2002 Combustion Technology University Alliance Workshop

Break-Out Session Summary
September 12-13, 2002

National Energy Technology Laboratory

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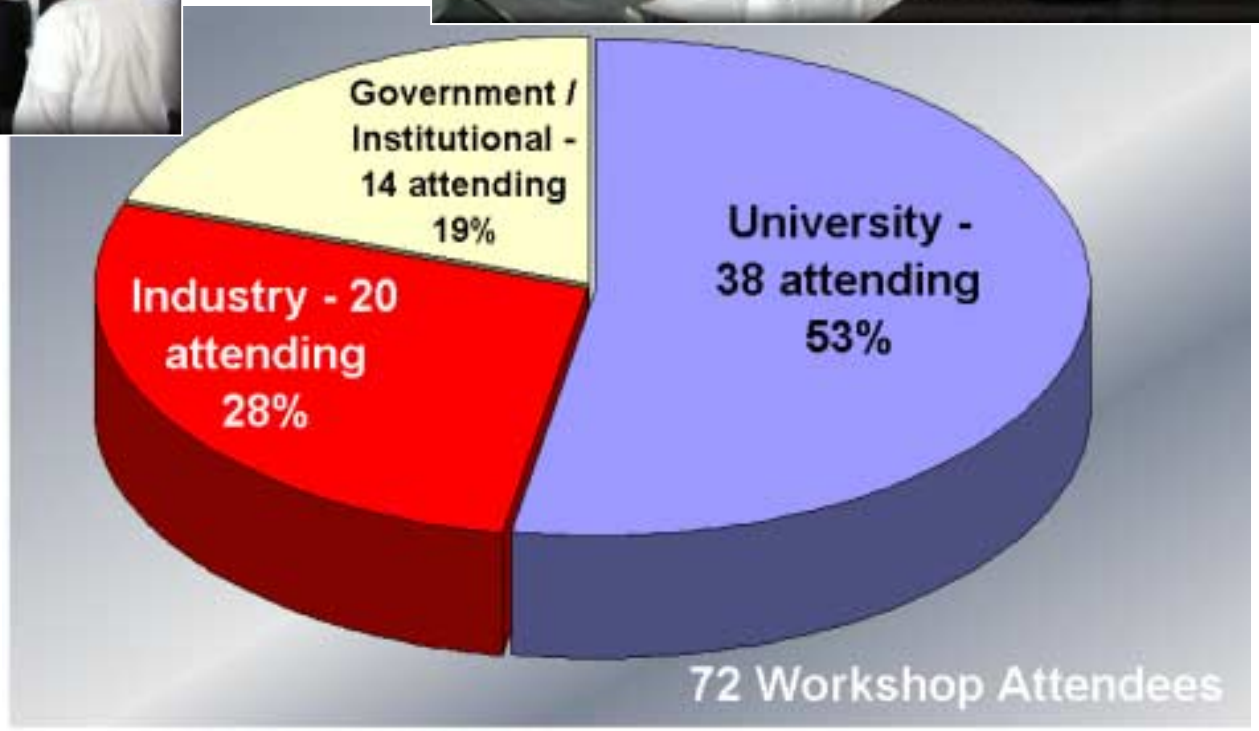
Salt Fork
Salt Fork

Demographics of Attendees



Three Break-Out Groups

- Those attending were assigned to one of three break-out groups
- The groups met in two half-day sessions
- These groups evaluated a number of technology areas, and assigned their own priorities for need for applied R&D
- The slides that follow summarize the combined observations from the three groups

