



Path to Market for Compact Modular Fusion Power Cores

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14th December 2011

Background: DOE planning, community discussion.

Problem: economic fusion 'very distant'

Solution: making fusion systems compact and modular opens path to market

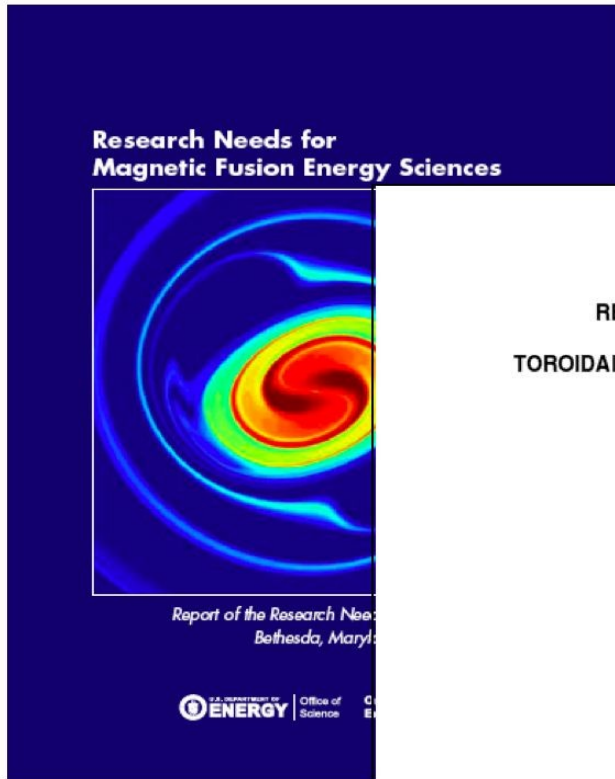
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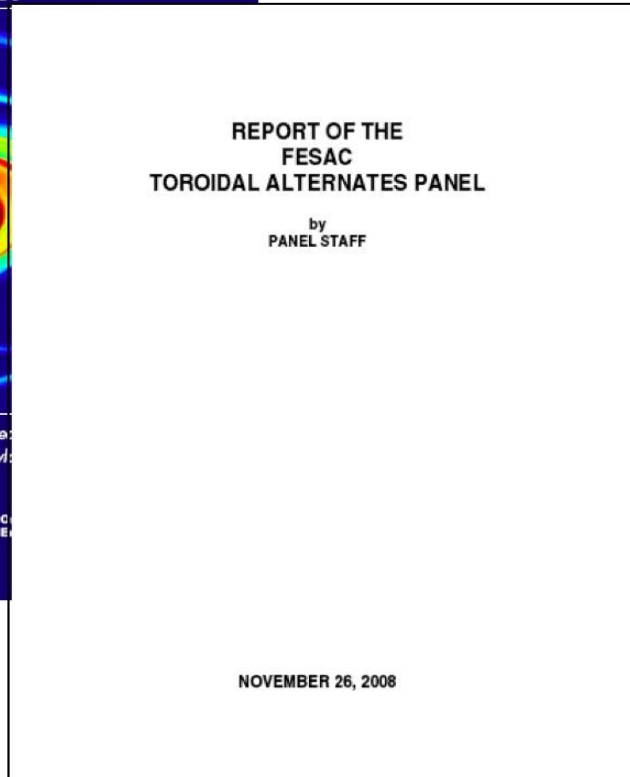
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Lead author



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BRIEF COMMUNICATION

Path to Market for Compact Modular Fusion Power Cores

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Abstract The benefits of an energy source whose reactants are plentiful and whose products are benign is hard to measure, but at no time in history has this energy source been more needed. Nuclear fusion continues to promise to be this energy source. However, the path to market for fusion systems is still regularly a matter for long-term (20+ year) plans. This white paper is intended to stimulate discussion of faster commercialization paths, distilling guidance from investors, utilities, and the wider energy research community (including from ARPA-E). There is great interest in a small modular fusion system that can be developed quickly and inexpensively. A simple model shows how compact modular fusion can produce a low cost development path by optimizing traditional systems that burn deuterium and tritium, operating not only at high magnetic field strength, but also by omitting some

components that allow for the core to become more compact and easier to maintain. The dominant hurdles to the development of low cost, practical fusion systems are discussed, primarily in terms of the constraints placed on the cost of development stages in the private sector. The main finding presented here is that the bridge from DOE Office of Science to the energy market can come at the Proof of Principle development stage, providing the concept is sufficiently compact and inexpensive that its development allows for a normal technology commercialization path.

