High-Megawatt Converter Technology Workshop

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National Institute of Standards and Technology

RECALL THE INVITATION TO THIS MEETING STATES:

"[It] will provide a forum to review Federal and Industry Wants and Needs for High Megawatt Applications and to discuss the planned Interagency Agreement efforts. The desired outcome of the Workshop is the organization of a roadmapping exercise to define the R&D required to support the future availability of significantly lower cost High Megawatt converters for use in a variety of applications including but not limited to Integrated Gasification Fuel Cell Power Plants"

I WANT TO <u>BRIEFLY</u> SHARE SOME

BACKGROUND INFORMATION

The Three Horsemen of the Energy R&D Apocalypse: pollution, high cost, low efficiency

Cropped from painting by Victor Mikhailovich Vasnetsov

DOE IS STRIVING FOR NEAR ZERO EMISSIONS, LOW COST COAL PLANTS

Coal

Gasification

Syngas

(hydrogen + carbon monoxide)

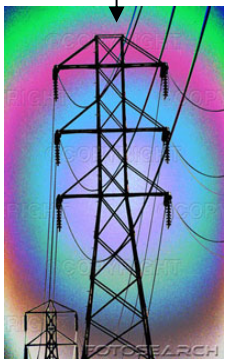
Sequester CO_2

Hydrogen

Turbine Power Block < $400/kW

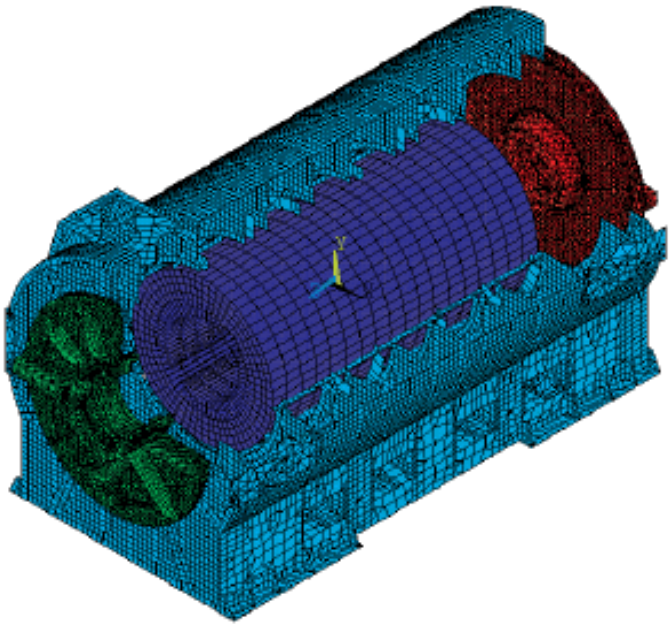
Fuel Cell Power Block < $400/kW

~60% η IGFC



Turbine systems are the right size and inexpensive

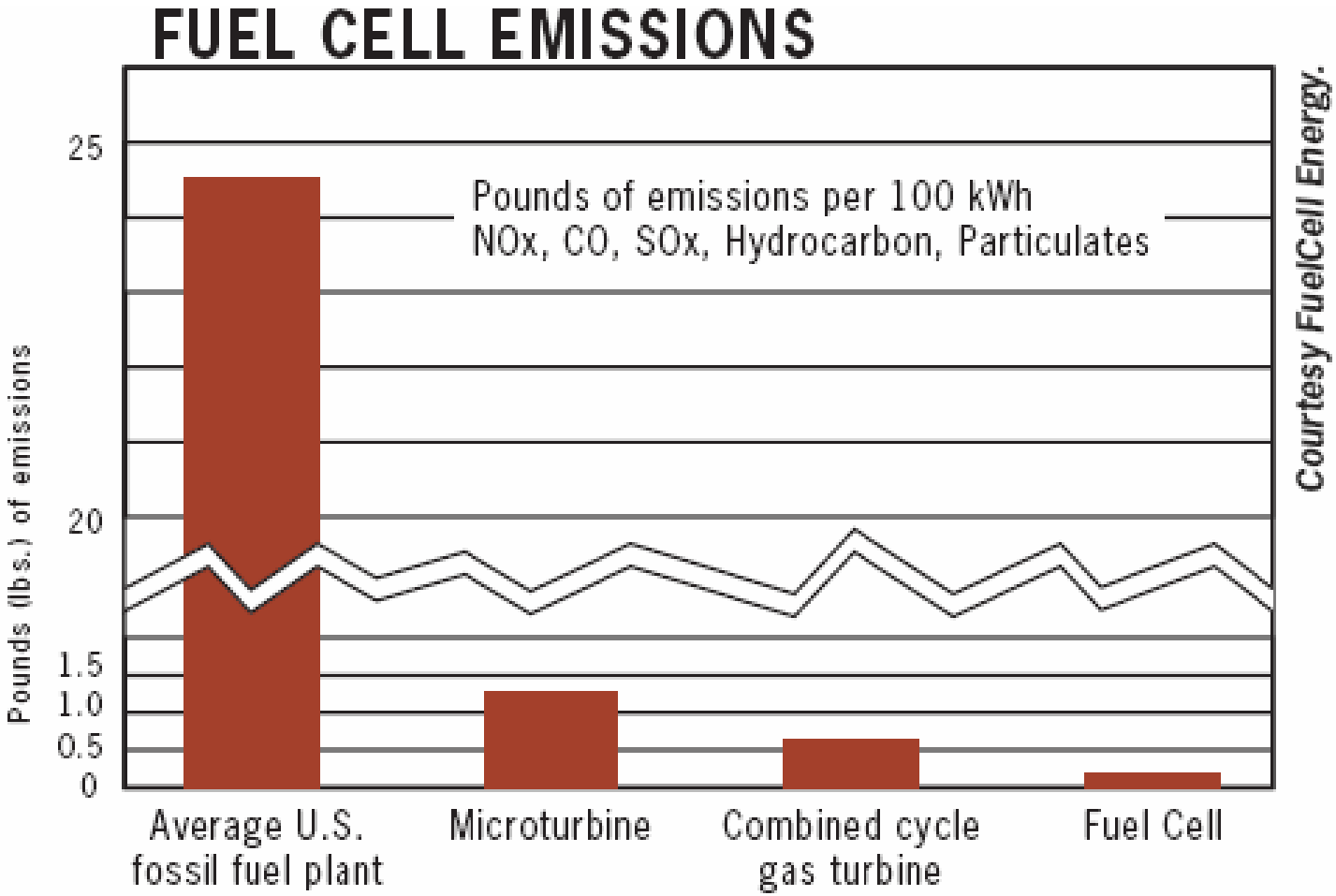
< $400/kW



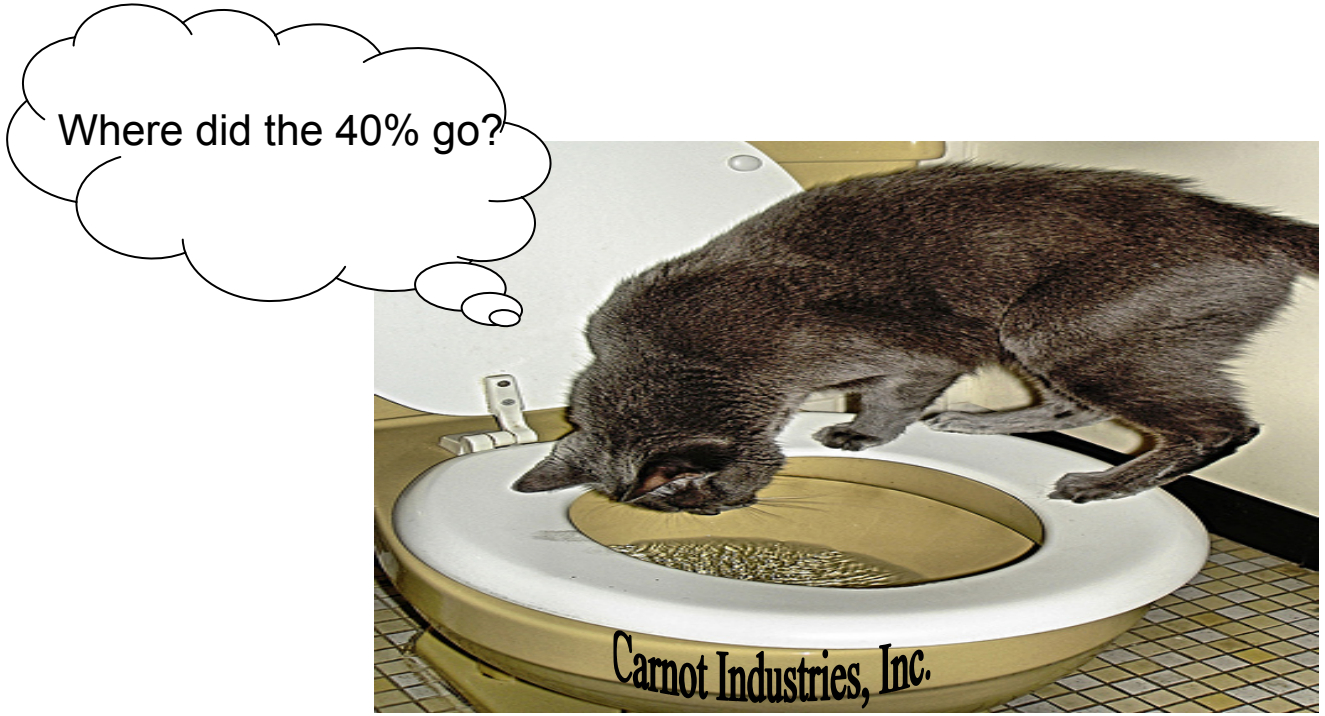
	7FH2 Model 741 / 743 ‡
	Hydrogen directly cooled rotor
Cooling	and conventionally cooled stator
Configuration	Single-end drive, end shield mounted
Rated Speed	3600 rpm/60 Hz
Output	195.5 MW/60 Hz
