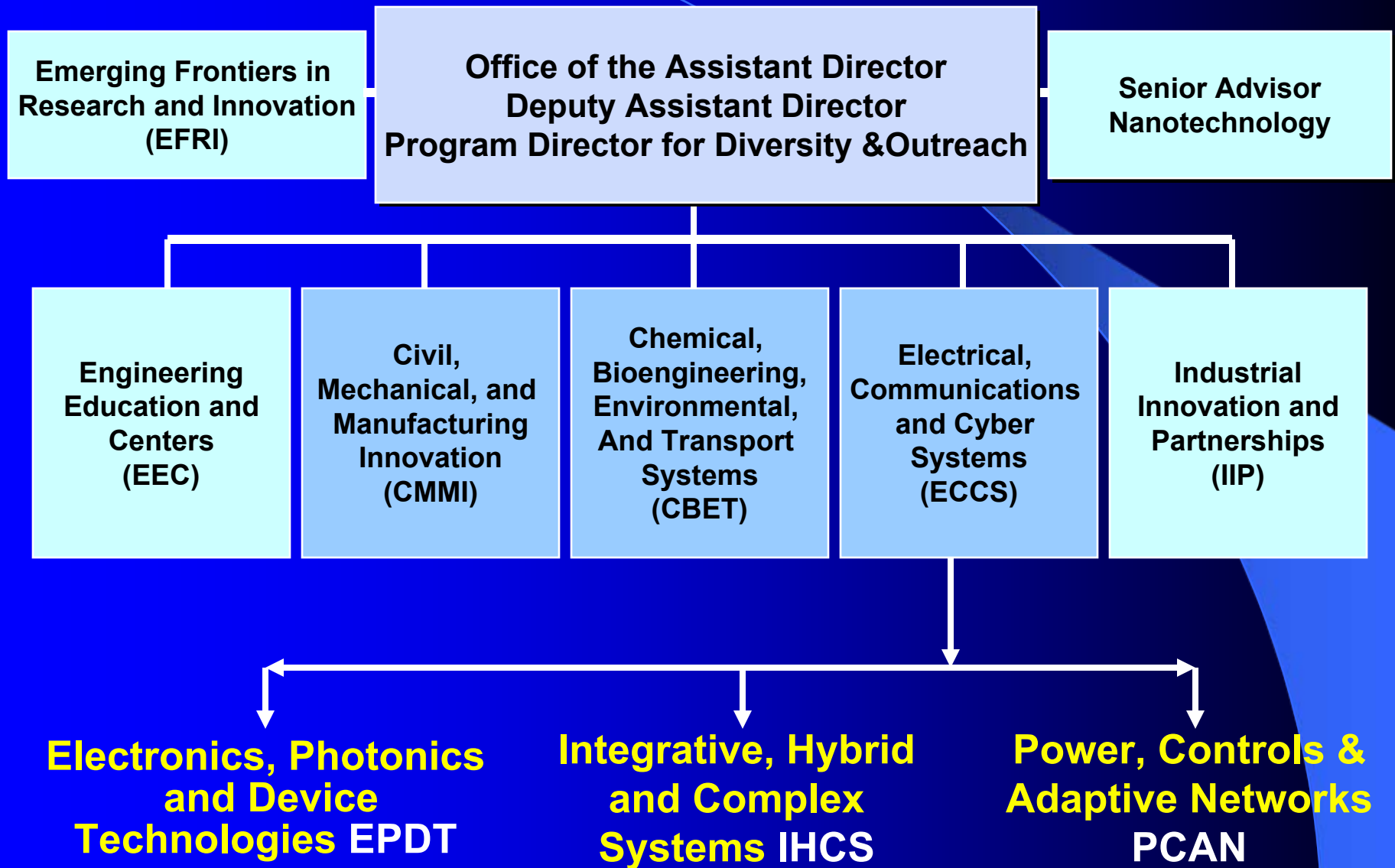


A Drug Discovery Approach to Breakthru Batteries

- How could NSF, DOE and the research community produce **maximum possible value** to US energy security, **if** there were a new \$10-20 million effort in FY10 taking a crossdisciplinary approach to novel research aimed at breakthrough batteries, **considering the realities** at all levels from materials to systems and markets?
- What is at stake for the US, and how we got here
- Translating the big question into something more concrete
- Hopes for new NSF funding – hopefully with DEO/OSTP/DOD links

Paul J. Werbos, Engineering Directorate of NSF, **and colleagues**
pwerbos@nsf.gov

Directorate for Engineering





American Council for
**The United Nations
University**

The Millennium Project

2004 State of the Future

JEROME C. GLENN AND THEODORE J. GORDON

www.stateofthefuture.org



CD-ROM
Energy
Paper

The enclosed CD of over 3,000 pages contains the cumulative work of the Millennium Project since 1996 and details of the studies included in this print section.



