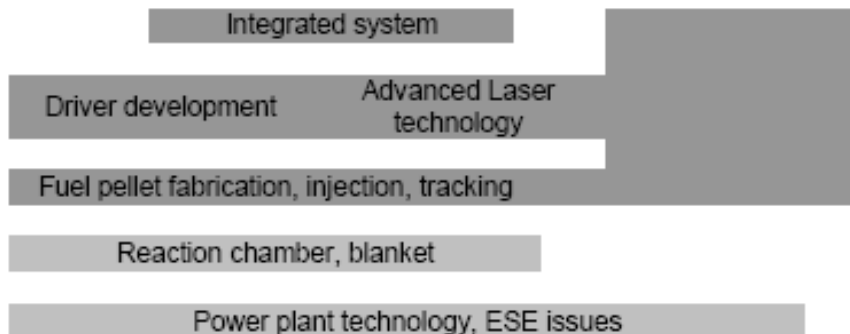
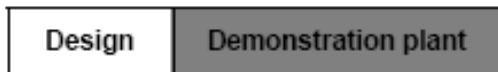
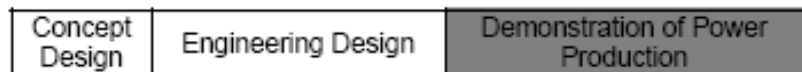
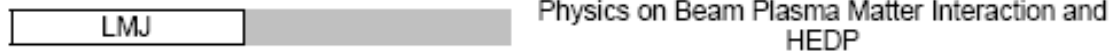
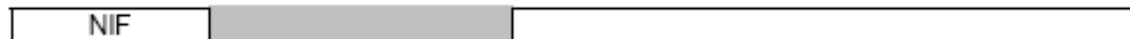
Road Map toward IFE Power Plant

2005 2010 2015 2020 2025 2030 2035 20xx

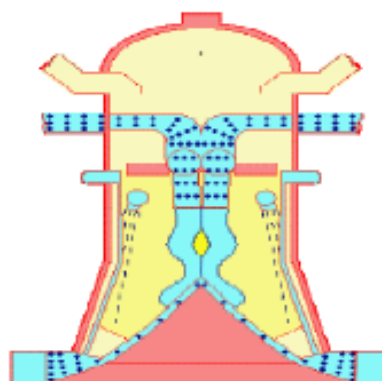
Ignition

Power production

Commercialization



SOMBRERO



HYLIFE-II

Economic Impact

Inertial fusion R&D is a major driver of innovation

– with important linkages to current Alberta innovation strategy

- **High power lasers** (diverse applications)
- Precision optics and opto-electronics
- **Photonics** (superseding electronics)
- Sensors, instrumentation and data processing

Economic Impact

- **Nanotechnology** (lasers, optics, targets, chamber materials)
- Supercomputer modeling (fusion scientists were pioneers)
- **Particle beam production & acceleration** (medical applications)
- High energy density physics (laboratory astrophysics)

Fusion Economy - Canadian Impact

Data from A/CFEI Economic Impact Study

Near, medium & long term economic return

(for 20 year, \$800M total investment)

- \$7 billion over 30 years (total multiplier effects)
- \$3 billion/yr photonics business (30 years onwards)
- \$100 billion/yr fusion economy (80 years onwards, 2% of world)

Skilled jobs

- 400,000 jobs for fusion economy (80 years onwards)

Fusion Energy - Alberta Opportunity

Why Alberta?

- Canada is the only OECD country without a fusion energy program – Alberta can change this
- Europe, Japan & the USA have opened their doors to us to collaborate in developing IFE – linkage and leverage
- Alberta has an image opportunity – to position us as an energy leader beyond 2040 (CCS bridging to fusion and renewables)
- Alberta investment - as for oil sands - for large future return (all international fusion programs are government funded since timeframe is >20 years)

Fusion Energy - Alberta Leadership

- Provide national leadership in “clean” inertial fusion energy
- Leverage investment (international linkages)
- Early adopters will gain technological edge
- Economic diversification (large program will attract high tech companies)
- Potential host site for international test reactor
- **Alberta would gain significant profile and economic benefits from an overarching fusion energy/environment initiative**

Implementation - The Way Forward

- **Phase I (2 years, \$280K, completed)**
 - develop R&D plans; international linkages; forums; etc.
- **Phase II (1 year, \$97K, where we are)**
 - build constituency; international relations; conference
- **Phase III (3 years, \$21M)**
 - initiate fusion program with international partners
 - **inaction will result in loss of credibility & international linkages**
- **Phase IV (5 year plans, ~\$40M/year)**
 - develop enabling technologies for fusion energy systems

In Conclusion

- Fusion ignition is imminent – a global win!
- Alberta/Canada must be prepared!
 - write your MP and MLA
 - maintain your participation & contribute
- Proposed action plan for 2010
 - maintain our international network - \$61,500
 - assess Alberta economic implications - \$16,300
 - launch a national conference - \$10,000
 - maintain communications - \$10,000
 - develop fusion link to EXPO 2017 bid

Fusion Steering Committee

Current Representatives/Organizations:

Perry Kinkaide/AB Council of Technologies

Allan Offenberger/University of Alberta

Robert Fedosejevs/University of Alberta

Peter Tertzakian/ARC Financial

Dini Corbett-Lourenco/Sway Energy

John Chomiak/Hemisphere Engineering

Brian Kryska/Innovation Management Group

Neil Kaarsemaker/Edmonton Research Park

Al Maurer, Gary Woloshyniuk (alternate)/City of Edmonton

Axel Meisen/Alberta Research Council

Will Bridge/TransAlta

Glen Stowkowy/Stantec

Richard Luhning/Enbridge

Robert Chow/Capital Power

Stuart Cullum/NAIT

Jerry Keller/Alberta Environment

Ted Cyr/Alberta Energy

Thank You - Questions?

Vision for this century – and legacy:

- Fusion energy harnessed to give sustainable, environmentally acceptable energy - solution to world's growing energy demands
- Alberta/Canada to be recognized as a leader in developing fusion & benefiting from commercialization of related technologies
- Grandchildren benefiting from “clean” energy source & rewarding career opportunities
- Fusion will be transformative (energy/environment/economy)