Power Factor	0.85 lag
MVA Rating	230 MVA/60 Hz
Terminal Voltage	18 kV
Temperature Rises	Allowable Class B per IEC/50 Hz And ANSI/60 Hz Standards
Insulation Class	Rotor - Class F; Stator - Better than Class F
Excitation System	Bus Fed, Static Excitation

‡ Note: Could be **W501G. with 1S.W501G**

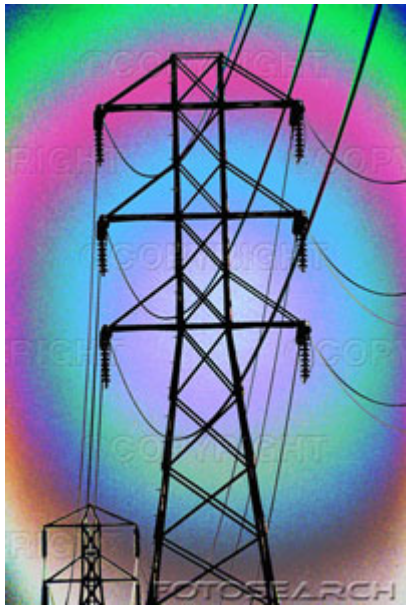
Fuel Cells are much cleaner but still relatively small and expensive



Efficiency Is Also Major Factor



Inspired by Mary Peters Fieser (1909–1997)



Line Losses Further Deplete Generation

- A typical loss factor of an ac overhead line is 4.4% per 100 miles at 345 kV.
- At 500 kV, the ac overhead losses are down to 2.5% per 100 miles.
- The losses for 400 kV dc overhead are lower than 1% per 100 miles‡.

