Apollo Energy Program
Not Your Parents’ Moon Shot!

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Apollo Energy Program

- Houston, we have a problem!
- Spaceship earth – where are we headed?
  - Understanding our PAT trajectory
- Why is this an Apollo project?
  - BHAG, systems approach, a timeline
- An emergent system
  - Apollo projects abound, pulling together
- Flying spaceship earth
Houston – *We Have a Problem!*

- *And it’s a big one too!*
- Life support systems in trouble
- Accelerating symptoms
- We are way off course
  - Are we sustainable?
- Two CO$_2$ trajectories
  - PAT => 450 ppm
  - Apollo < 450 ppm

*ESA – The Living Planet Programme*
Earth’s *Life Support Systems*

- 24 life support systems on earth
- *All are in decay => accelerating decay*
- Water, air, soil, complex feedback loops
- Ice sheets and arctic sea ice are vanishing
- *And this is just one degree Fahrenheit!*
  - Thermal inertia => we still owe a degree
  - In the next 30 years we will ‘owe another’

*ESA – The Living Planet Programme*
Understanding Vostok

For over 750,000 years there has been a near perfect correlation between CO$_2$, temperature, and sea level rise. It is a very complex relationship => Coupled Carbon Cycle Climate Model feedback.

CO$_2$, one of four key GHGs, doesn’t just affect temperature – it regulates the operating temperature of the biosphere. It is part of a biogeochemical thermostat - the last thing that you would tinker with!
Trajectories for Spaceship Earth

• 2 ppm additional CO$_2$ per year
  – 400 ppm by 2015, 450 ppm by 2032

• 450 ppm is 3 degrees F over historic
  – Dangerous Anthropogenic Interference

• PAT – Population Affluence Technology
  – Increase income 4x => emissions increase 10x
  – 20,000 BTU per $ for very poor
  – 10,000 BTU per $ for developed
Projected CO₂ Emissions – A Look into the Next 30 years

Global carbon emissions have accelerated in recent years, principally due to growth in electrical energy demand from developing countries, especially China and India.

Of primary concern is the growth in coal plants in China, which is adding about 70 GW of electrical capacity annually. These plants have no carbon capture capability, and have a projected lifetime of at least 25 years.

There is a near perfect relationship between carbon emissions and rise in atmospheric CO₂ (Cormia 2005). At the current rate of carbon energy use, we will reach the ‘450 ppm tipping point’ (Hansen 2006) in the year 2032 – just 25 years from now!
Hard or Crash Landing in 2032?

• **450 ppm CO₂ ‘tipping point’**
  – 3 degrees F ‘thermal debt’
  – Over 60 degrees F by 2100

• **Understanding thermal inertia**
  – 25 - 50 year lag to ‘feel’ radiative forcing

• **Calculating the degree years**
  – Prolonged damage from cumulative heat
Thermal Inertia / Degree Years

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<th>Years</th>
<th>Deg-Yrs</th>
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<tr>
<td>2100</td>
<td>3.00</td>
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Forcing / Temperature deg F

Assume 25 to 50 years to warm To 60% of the equilibrium forcing

Degree-years is an estimate of total heat added to the oceans over a period of time
Fourth Generation of Civilization?

Electricity and the Human Prospect - Kurt Yeager, Electric Power Research Institute
Why an Apollo Program?

• **BHAG**
  – Big Hairy Audacious Goal (bend PAT)

• **Systems approach**
  – A dozen interconnected technologies
  – Four dimensional coordinated approach

• **Timeline**
  – We are on a trajectory to crash
  – Need to bend the PAT curve now
Interconnected Human Systems

• **Spaceship earth requires energy for:**
  – Buildings
  – Transportation
  – Industry and work
  – Agriculture
  – Water

• **What would an ideal system look like?**
  – A sustainable techno human / natural system
Techno Visions of the Future

Inhabitants in North America 2107
A Dozen Big Programs to Manage

- Solar
- Fuel cells
- Batteries
- Hydrogen
- Smart energy
- Advanced materials
- Safer nuclear?
- Coal technologies
- CO₂ sequestration?
- Desalinization
- Biofuels
- GMO / nano-bio
Atlas of Apollo Energy Program
NASA-Ames – ‘Spaceship Earth’

- Google tech talks
- NASA-Ames focus
- Energy enlightenment
- Topical seminar series
- Technology critique
NASA GREEN Team

- Jonathan Trent
- John Hogan
- Robert Baertsch
- Lee Bebout
- Brad Bebout
- Tori Hoehler

- Deborah Bazar
- Robert Cormia
- Lisa Chu
- Mel Averner
- Richard Mogford
- Bill Buchanan
Energy Technology Symposia

