2004 DOE Program Review Presentation

Hydrogen Generation from Electrolysis

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May 2004

TELEDYNE
ENERGY SYSTEMS, INC.
A Teledyne Technologies Company

Power Systems

Better Engineered Solutions.
What Listening Generates.

Objectives

- To advance water electrolysis technology and develop an Electrolytic Hydrogen Generator with the following features:
  - Delivers hydrogen at high-pressure, 5,000 psig
    - Develop a relatively inexpensive hydrogen generation & pressurization solution
      - Collaborate with compressor manufacturer
      - Collaborate with power supply manufacturer
  - Production capacity 10,000 scfd
  - High conversion efficiency
  - Cost objective < $600/kW for 10,000 units per year
  - Reliable, low maintenance cost, & durable

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Budget

- Total funding for the project = $3,127,764
  - DOE share = $1,563,882
  - TESI share = $1,563,882
- Total funding in FY04 = $490,000
  - DOE share = $245,000
  - TESI share = $245,000

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Technical Targets & Barriers – Efficiency

Based on 2005 Targets & LHV of H_2		
Characteristic	**Target**	**Barrier**
Power Conversion	Efficiency = 96%	AC to DC: Turndown ratio & rectification technology DC to DC: Matching power source with the H2 Generator
Cell Stack	Efficiency = 70%	Membrane resistance, catalyst technology, corrosion due to hi-temp operation
Balance of Plant	Efficiency = 97%	Gas purification technology & other parasitic losses
Compression	Efficiency = 90%	High-pressure gas generation and motor & compression technology

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Technical Targets & Barriers – Cost

Based on 2005 Targets & LHV of H_2		
Characteristic	**Target**	**Barrier**
Power Conversion	Cost = $0.21/kg	Mfg & Rectification technologies
Cell Stack	Cost = $0.79/kg	Mfg & Production technology
Balance of Plant	Cost = $0.14/kg	Gas purification & mfg technology
Compression	Cost = $0.21/kg	Compression & mfg technology

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Approach

- Develop low-cost, high efficiency, & safe alkaline water electrolysis system for hydrogen production
  - Small-scale membrane testing & development for high-pressure and high-efficiency
  - Conceptual system optimization
    - Pressure vs. hardware cost trade studies (As the system and compressor pressures increase, the cost of components increases.)
  - Optimize cell, stack, & system designs
    - Catalysts
    - Parasitic loss reduction
    - Power supply & compressor optimization
    - Design for manufacturing & assembly

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Project Safety

- TESI has over 30 years of commercial hydrogen generation and safety related experience.
  - Users are trained to safely operate the systems.
  - Generators are typically monitored for cross-contamination and out-of-tolerance conditions.
  - Generator installation areas are constantly monitored for hydrogen concentrations and sometimes infrared emissions.
- HAZOP & FMEA studies will be performed as part of the trade studies and on final system.

Project Timeline

03/04 - 09/04	10/04 - 9/05	9/05 - 9/06	10/06 - 02/07
Phase I	Phase II	Phase III	Phase IV
1 2 3	4 5	6 7 8	9

- Phase I – Feasibility
  1. High-pressure membrane testing
  2. High-pressure cell design & testing
  3. Component trade studies
- Phase II – System Conceptualization
  4. System conceptual design & trade studies
  5. Stack modeling & design

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Project Timeline (cont'd)

03/04 - 09/04	10/04 - 9/05	9/05 - 9/06	10/06 - 02/07
Phase I	Phase II	Phase III	Phase IV
1 2 3	4 5	6 7 8	9

- Phase III – Finalize design & Implementation
  - 6. Complete system design & component selection
  - 7. DFMA studies
  - 8. Build demo unit
- Phase IV – Site Test
  - 9. Factory test & deliver demo unit to site, begin site testing, performance verification, public awareness & education

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Interactions & Collaborations

- AeroVironment Inc.: Charles Botsford – Maximizing safety, reliability, power conversion efficiency, and reducing cost.
- Pdc Machines, Inc.: Sy Afzal - Maximizing safety, reliability, & compression efficiency, and reducing cost.
- Maryland Energy Admin.: W. Dale Baxter - Cooperation for providing a demonstration site and public education & awareness.