- So further reducing generation losses will help offset foot-warming losses.

‡From Advanced Power Transmission of the Future**,** Mario Rabinowitz
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Wants/Needs In Re: Theory of the Government's Role

- Needs are set by future turbine (7FB or W501G type) power block's expected low costs and high performance.
- Wants will depend on the stretch goals

  -purpose of stretch goals is to inspire efforts to go well beyond what is currently feasible; such goals are only achievable if they stimulate and inspire creativity, invention and innovation.
- Stretch goal are not just desirable, they are needed to justify government funding.

Theory of the Government's Role

- Megawatt scale fuel cell power conditioning technology is needed
  - -at very low cost; perhaps as low as $40/kW
  - -at very high efficiency; likely >98%
  - -and perhaps better than today's (e.g.,7FH2/1S.W501G) demonstrated high availability

Theory of the Government's Role

- Need to understand what economists call "spillovers" and the concept of "market failures."
- (Note: *Check out e.g., web articles on foreign direct investments (FDI) and spillovers in electronics in various countries, e.g., U.K., Taiwan, Baltics, etc*…)

Spillovers

From the firm's perspective, the firm invests in R&D until the expected risk-adjusted private returns of the last research project equals its costs.

Average returns to R&D to the firm are high— 20 to 30 percent, on average[1]— but the returns to society are even higher— often 50 percent or more.

These R&D "spillovers" occur as others use research results and extend them in directions the original innovator often could not have imagined.

The result of spillovers is that an innovator is compensated for only a fraction of the total returns.

Stiglitz (Nobel Prize in Economics in 2001) said,

"Market failures" cause firms acting in their own best interests to under-invest in R&D from society's perspective.

Under-investment occurs because firms cannot appropriate all the returns ["spillovers"] to their R&D investments

And because capital market imperfections may make financing R&D more expensive [i.e. R&D cannot be collateralized] than other investments.

Much of government direct R&D funding goes to **applied research and development** in industry,

Traditionally, most of this funding has been to satisfy directly government objectives like space, defense, health research, environment, energy, transportation, agriculture, etc.