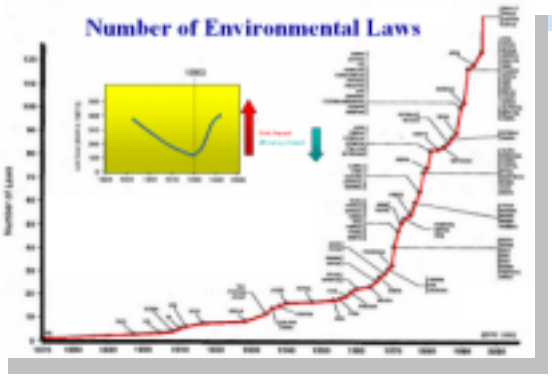
Group 1

Group 2

Group 3

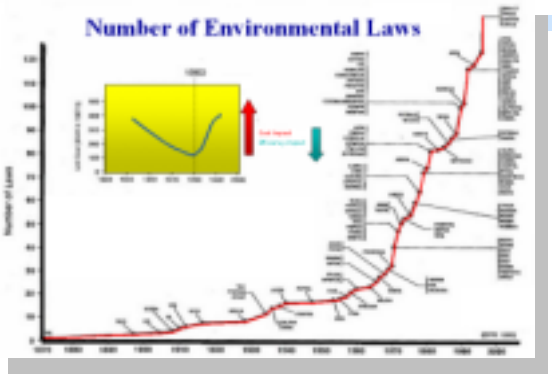
The Main Issues

- **Emissions Concerns**
- **Collaboration Barriers (real or perceived)**
- **Combustion issues**
- **Policy issues**
- **Remaining issues, in descending order of votes, were:**
  - Coal, Instrumentation/control issues
  - Modeling issues
  - Steam Cycle issues
  - Materials handling and economics, and
  - Ash Use



Top Environmental Emissions Control Issues

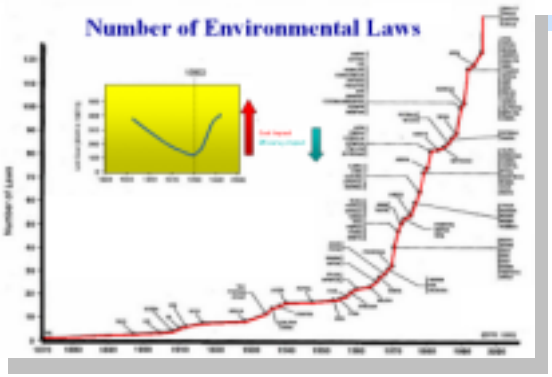
- **Multi-pollutant control**
  - Avoid cross problems
  - Single process with improved sorbents and catalysts
- **Mercury capture and monitoring: fate of mercury, disposal of reagents afterwards; Mercury capture and disposal**
- **Applied research to better understand the underlying reaction chemistry (SOx, NOx, Hg) during combustion**



Other Environmental Emissions Control Issues

Middle Interest

- **Measuring other heavy metals**
- **Reburn techniques to lower the NO floor**
- **Understanding ash characteristics to avoid sintering and bridging**
- **What is the effect on byproduct sales from the use of the new pollution control equipment / processes?**
- **Ultra-fine particulate removal**



Emissions of Mercury (Hg)

- Specific R&D focused on Hg capture may not be required, since in the long term Hg will be captured with other pollutants and CO_2
- Scrubbers, especially multi-pollutant types, will capture a large fraction of the exhaust-bound Hg, however, ash-bound Hg (in bed ash) will not be captured this way
- R&D is required to assess the fate of Hg in specific systems. Before we can set out to effectively capture Hg, we need to know where it ends up in the system, and in what forms. This can vary between systems, and possibly between fuels in a given system

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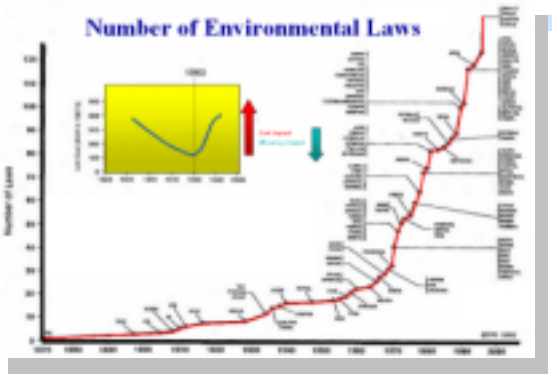
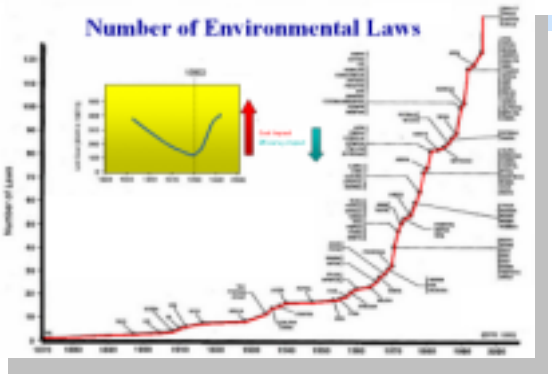