FUTURES OF THE PERSIAN - ARABIAN GULF REGION

Presented by

Dr. Ismail AlShatti

President

Gulf Institute for Futures and Strategic Studies

3. SCENARIOS OF THE PERSIAN ARABIAN GULF

3.2 Scenarios of Security and Peace

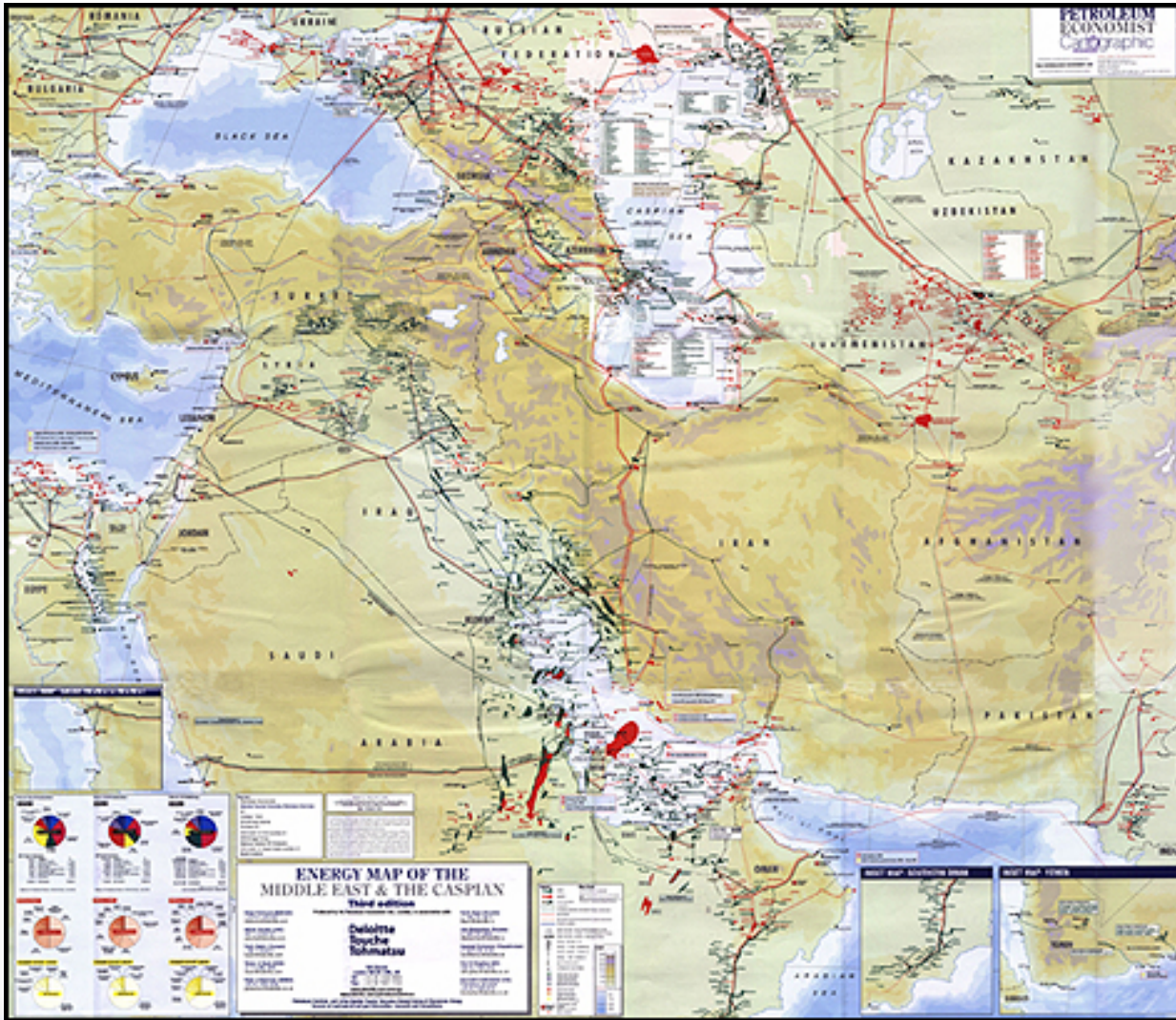
Escalating the importance of the region for western civilization