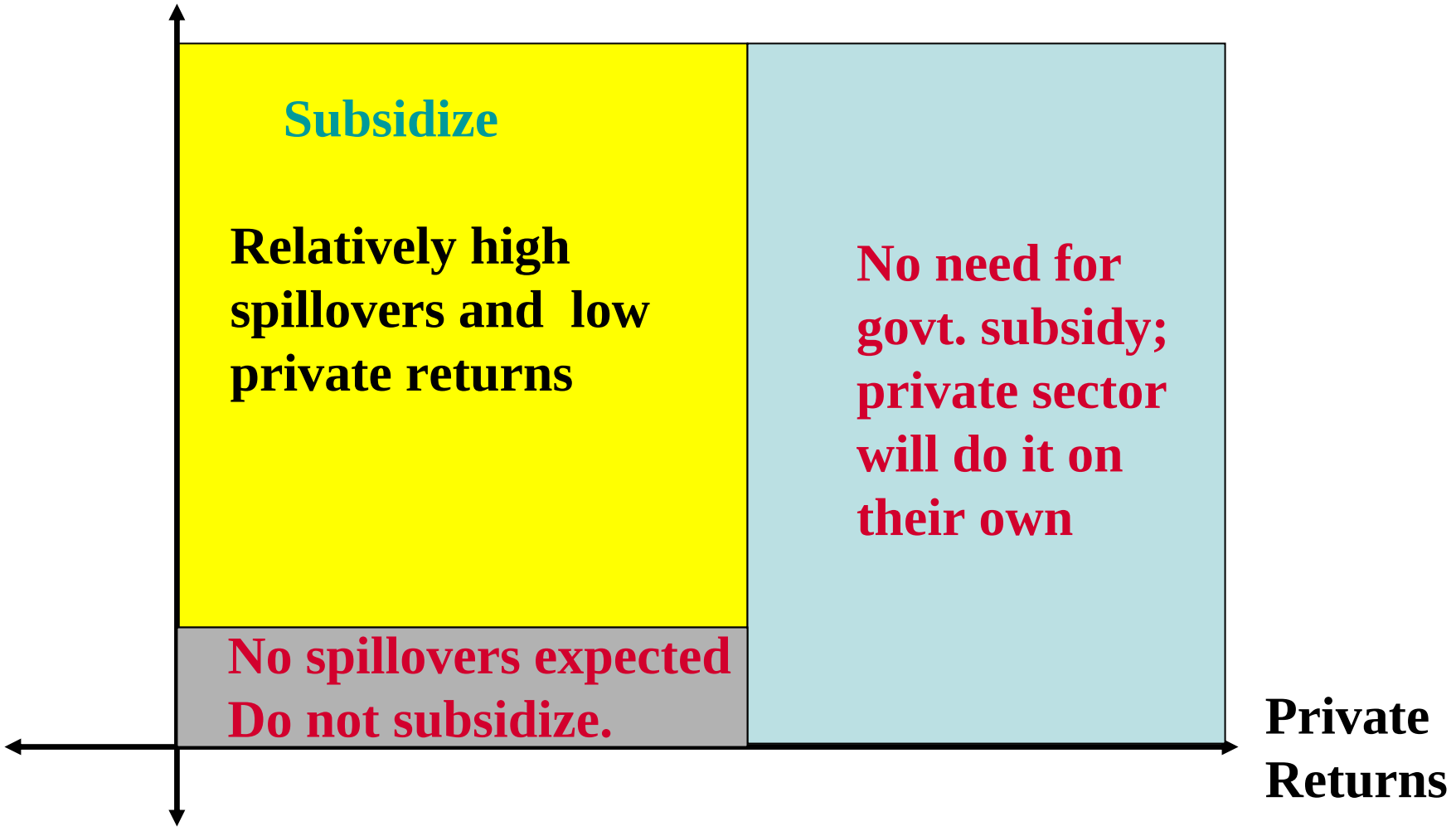
While the “market failures” may be less extreme in applied research and development than in basic research, they still exist.

Even the most applied R&D is inherently risky and can generate large “spillovers.”

The rationale for government intervention is not that the government is better than the private sector at picking winners, but that there exist important spillovers ***even for applied technology.***

The objective of the government is thus to identify winning projects that would be privately unprofitable but socially beneficial because of high spillovers.

Candidates for Subsidies: Expected Social v Private Returns



(adapted from Stiglitz and Wallsten: Public-Private Technology Partnerships: Promises and Pitfalls)