Emissions of Mercury (Hg)
(continued)

- **Recommended Activities:**
  - Increased mechanistic understanding of the fate of Hg and other heavy metals; how does this compare to field data?
  - Need an accurate, reliable on-line method to measure Hg
  - Make sure work is coordinated with existing plant data
  - Assess Hg behavior in O_2-enriched combustion and partial gasification systems
- **Hg SCR issues**
- **Oxidation, extraction, capture**
- **Metal vapor, substrate interactions**
- **Absorption by raw materials**



Nitrogen Oxides

- Need alternatives to SCR- and SNCR- (ammonia) based reduction
- Need to develop alternative catalytic reduction techniques (e.g., carbon-based catalysts)
- Assess multi-pollutant control (SOx / NOx) – development of new system or better understand existing systems
- Multi-pollutant solutions systems approach
- Mechanisms of advanced reburning and predictive modeling
- Evaluation of O_3 (ozone) oxidation of NOx, including Hg removal

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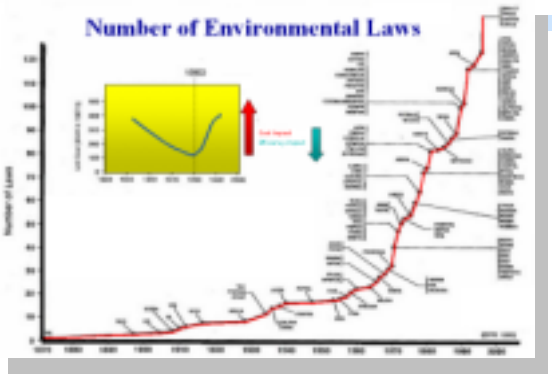
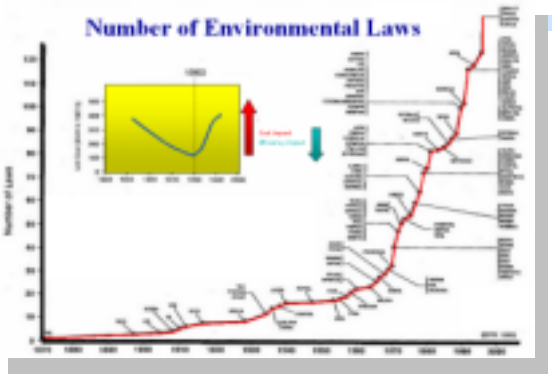


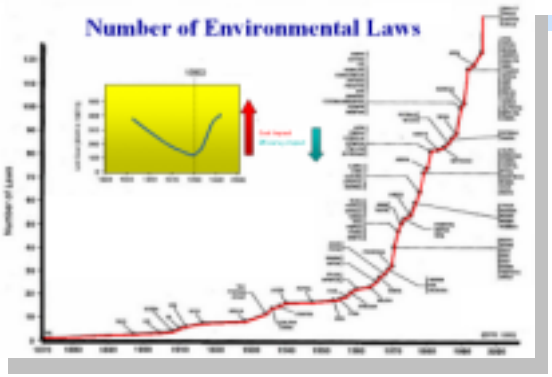
Nitrogen Oxides
(continued)

- **Emissions Control: Ultra Low NOx Through Burner Modifications**
  - For existing PC plants
  - Predictions of flame ignition & attachment Combustion efficiency
  - Corrosion
  - In-furnace NOx control
  - Self diagnosing, self tuning, adaptive control



Carbon Management

- Life-cycle analysis needs to be done first
- Develop process schemes that include combustion for Vision 21 (including energy-crop management)
- Assess advanced combustion processes



Other Emissions Related Issues

- **Emissions Control – By-Products**
  - Reuse sludge from water solutions
  - Activated carbon injection
  - Extract products from ash
- **Emissions Control – Long Term Chemical Stability Corrosion mechanisms, models**
  - Corrosion resistant materials
  - Oxidation mechanisms (solutions, coatings)
  - Metallurgical issues
  - Life, creep, fatigue
  - Codes – USCS, ASME