The use of oil as a weapon in confrontation between Western and Muslim societies is the main concern of the strategic decision makers in the west. This use will make the military power useless without fuel. It will remain pile of metal scrap.

3. SCENARIOS OF THE PERSIAN ARABIAN GULF

3.2 Scenarios of Security and Peace >> a. Oil Security Track



Where should the military existence achieved?

This map shows the Oil & Gas field location In Persian Arabian Gulf region and Caspian sea region. The green spots indicates oil field and the red spots indicates gas field. The Green line indicates the oil pipelines and the red lines indicates the gas pipelines. This map gives an idea where the western military existence should be achieved to protect oil field.

3. SCENARIOS OF THE PERSIAN ARABIAN GULF

3.2 Scenarios of Security and Peace >> a. Oil Security Track



Military existence on the oil fields and multiplying the oil export inlets are not enough for the oil security strategy. Terrorism can hinder the flow out of oil by destroying oil establishments. Military forces are not prepared to fight terrorist groups and gangs. That is why oil security needs political achievements to fill the gaps of this strategy.

How Can We Zero Out America's Need to Import Oil and Gas at the Soonest Possible Time?

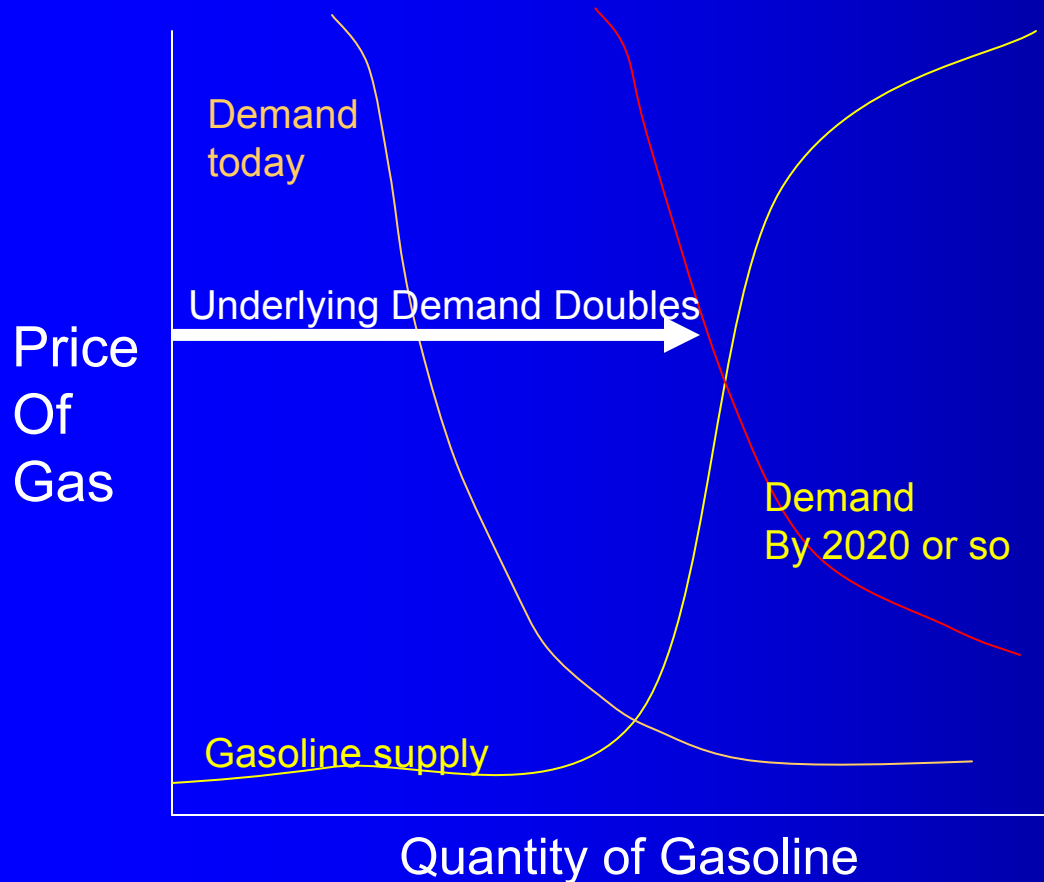
1/26/06: Talk to 200 House of Representatives people, sponsored by office of Congressman Kingston, posted at www.werbos.com..