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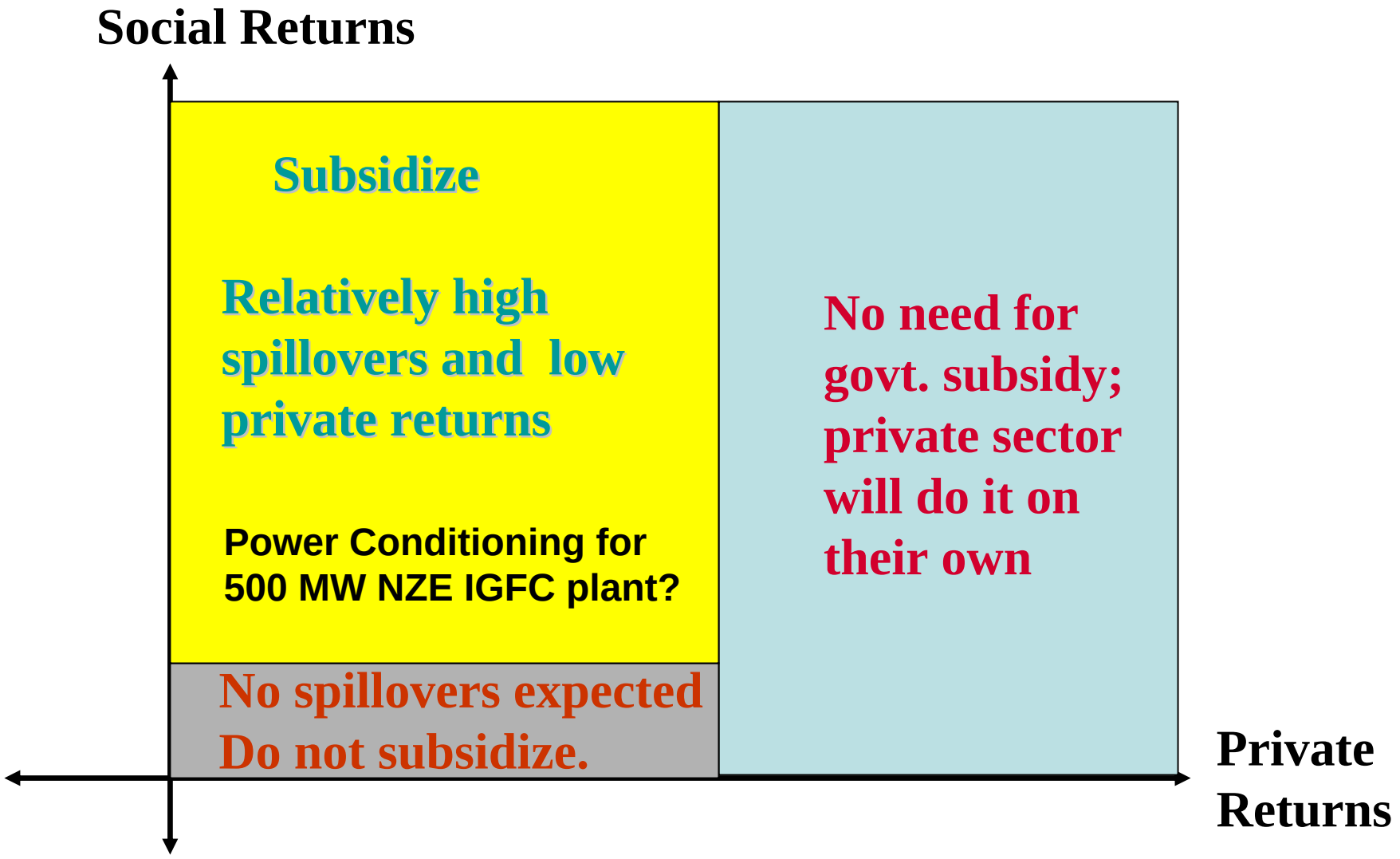