Keywords Commercial fusion systems · Compact fusion power cores · Spheromak · Compact torus · Deuterium-tritium fusion

Introduction

While the day of fusion systems designed for net power production is dawning, follow-on devices are being proposed that require large capital outlays which inhibits both their development and commercial deployment. The Department of Energy (DOE) Office of Science supports fundamental research which could potentially lead to the future deployment of commercial systems, and while this research is comprehensive, it is also primarily directed at the most developed and usually the largest systems. DOE Office of Science programs will therefore have an inherent time-line that is longer than industry typically tolerates, and a preference towards systems carrying the lowest scientific risk. Within the commercial sector, time-lines for demonstrating critical milestones are short and resources scarce, requiring a very different approach in the design of commercial systems.

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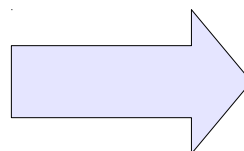
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Springer Energy Brief:

'Path to Market for Compact Modular Fusion Power'

Soliciting wider input from energy, business and scientific community.

'Path' widely discussed

DOE SBIR program:



Commercialization assistance:



Scientific:

Mike Brown (Swarthmore)
John Sheffield (UTK)
Lynda LoDestro (LLNL)
Harry McLean (LLNL)
Bick Hooper (LLNL)
Tom Dolan (UoI)
John Galambos (ORNL)
Brett Chapman (Uwisc)
Uri Shumlak (Uwash)
Ralph Moir
Paul Bellan (Caltech)
Steve Dean (FPA)
David Kingham (TSUK)

Business/investment:

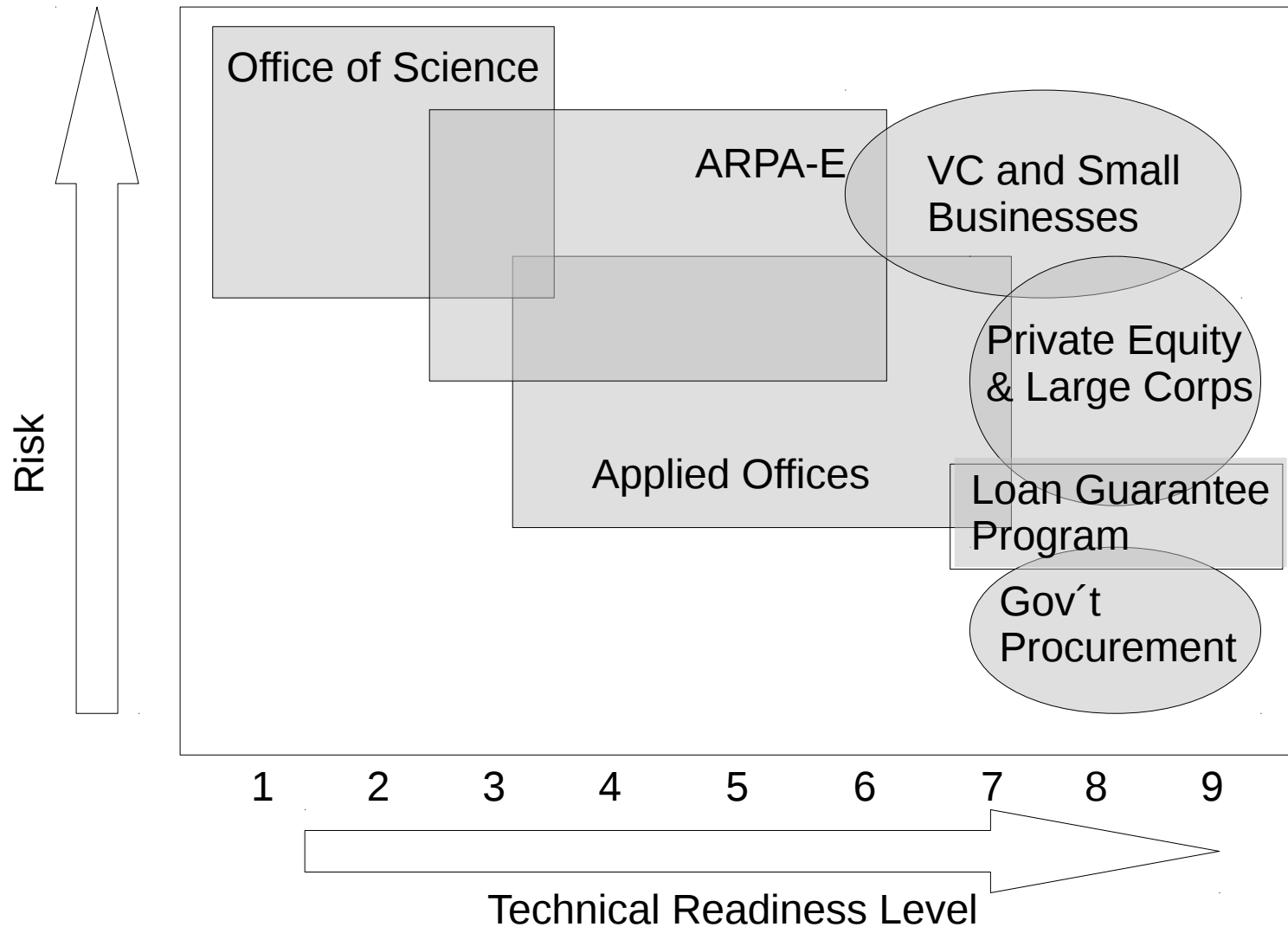
Amadeus
NEA
North Bridge
Washington Research Foundation
Ray Williams
Northwest Entrepreneur Network
Lars Johansson, NW Energy Angels
Kevin Doren, Divergent Ventures
Mike O'Donnell, iCopyright
Foster Business School
SCORE
Energy Northwest
Boeing