Combustion

- **High intensity O_2 combustion**
  - understanding the physics
  - changing chemistry, and
  - effects on Hg, NOx, and minerals
- **Re-address high-temperature / high-pressure gas cleaning**
  - make sure it addresses advanced systems

Coal/Fuels

- Generally, these are very site- and fuel-specific; technology applications would be application-specific
- Investigate pre-combustion removal of S, N, etc.
- Suggest integrate with Vision 21 roadmap

Top Ultra-Supercritical Issue

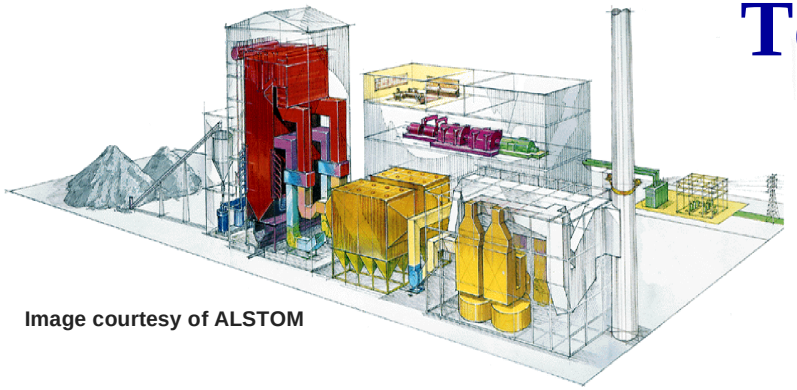


Image courtesy of ALSTOM

Group 2 defined an ultra-supercritical (USC) cycle as one having a steam plant with over 1150ºF steam temperature and over 4,000 psig throttle pressure.

- **Materials that can be assembled into a USC in a cost-superior manner, considering:**
  - composition of materials
  - fabrication/welding
  - corrosion resistance
  - the net present value of the improved materials must be below the increment in benefit from their use
  - High strength / high temperature materials
  - Defect-free materials
  - Ceramics

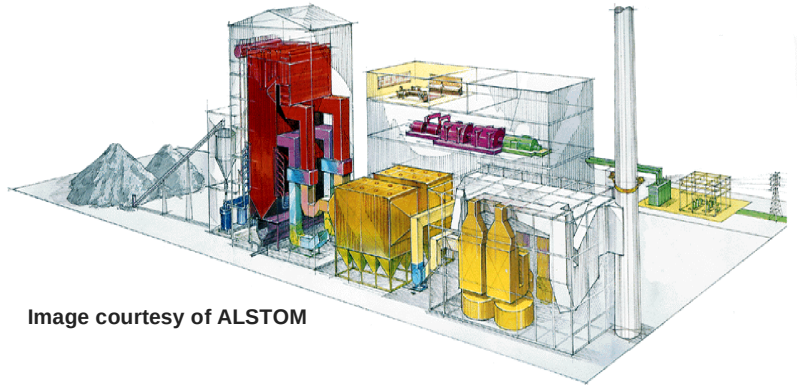


Image courtesy of ALSTOM

Other Middle to Low Interest Ultra-Supercritical Issues

- Formulation of new alloys for high temperature for both the steam generator ('boiler') and the turbine
- USC water chemistry
- Steam turbine design is as critical as the steam generator ('boiler') design
- Complex chemistry modeling for this environment
- Establish solids heat transfer in circulating fluidized bed (CFB) so there is adequate heat transfer, since a CFB bed has a much closer temperature approach to USC steam temperatures
- Exotic lubricants

Top Vision 21 Issues

- **Oxy-combustion, high-intensity combustion design, cooling, corrosion, etc.**
  - Blown coal combustion, NOx
  - Partial gasification, char, integrating with fuel cells
  - Toxic metal control
  - Flame-enrichment, ignition
  - Reduce CO_2 Capture costs
  - Ash effect
- **CO_2 sequestration, and possible re-release of CO_2 in the future**
- **Vision 21 Solids**
  - Bed dynamics,modeling, attrition, agglomeration, slagging
  - Beyond cyclones
  - Ultra-structure effect