• October 19\textsuperscript{th} Opening event
• Five symposia focus groups
  – Renewable energy (Nov 07)
  – Transportation (Jan 08)
  – Batteries and fuel cells (Feb 08)
  – Smart energy (Mar 08)
  – Biofuels (Apr 08)
Video Archives and Wikibook

- NASA.gov
  - Details of upcoming events
  - Links to video, wikibook, documents
- Podtech.net
  - Interviews on selected topics
  - On demand video of key events
- www.energy-wiki.com
  - Wikibook / collaborative dialog on technology
Many Apollo Projects

• Over 1 million groups are active in Apollo
• Apollo Challenge
  – http://www.apollochallenge.org/
• Apollo Alliance
  – http://www.apolloalliance.org/
• 25x25.org
• NASA-Ames
  – NASA Green Team
    http://www.nasa.gov/
Many Apollo Networks

- Stanford community
  - GCEP, Woods Institute, and Precourt Institute
- Campus Climate Challenge
  - http://www.climatechallenge.org/
- Cool Cities - http://coolcities.us/
- Presidents Climate Commitment
  - http://www.presidentsclimatecommitment.org/
- US Mayors Climate Protection Agreement
  - http://www.usmayors.org/climateprotection/
Our 4-D Steering Wheel

• We fly this with a pyramid
  – Technology
  – Markets
  – Policy
  – Behavior

• Every corner touches all other corners

• Synergy comes from multiple connections
Steering Spaceship Earth

Technology

Markets

Policy

Behavior
Playing all Four Corners

• Techno-policy examples
  – Buildings and solar / AC
  – Petroleum and vehicles
  – Carbon capture – carbon tax
  – Direct access power purchases
  – *Carbon neutral communities*

• Make *visible policy decisions* that reinforce technology, affecting markets and behaviors
You Can Fly Spaceship Earth

• Grab hold of the pyramid
• Get involved with policy
• Make demonstrative choices
• Be a conspicuous example
• Make this a voting issue!
Local Carbon Projects

• *Know your emissions!*
• Set a GHG reduction goal
• Build or join a network
• Follow a simple strategy
  – *Lean it*
  – *Green it*
  – *Offset it*
• *What get’s measured gets managed*
Be Proud of Your Power!

• Energy should be:
  – Affordable
  – Reliable
  – Responsible

• Talk with your vendor
  – Green-e certified power
  – PG&E ClimateSmart offsets

100% Wind Energy

http://www.pge.com/climatesmart/
Vote with Your Dollars

• **You can hit three corners at once**
  – Behavior
  – Markets
  – Technology

• **Invest in sustainable technology**
  – *Take an equity position in a sustainable economy*

• **Promote new technology adoption**
  – RECs, offsets, low carbon, high efficiency products
The Need for **Personal Leadership**

- You, and I, set an example in behavior
- *Show others by doing, and explaining*
- Be an example in what / how you purchase
- *Talk with ‘electeds’ about your concerns*
- Become politically active – and useful
- *Can you drive a local climate action plan?*

If you are going to fly spaceship earth – you need to be a leader, not just a passenger!
Prepare for a Very Rough Ride

- Turbulence ahead!
- Climate change is here today
- Can you help in mitigation?
  - Drought
  - Famine
  - Disease
- Keep the world at peace in a time of crisis
No Time for Distractions

- *Stay focused on the pyramid*
- Solve problems as they arise
- Diplomacy rather than force
- Calculate the opportunity cost
- *Keep your eyes on the prize!*

[Image of United Nations Headquarters]
Success vs. Failure

• There is no ‘moon landing’ in this effort
  – We can measure carbon intensity of energy*
• We are bending a PAT curve – below 450 ppm
  – We can measure emissions / $ of income / capita*
• Success means we did everything we could
• Failure is not to try, or worse, not to care
• We, and you, are rebuilding - Civilization 2.0

*These need to be on the dashboard of spaceship earth, this is what we manage
Do You Have the Right Stuff?

- Innovation
- Collaboration
- Leadership
- Discipline
- Will to win!
Failure Is Not an Option

- The future is counting on us!
- You *do* have ‘the right stuff’
- This is a BHAG – and doable
- *Steering this is the hard part!*
- Be the change you want to see in the world
  - We can do this, *but not without leadership*
  - *Because failure isn’t part of our vocabulary!*
References

- GCEP - [Global Climate and Energy Project](http://www.global-climate-energy-project.org)
- Presidents Climate Commitment
- [US Mayors Climate Protection Agreement](http://www.usmayors.org)
- Alliance for Climate Protection – [climateproject.org](http://climateproject.org)
- Campus Climate Challenge - [climatechallenge.org](http://climatechallenge.org)
- ESA Living Planet Programme