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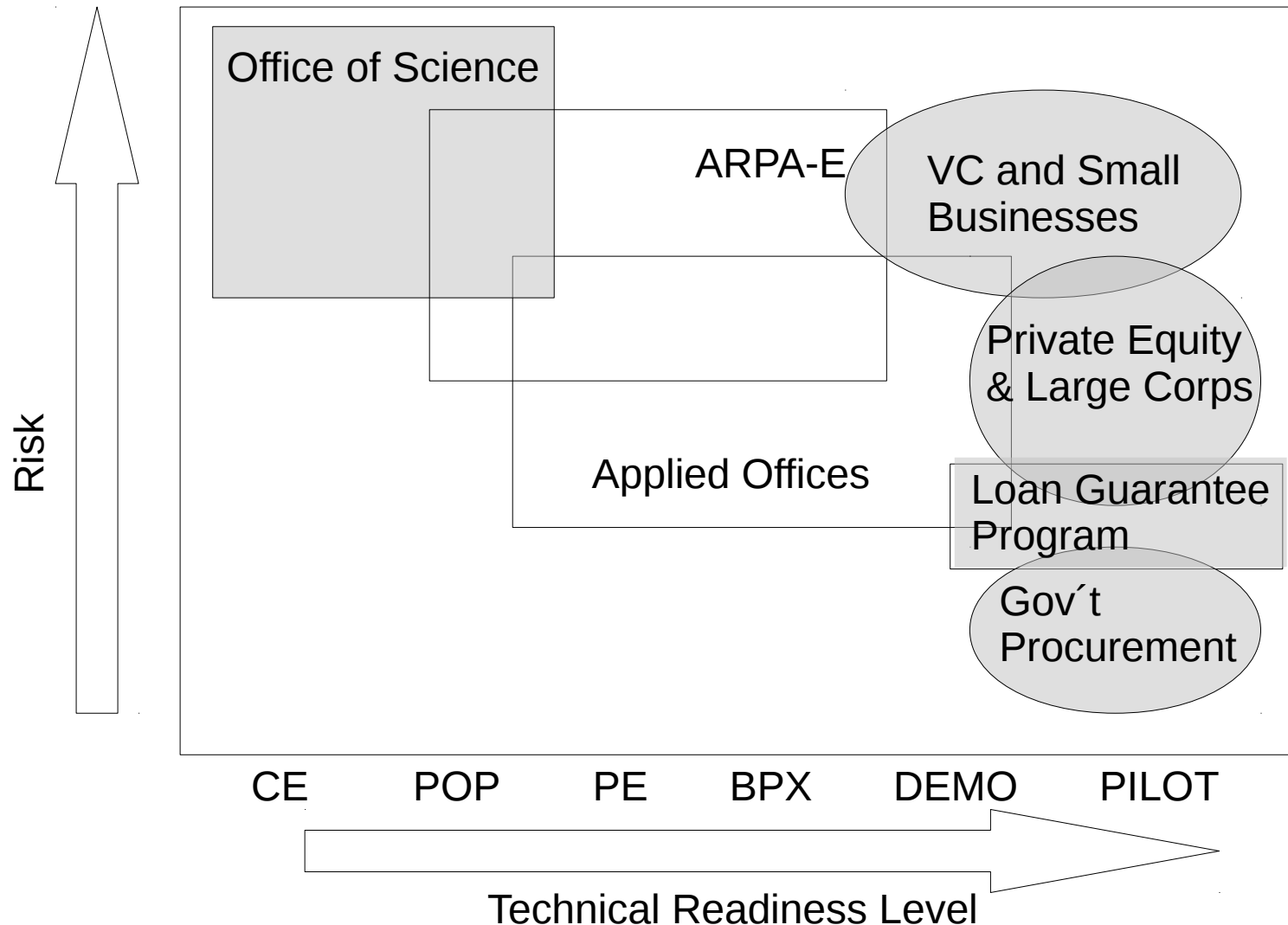