Other Vision 21 Issues

Middle Interest

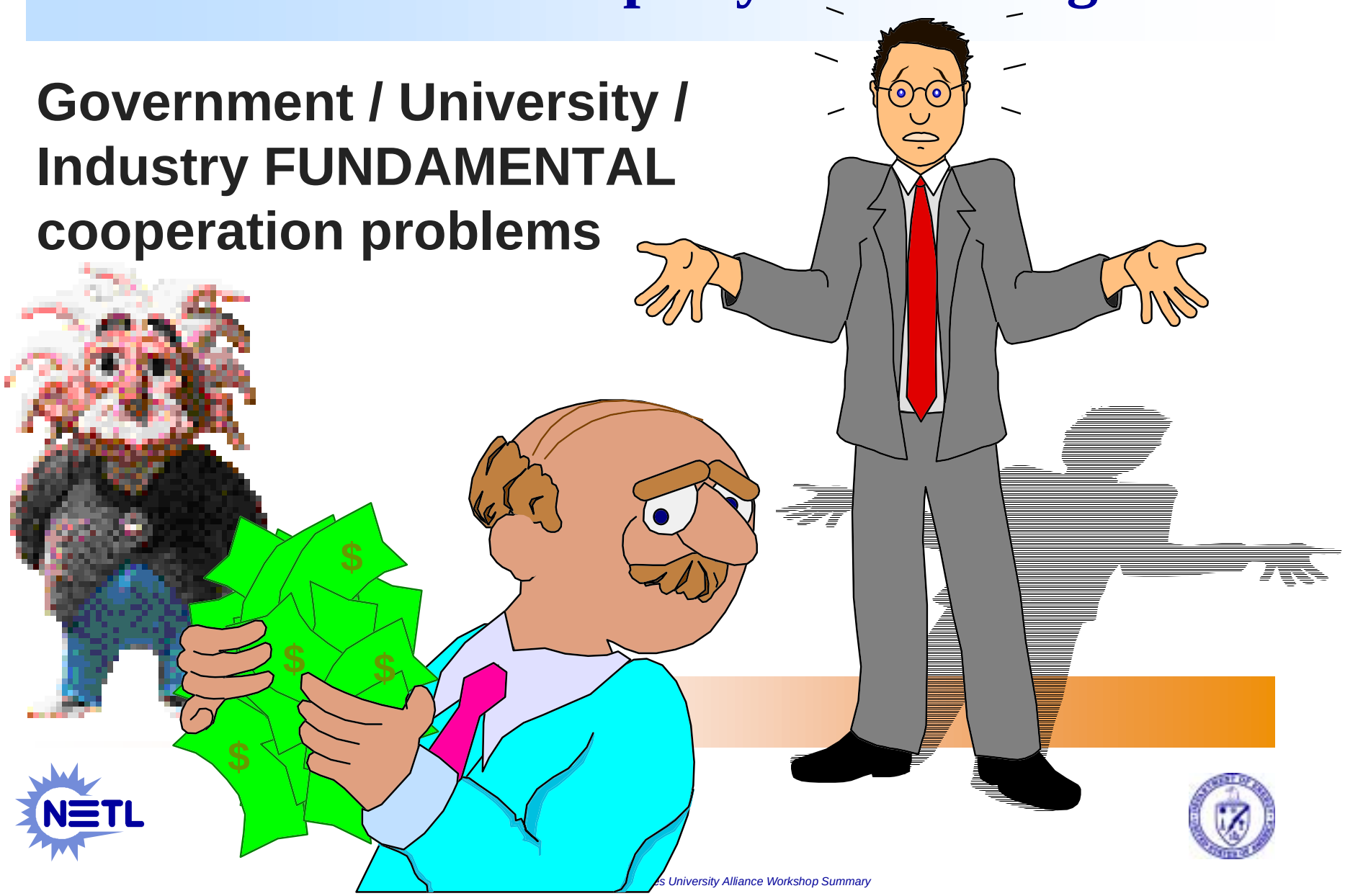
- **Materials (solids handling)**
- **Dust control 1600ºF high temperature filtration**