- Why we **need faster action**. It is literally a matter of life and death – your life and mine!
- How we can do it in the real world of real technology
- No one **on earth** is doing enough yet!

Dr. Paul J. Werbos, personal unofficial views.

www.nsf.gov/staff/staff_bio.jsp?lan=pwerbos&org=NSF

How will you cut your gasoline use by 50% or more?



- If output falls, free market raises prices enough to **force** you cut your use in half or more.
- The only question: how? Lower income? Small car? Or market-friendly new technology?
- Antimarket tricks like price caps, hi interest rates, pressures on Arab states only lead to worse outcomes (Nash)

Long-term price elasticity of driving = -0.2 ; price doubling Of GASOLINE only gives 14% reduction

Can we Cut our Need to Use Oil and Gas by >50% in 20 years? How?

- How do we keep our **cars running**?
- **The big problem**: the car fleet takes 15 years to turn over. Thus new cars must be >50% gasoline independent **in 5 years** to make it possible.
- Giving up would be crazy – but where is there hope? (But: fuel has more time to catch up.)
- Where does the new fuel or electricity come from? **Sources? Distribution?**
 - **Rapid growth in imports of LNG**
- Serious hope of avoiding a crisis of dependency in time **but no guarantee**

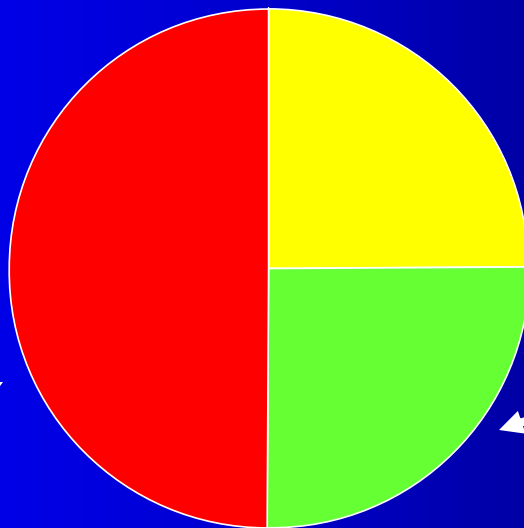
IEEE Computational Intelligence Society – Alternate Energy Task Force

<http://iee-cis.org/isa/alternative/>

- Rajashekara, Rolls-Royce
(former Delphi hybrid leader)
 - Prokhorov, Toyota
 - Anya Getman, Caterpillar
 - Marko, Bosch
 - Feldkamp, Ford
 - Javaherian, GM
 - Bonissone, GE
 - Zimmerman, Siemens
 - Fei-Yue Wang, Chinese Academy of Science
 - Chair: Werbos
 - Estevez
 - Fukuda
 - Sarangapani
 - Venayagamoorthy
 - Liu
- Research for Honda, Caterpillar, ABB, others

How To Zero Out Gasoline Dependency: Best Near-Term Hope for 100% Renewable Zero- Net-CO2 cars & **Total Security** for Car Fuel

Highest mpg
Hybrids Cut
Gas per Mile
By 50%



With **GEM fuel-flexible** cars,
biofuels might supply $\frac{1}{4}$
of present liquid fuel
demand trends

Plug-in Hybrids
with 10kwh batteries
get half their energy
from electricity

GEM fuel-flexible plug-ins offer a 100% solution based on near-term technology! www.ieeeusa.org/policy/positions/PHEV0607.pdf

Plug-in Hybrids (PHEV) : A Large-Scale Opportunity Here and Now

- Hybrids cut liquid fuel use 50% already. Plug-ins cut **50% of that**.
 - “Researchers have shown .. (PHEV) offering.. electric range of 32 km will yield... 50% reduction..” (IEEE Spectrum, July/05). Shown in working Prius.
- Battery **breakthroughs in China**: from 10/07, 10kwh batteries (larger than) cost **\$2,000**. www.thunder-sky.com. Thus an extra \$2,000 per car can cut gas dependence in half.
- Gives **economic security** in case of sudden gasoline cutoff.
- Does not strain grid – actually strengthens it, if done right



China, US, Japan and Korea: Who Will Win the Race towards Plug-In Cars?