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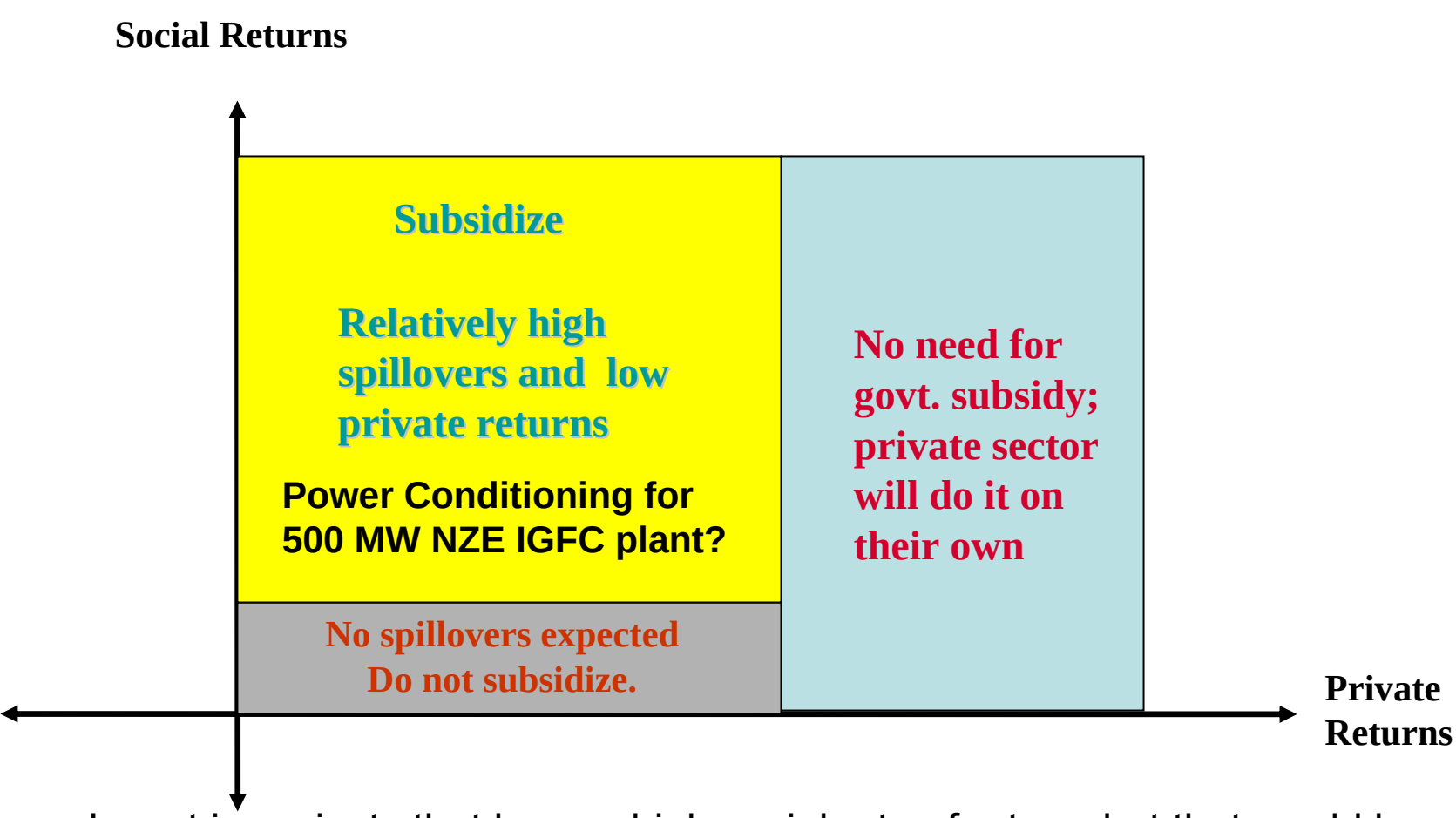
R&D spillovers are "positive externalities."



•Invest in projects that have a high social rate of return, but that would be underfunded, delayed or otherwise inadequately pursued in the absence of government support.

•Pursue projects for which the gap between the social and private rates of return ("the spillover gap") is large.

Tangible Benefits of Private/Public Collaboration

- Value of derivatives should provide incentives for both public and private organizations, and
- Collaboration would enable leveraging resources

Why does DOE care about these issues now?

- There are no current market incentives to develop power conditioning systems for multi-hundred megawatt fuel cells systems and to achieve stretch goals for cost, efficiency, and reliability.

- Such PCS systems would lead to substantial public benefits. The potential spillover gap is large.

The Three Horsemen of the R&D Finance Apocalypse: the time value of money; the risk of technical failure; and the cost of the R&D program itself.

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Thank you for your attention