Oxygen Production

- Develop low-cost air separation
- Assess new techniques for air separation, production, and delivery
- The type units and technology needed will probably be different than those designed to serve gasification systems

Intellectual Property and Timing

Government / University / Industry FUNDAMENTAL cooperation problems



Observations

When thinking about research, there is and remains a continued gap between the university and industry:

- **Industry people think short-term applied research**
- **University people persist in thinking long term…**

This gap needs to be bridged

The *PROCESS* Has To Be Fixed

The Combustion Technologies University Alliance can be an important catalyst that removes some of the barriers hindering the successful exchange of projects and ideas between the Universities and Industry -- particularly, removing barriers in:

- **Intellectual property ownership**
- **Re-engineering the timing difference between University and Industry Funding**

Intellectual Property Ownership
PROBLEMS

- Intellectual property makes or breaks a project
- Its one of those issues always out there
- If you're serious, you need to get this decision settled early on, or you're wasting everyone’s time
- 100% Government funding, the Government retains the rights, it belongs to the public. When co-funding with Industry or Universities, it get murky.

Intellectual Property Ownership
SUGGESTIONS

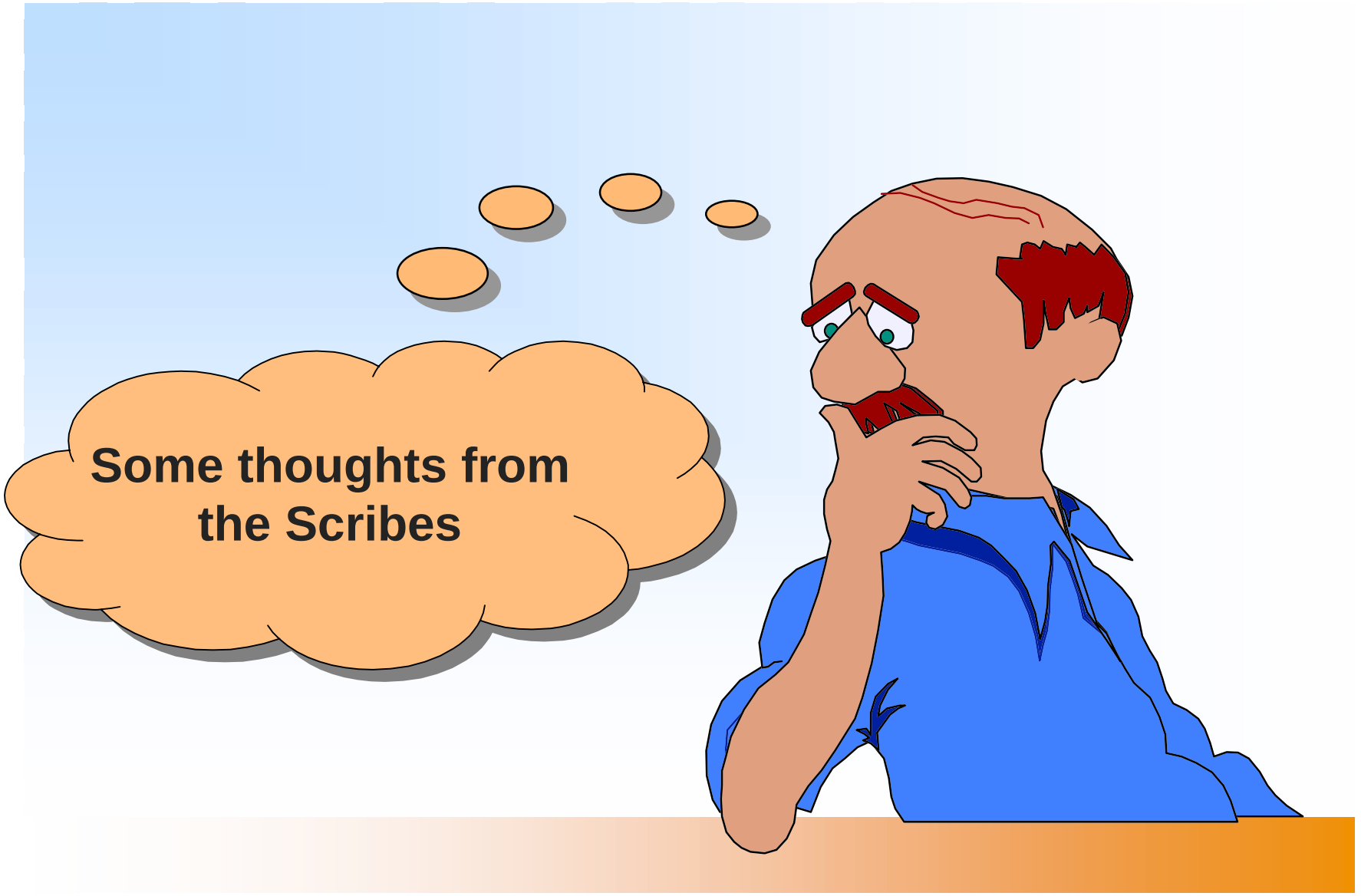
- DOE can act as catalyst to get University Intellectual Property (IP) Experts to meet with Industry IP Experts
- A set of bylaws or 'model agreements' should be established for the Alliance, perhaps multiple models for different funding fractions between DOE, University, and Industry
- "If you want to play, you will use these guidelines"
- A good starting model is in the SBIR and STTR requirements
- ONE MODEL: one Industry has a pre-arranged Agreement with one University: patent owned by University, have pre-agreed exclusive license arrangement, balanced to Industry investment, so the Industry knows the situation in advance, going in. University gets committed support for x-number of scholars who in turn are committed to working on that company's specific projects