Dr. Paul J. Werbos

-- personal, **not official**, views
IEEE-USA, IEEE, NSF,
UN State of the Future
1979-89: EIA/DOE lead analyst
for long-term energy futures

www.werbos.com/energy.htm



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Factors Which Decide Who Wins

- Who gets to mass-market first
- Who gets to low cost first
- National support and market conditions
- Rate of ramp-up in production
- But: **all oil consuming nations benefit** if all decent car factories shift to affordable PHEV as soon as possible! In a globalized world, collaborations will decide who really wins. E.g. If US spent \$3000 per 14 kwh battery for all 15 million cars/year, \$42b << \$700b on oil and risk of higher prices still during next 10-20 years.

First BYD then other contenders

- GM Volt, 14kwh, 40 miles: planned for late 2010, using A123 or LG Chem advanced lithium battery. **Enough for 90% of US to get to work** in case of total gasoline embargo, if employer parking lots have recharge stations.
- Hyundai: US mass-market hybrid 2009, no comment on plug-in, deal with LG Chem and massive new Korean battery program www.eetimes.eu/power/196600822
- Toyota: 2010 PHEVs to fleet owners only, a test, using **proprietary** advanced lithium-ion battery and power electronics technology GM cannot buy. Plans to keep doubling hybrid output every year.
- Chery (China) says by 2010: half of its million cars per year will be hybrids, half of them on alternate liquid fuels. 40% will be for export.
- Dongfeng Electric Car Company, and Chang'An

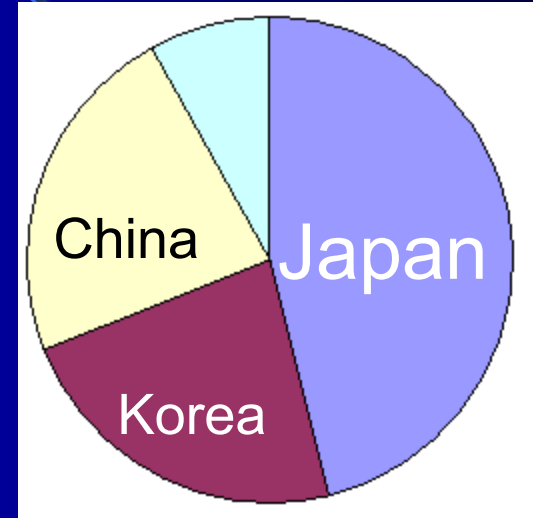
What limits rate of deployment of hybrids & plug-ins? Cost, cost, cost...

- Hybrid Prius vs. regular Prius: cost penalty = **\$3000** (2006 data Car & Driver, Financial Times) about enough to pay off at \$3-4/gallon without interest
- About **\$2000** of the \$3000 is for small fast battery, currently nickel hydride less than 1kwh.
- **\$1,000-\$2,000 tax incentive** per car, for the first million hybrids from each manufacturer, essential to speed of development, becoming cheaper, **in US**
- **Outside the US**, higher gas price bigger market now, but subsidized gasoline prices in China cheaper than US
- For VOLT in 2010, many predict **\$7000 extra cost**, calling for higher tax incentive. 1 million*\$7000=\$7 billion.

How incentives/markets are changing the game: Better batteries are coming



Thunder Sky, China, 10kwh now \$2000
(Werbos in-depth visit June 2007)



World Li Battery Output

Toyota says it will go to Li batteries next year or so, that its new joint venture with Mitsubishi is far ahead of everyone else. But Korea's new thrust aims to beat Japan in rechargeable sales by 2012, by focusing on next generation technology.