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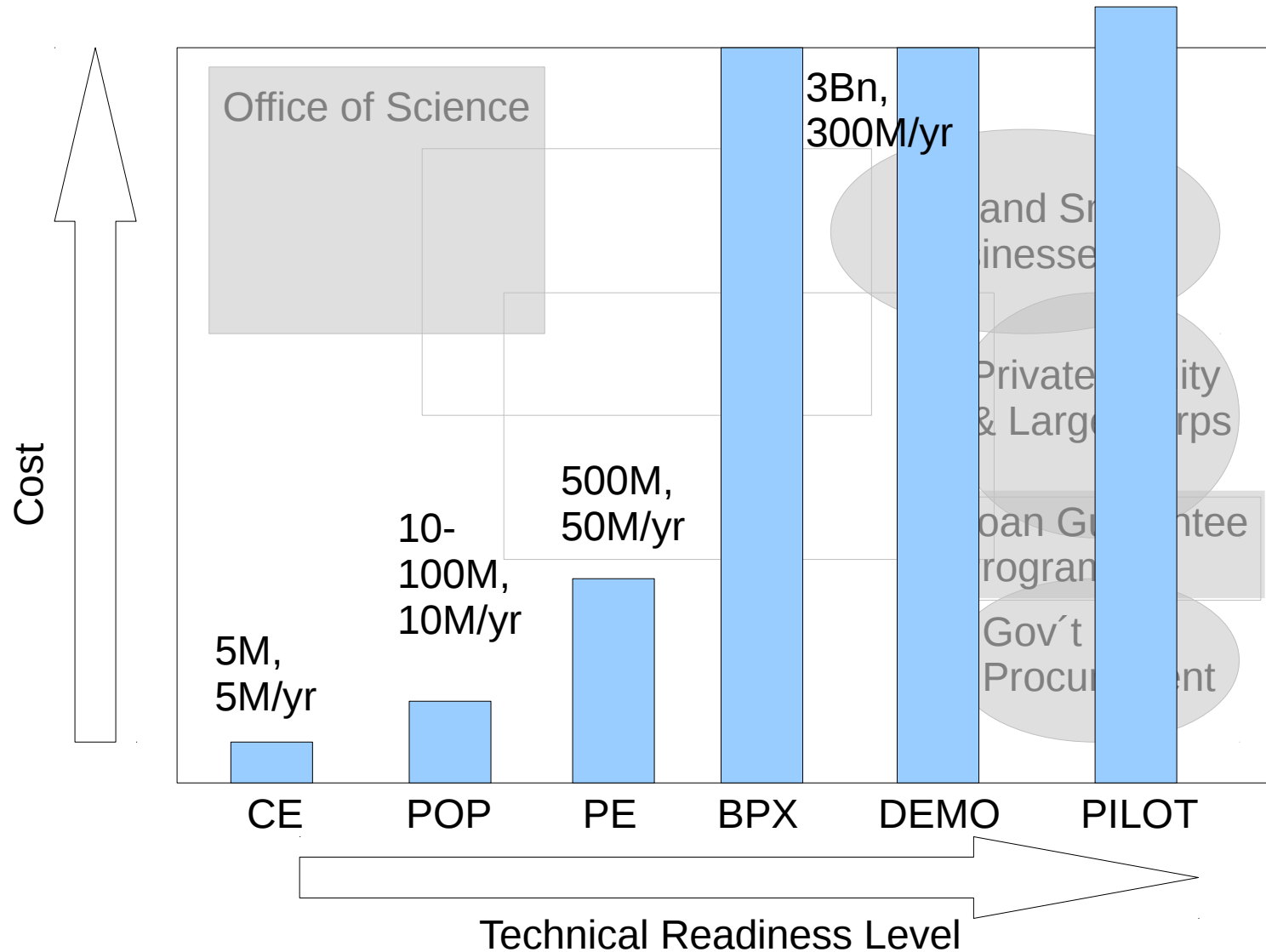
Path to market for energy technology