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Future Work

PRODUCT PORTFOLIO

- Perform according to the timeline

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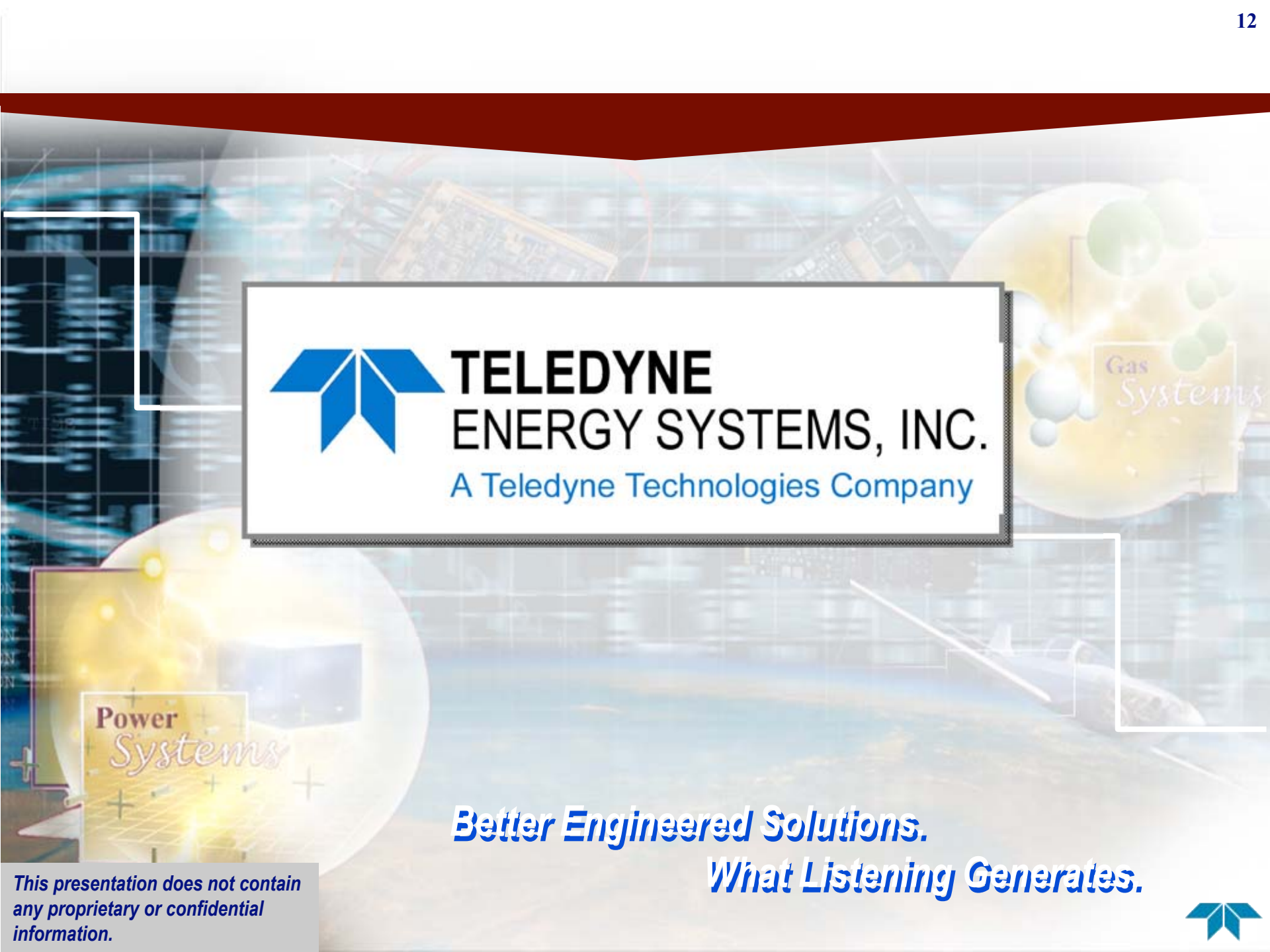

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