Needs for Action

- Restore tax credits for GEM-flexible plug-in hybrids; raise caps to 250,000 cars/year.
- More aggressive, transformative battery research
 - WTEC international battery visits
 - Joint call to all universities and small business
 - Only consider batteries at Li or more energy density
 - International partnership
 - Include computational intelligence and new chips
 - Start from (unfunded) proposals of DOE/BES, and of Sadoway of MIT, adding “drug discovery informatics”
 - Open source battery modeling to assist development of more general battery management systems
- US-funded battery testing facility under DOT
- New standards and incentives for recharge stations in employee parking lots and public parking lots serving commuters or big warehouse stores

Where This Workshop Fits In: From The Global Goal to A Concrete Target

- How can we minimize the **expected value** of the time between now and when a “breakthru battery” suitable for plug-ins is **fully available** to GM & others?
- An image of what we need to get to:
 - **Cost per kwh \leq ½ today’s best LiFePO4**
 - Energy density (/kg or cc) at least as good, 14-100kwh
 - Controllability and manufacturability, e.g. battery and battery management system (model?) allow \geq 10 years of safe operation under automotive use
 - A network or pipeline of collaborations
- An adaptive R&D strategy **which NSF can fund**, and which can mobilize the world R&D community, in a 5-20 page report and best possible web site, to go to my colleagues.



EFRI Update: FY 2009 and 2010 Plans

Sohi Rastegar

*Office of Emerging Frontiers in
Research and Innovation*

NSF ENG Spring Advisory Committee Meeting
April 24-25, 2008

EFRI- “One Slide Description”



- **Established on October 1, 2006, EFRI supports higher risk, higher payoff opportunities leading to:**
 - **new research areas for NSF, ENG, and other agencies**
 - **new industries/capabilities resulting in a leadership position**
 - **significant progress on advancing a “grand challenge”**
- **Successful topics would likely require:**
 - **small- to medium-sized interdisciplinary teams**
 - **the necessary time to demonstrate substantial progress and evidence for follow-on funding through other established mechanisms**
- **The current investment for EFRI totals \$25 million for 4-year awards at \$500k per year.**



EFRI OFFICE TOPICS

Steady State: 8-10 Active Topics
~50 Active Awards

Current competition

FY 07:
Auto-Reconfigurable
Engineered Systems
(ARES)

FY 07:
Cellular and Biomolecular
Engineering
(CBE)

FY 08:
Cognitive Optimization
& Prediction (planned)

FY 08:
Resilient and Sustainable
Infrastructures (planned)

FY 09:
Hydrocarbons from
Biomass
(HYBI)

New Topics

FY 09:
BioSensing & BioActuation
(BioSA)

FY 10:

Modified
Approach

FY 10:

FY 11:

FY 11:



EFRI Personnel

**Office Director
Sohi Rastegar**

Current competition

**FY 07:
Auto-Reconfigurable
Engineered Systems
(ARES)**

**FY 07:
Cellular and Biomolecular
Engineering
(CBE)**

**FY 08:
Cognitive Optimization
(COPN)**

**FY 08:
Resilient and Sustainable
Infrastructures (RESIN)**

**COORDINATORS:
Scott Midkiff, ECCS
Abhi Deshmukh*, CMMI**

**COORDINATORS:
Fred Heineken, CBET
Jimmy Hsia*, CMMI**

**COORDINATORS:
Paul Werbos, ECCS
Semahat Demir, CBET**

**COORDINATORS:
Joy Pauschke, CMMI
Bruce Hamilton, CBET
William Schultz, CMMI
Matthew Realf*, CMMI**

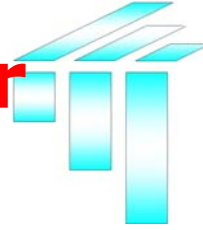
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Mario Rotea*, CMMI
Maria Burka, CBET
Bruce Hamilton, CBET
Stephen Nash, CMMI
Glen Larsen, IIP**