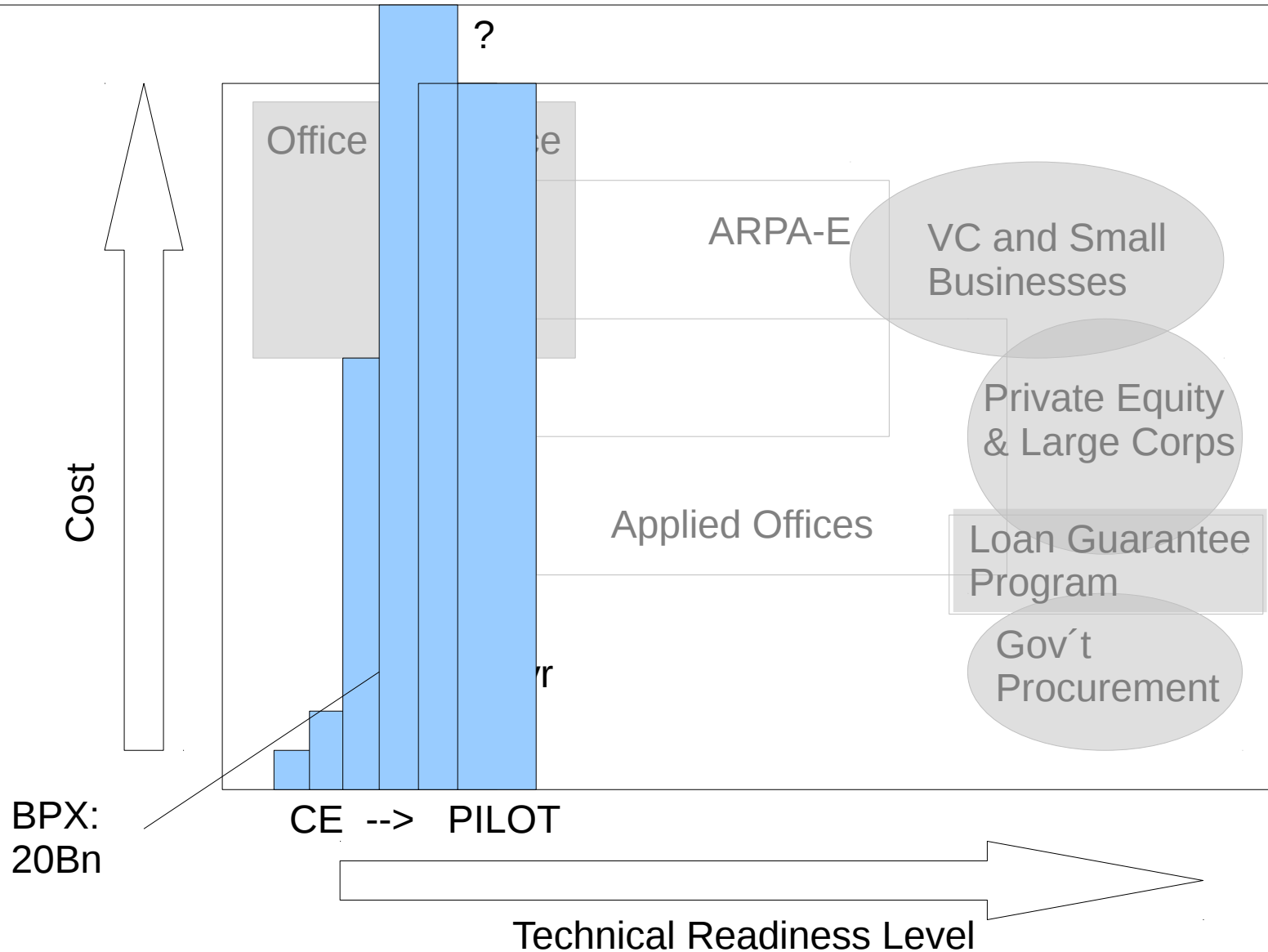
Path to market for fusion?