Re-Engineering the Timing Difference Between University and Industry

- Scholar funding in advance, so the student will be there in the pipeline to avoid delay when work is needed
- Its hard to do applied work when your skill is graduated every two years and new person has to be retrained
- Graduate student model is geared more to basic research than to applied research
- Don’t ignore the important mission of training the next generation; post-docs may make life easier for Industry, but is missing the critical function of training the new people

Things the Alliance Can Work On:
Re-Engineering the Timing Difference Between University and Industry

- Develop a constant funding source
- DOE can maintain a data base of expertise, to show who would be suited to solve the problem, DOE can be the data base source
- DOE can maintain a data base of problems seeking solutions
- Data base of students coming out of graduate school and where are they are: a high-level employment clearing house
- Alliance establish regional Industry visits / roundtable; industrial open-house


Some thoughts from
the Scribes

Clearer Description of Vision 21 Needed

- In future workshops, additional time should be devoted to better outlining the specific equipment that is the focus of Vision 21 discussion

More Attention to Low Cost!

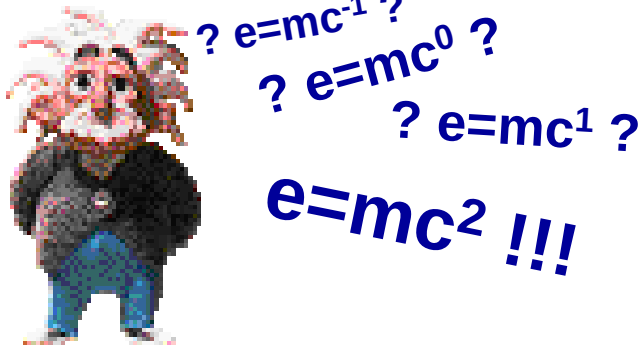
- **The scribes were surprised how limited the attention was to developing innovative *LOW COST* power plant approaches:**
  - Developing new lower-cost designs,
  - System design approaches aimed to lower cost,
  - Novel fabrication methods (faster, fewer parts, mould-to-final shape, factory-fabrication, quicker assemble)
  - Developing lower-cost materials
  - Easier to operate and maintain designs
- **University focus aimed solely at lowering cost, an important Vision 21 goal, should be given specific attention**
- **The scribes suggest that in future workshops a session be devoted to encouraging innovation leading to novel lower-cost plant designs**