**TEAM MEMBERS:
Lenore Clesceri*, CBET
Lynn Preston, EEC
Robert Wellek, CBET**

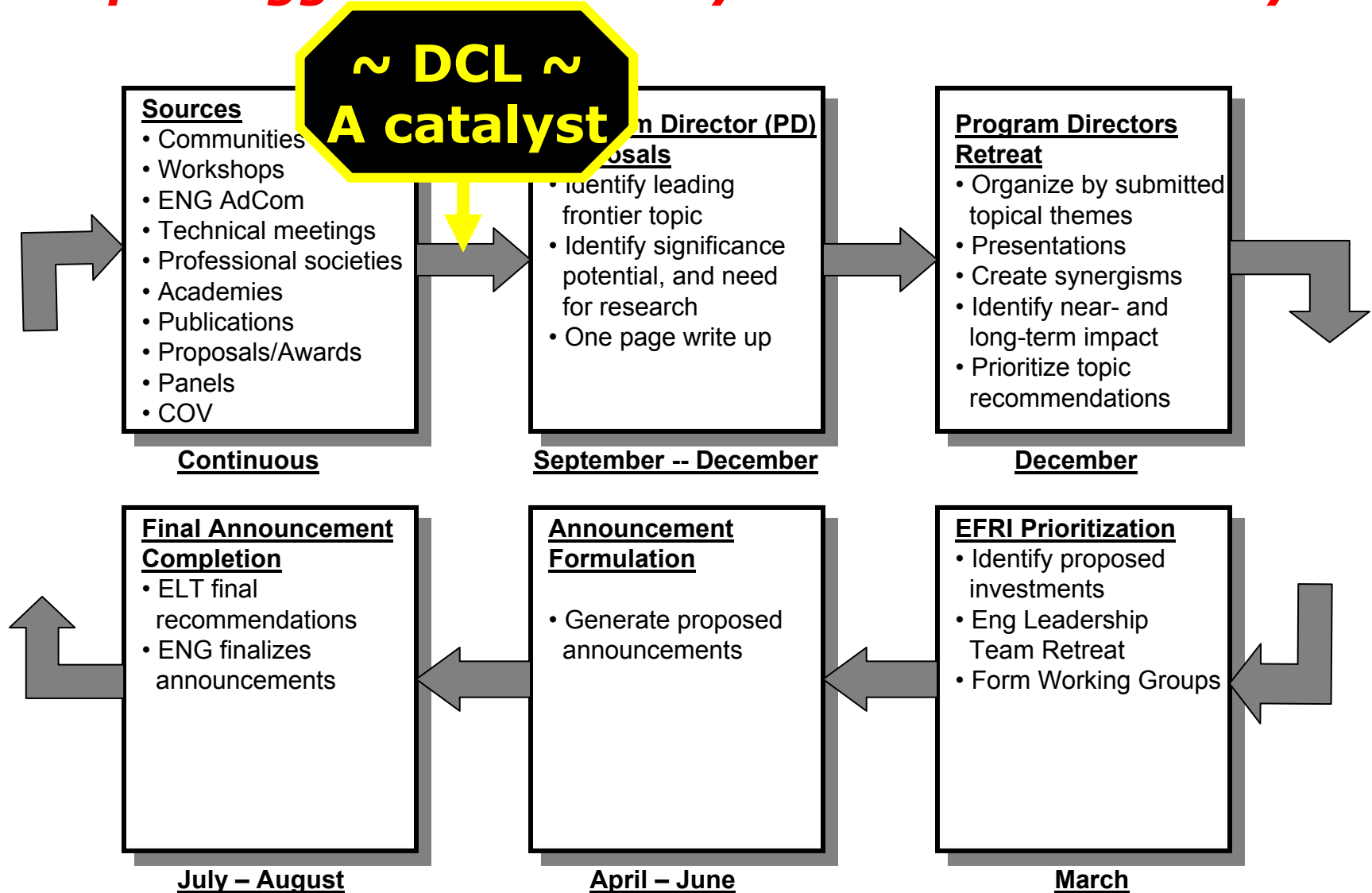
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Lynn Preston, EEC
Kenneth Whang, CISE**

**TEAM MEMBERS:
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Barbara Kenny, EEC
Dagmar Niebur, ECCS
Dennis Wenger, CMMI**

*** Former PD/IPA**



EFRI Annual Process and Plans for FY10 Competition: *Topic Suggestions Directly from the Community*



PLANS FOR FY 10 Competition Dear Colleague Letter (DCL)



GOALS:

- Engender wider community involvement and input into the EFRI process of identifying topics at ***Emerging Frontiers in Research and Innovation***
- Provide a mechanism for submission of well defined ideas for EFRI topics via EFRI website- www.nsf.gov/eng/efri

WHO MAY SUBMIT:

- Individuals and groups may submit suggestions for topic areas
- Format and guidelines will be provided
- Submissions will be confidential
- No direct feedback provided to submitters