Development Cost projections circa 2000



Problem: ~all development remains through OFES



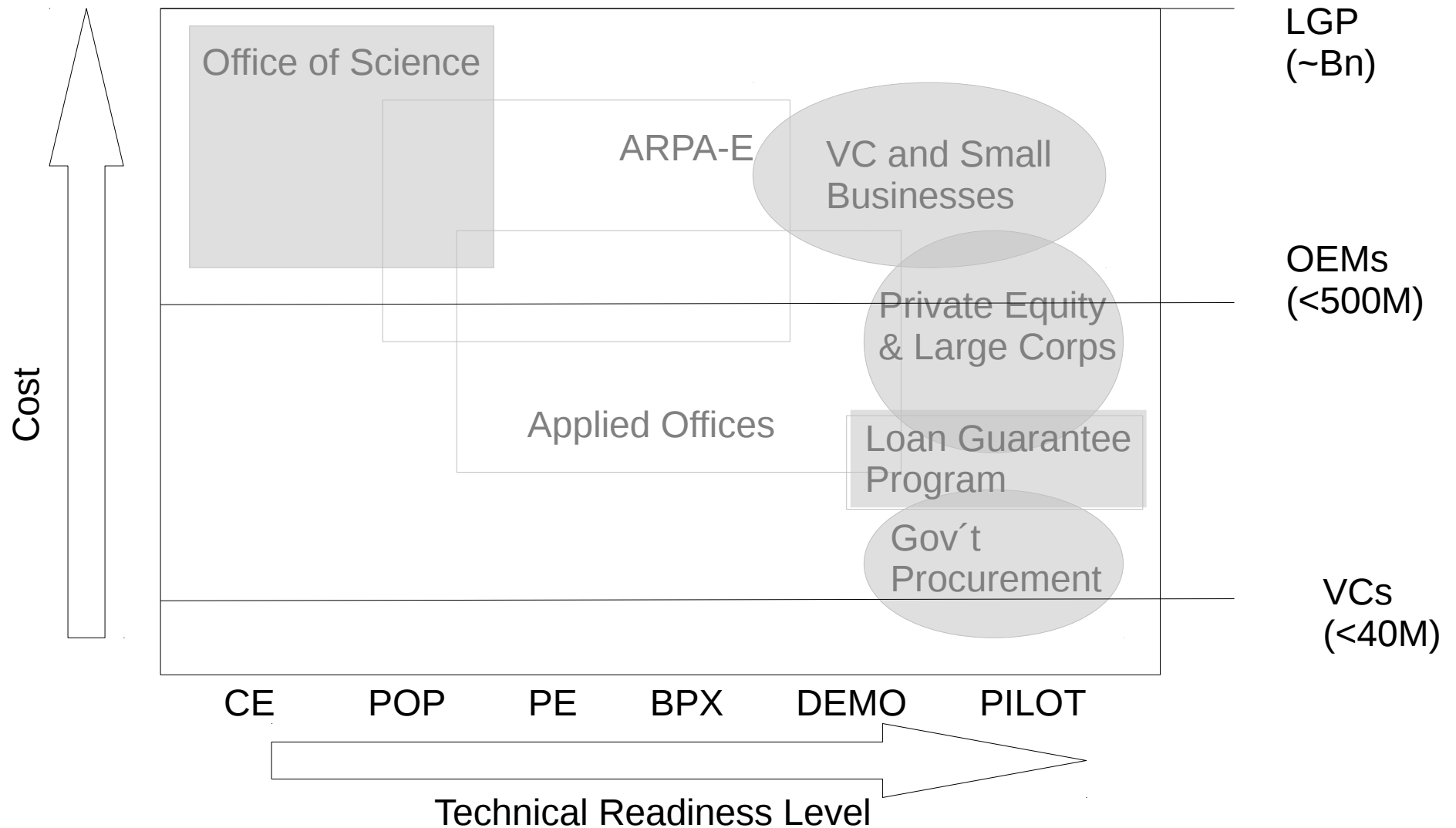
BPX:
20Bn

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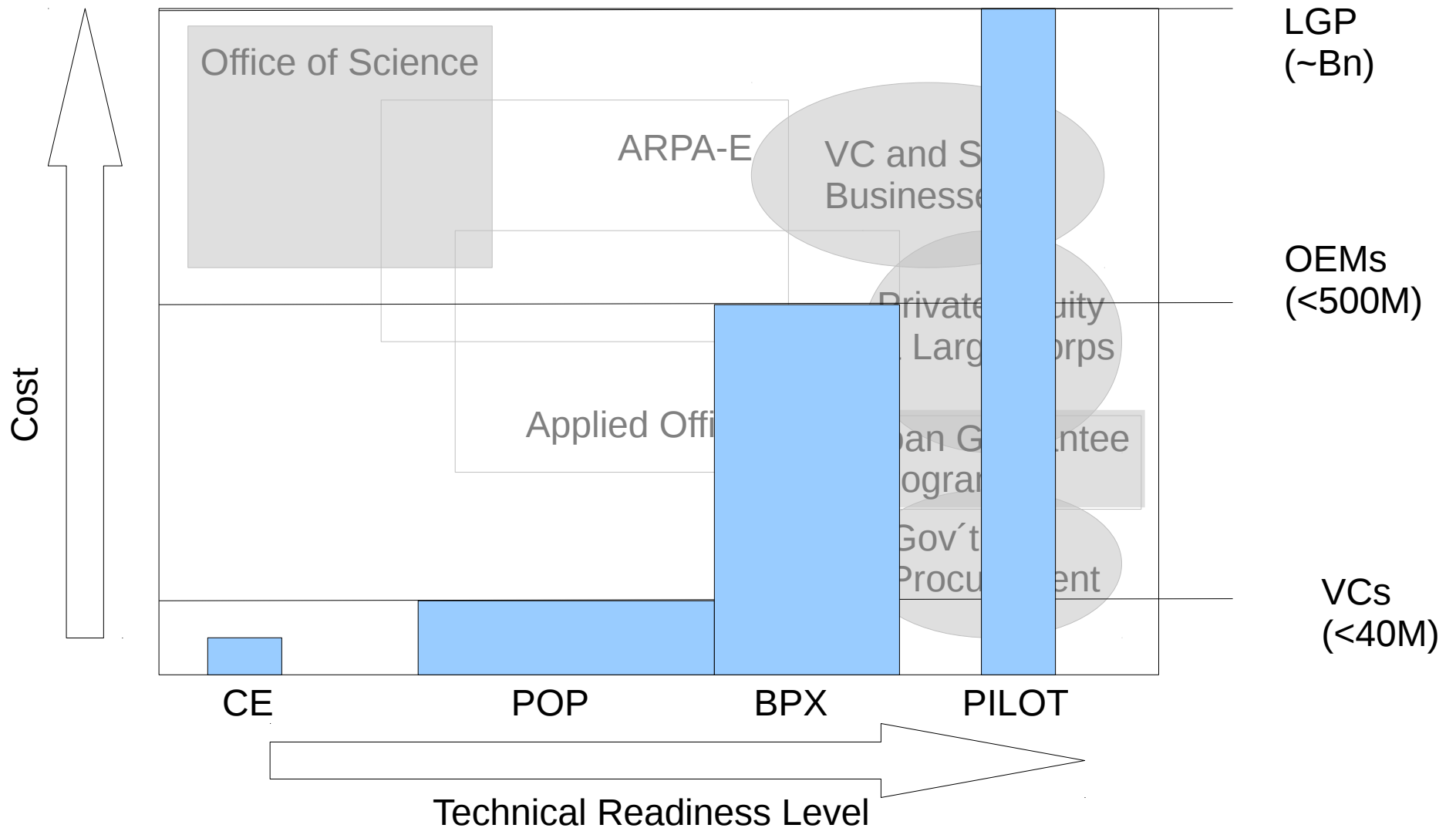
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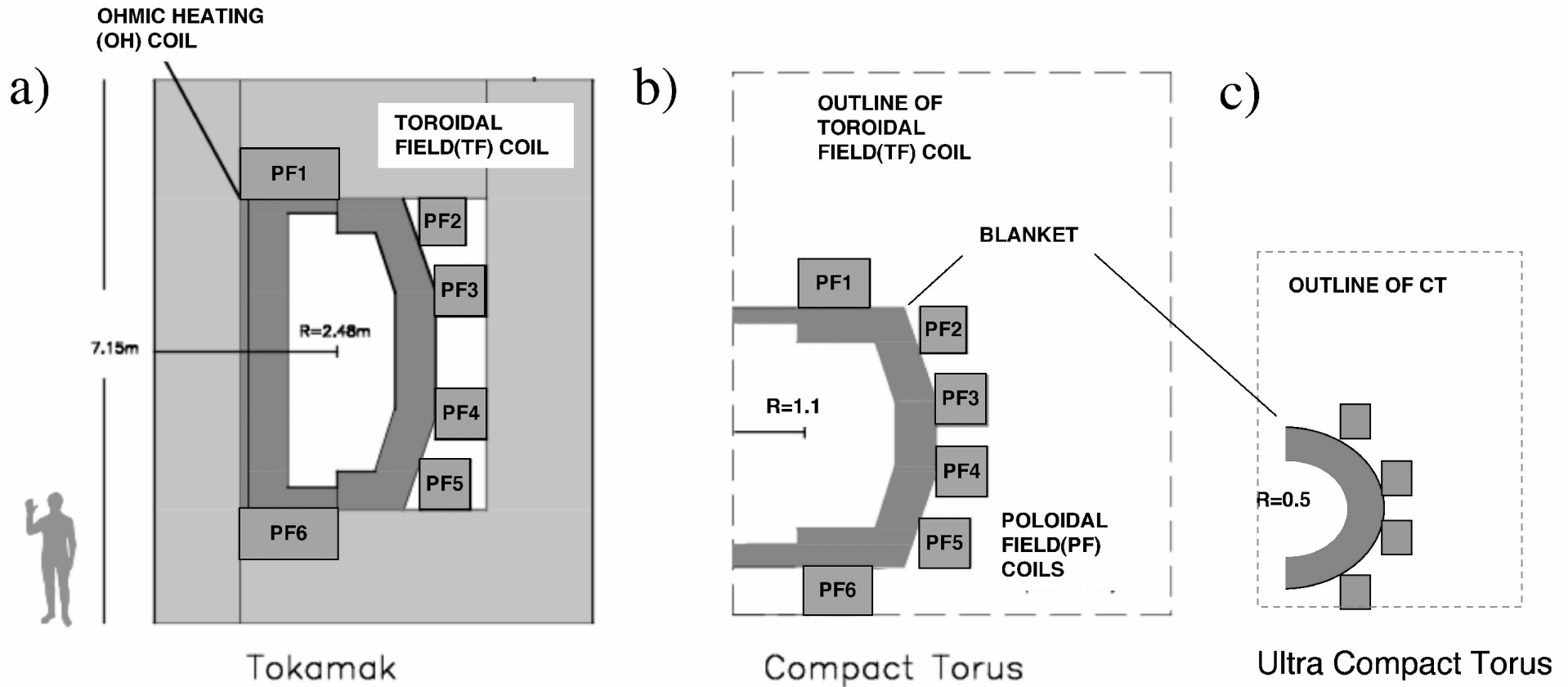
Apply 'usual' development cost constraints



Path to market for fusion



Cost constraints require compact & modular



Power: ~GWe

~GWe

<100MWe

Cost: ~3Bn

~1.5Bn

100M

Precedents?

- Small number of private fusion companies starting up, filing patents and finding >\$100M investment.
- Taking VERY aggressive approach:
 - Many scientific issues attempted in parallel
 - Uncomfortably short time-lines (for most in fusion)
 - Highly competitive and often secretive
 - Now hiring DOE scientists on staff, advisory boards

What to do differently?

Fusion is a tough nut to crack: need a broad base of support for success.

- **ARPA-E** could help develop Compact Modular Fusion.
- **Applied Offices** could be engaged in the discussion.
- More open discussion of the path to market in **OFES**.
- Engagement of **OEMs, VCs, Angel investors**
 - Workshop on 'compact modular fusion'...?

Context of DOE program presented – recent planning for compact fusion systems summarized.

Problem: GWe systems don't fit normal commercialization paths.

Solution: Make systems compact and modular.

Path to market still requires broad org / institutional support, and is not very short (still ~decade away).