…but…What About the "Low Votes" Issues

This summary lists only the issues having 'higher' votes …

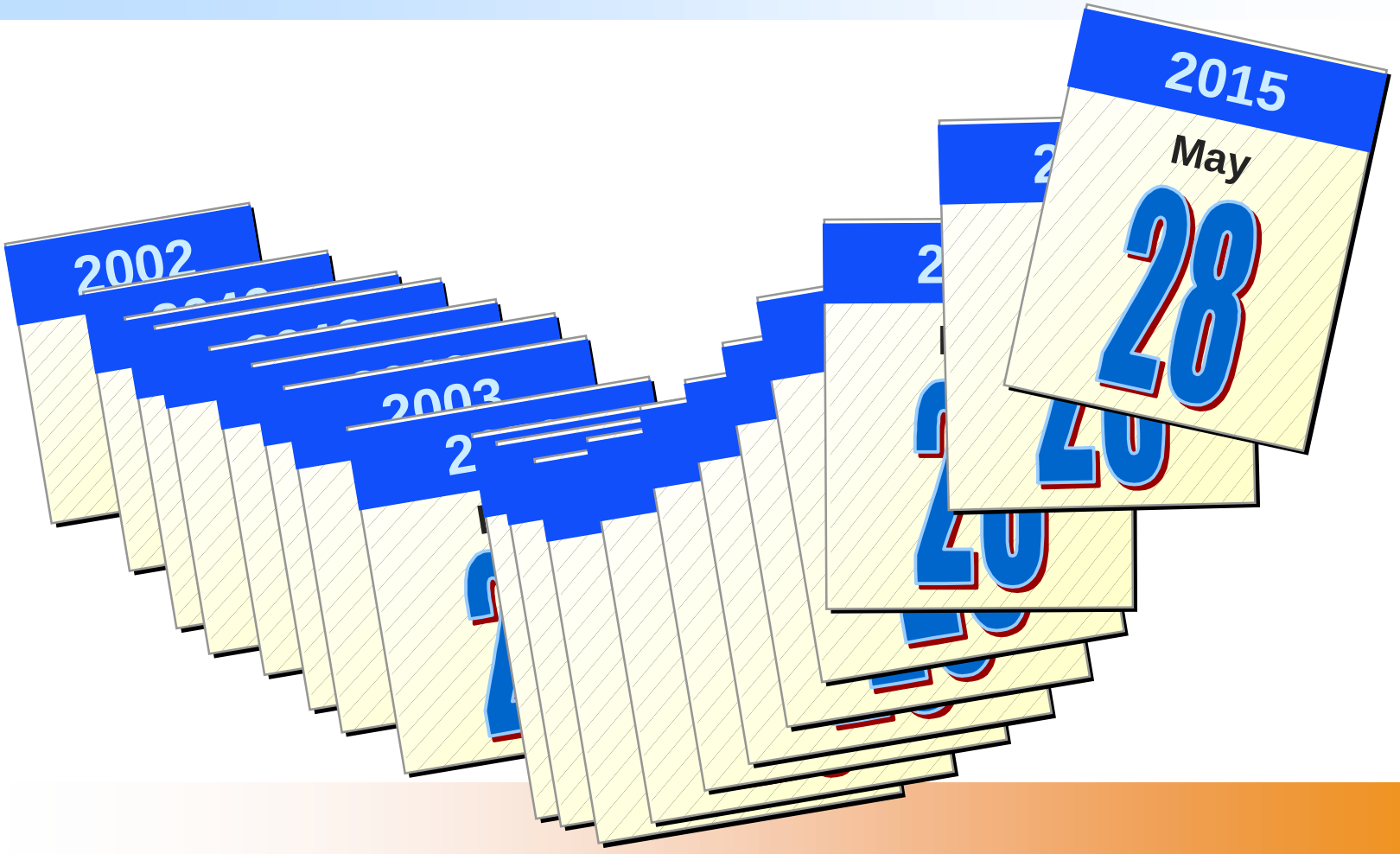
- **The votes prioritize those areas the collective group wished to concentrate their discussion time on**
- **This DOES NOT mean that lower priority issues are bad ideas, the more ideas, the better!**
- **This DOES NOT mean that lower priority issues shouldn't be funded… people should be encouraged to submit proposals in these areas…**

THERE ARE *NO* BAD IDEAS



… but do you have a new ideas for a higher priority issue area?

So…Where Do We Go from Here?




...Thats all

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