EHS in Renewable Energy Industry

WESTON SEMINAR
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Safety: Renewable Energies vs. Fossil Fuels

- Sumner-Layde Fuel Cycle Comparison (JAMA 2009)
  - Review of 3 renewable energies vs. fossil fuels
  - Mining (second most dangerous) with 27.5 deaths per 100,000 workers
  - Agriculture Industry (most dangerous) with 28.7 deaths per 100,000 workers
  - Average for US Industries is 3.4 deaths per 100,000
Fossil Fuels Notes

- Fossil fuel workers risk injury from extraction activities
- Extraction activities isolate workers from prompt EMS
- Fossil fuel extraction is a continuous process
- Fossil fuel production has risk of catastrophic incidents
- No. of extraction fatalities correlate with extraction frequency
- Many renewable energy technologies alter the traditional fuel cycle and reduce or eliminate fuel extraction phase
Biomass (Energy Production from Crops: Corn to Ethanol)

- Requires continuous extraction and combustion
- Petroleum–based fertilizers provide additional hidden injury costs
- No reduction expected in extraction related occupational fatalities
- No occupational safety benefit relative to fossil fuel predicted

Biomass (Energy Production from by-products: corn husks, wood chips)

- Requires continuous extraction and combustion
- By-products from ongoing activities and no increase in extraction
- Possibly safer alternative
Sumner-Layde Conclusions

Photovoltaics (Solar Energy)

- Raw material extraction only occurs once during life cycle (20-30 yrs): 1 time event
- Risk of catastrophic event limited
- Some hazards, such as working at heights, also found in fossil fuel
- Maintenance accident are most likely. Trends show panel maintenance decreasing
- Electricity distribution risks similar to fossil fuel
- Solar energy generation compares favorably with coal
PV Module Fabrication
III-V Specific Hazards

- Very similar to GaAs semi-conductor industry

- Chemical
  - Gases: $\text{AsH}_3$, $\text{PH}_3$, $\text{H}_2$, etc.
  - Liquids: metal organics, HF, acids, bases
  - Solids: Pb, slurries from wire-saws

- Equipment
  - Glass reactors
  - High temperature
  - Abatement systems

- Key Issues
  - Highly toxic gases
  - Chronic heavy metal oxides
CIGS Specific Hazards

- **Chemical**
  - Gases: typical industrial, possibly $\text{H}_2\text{S}$, remote $\text{H}_2\text{Se}$
  - Liquids: $\text{CdSO}_4$, $\text{NH}_3\text{H}_2\text{O}$, Thiourea, $\text{HCl}$, etc.
  - Solids: Se, Cd

- **Equipment**
  - Conveyers
  - High temperature
  - Vacuum

- **Key Issues**
  - Chronic exposure
  - Se (vapors and forming $\text{H}_2\text{Se}$)
CdTe Specific Hazards

- **Chemical**
  - Gases: typical industrial
  - Liquids: typical industrial
  - Solids (powders): Cd, Te, CdCl, possibly Hg & Pb

- **Equipment**
  - Bead blasting edges
  - Laser scribing cells (5% of film)
  - Robotics

- **Key Issues**
  - Chronic heavy metal exposure
  - Recycling
a-Si Specific Hazards

- Very similar to flat panel display industry
- Chemical
  - Gases: SiH₄, GeH₄, H₂, dopants, etc.
  - Liquids: detergents
  - Solids: metal and oxide targets
- Equipment
  - Conveyers
  - Vacuum
- Key Issues
  - PECVD processing
  - System maintenance
c-Si Specific Hazards

• Very similar to semi-conductor industry
• Chemical
  o Gases: SiH$_4$, NH$_3$, Ar, etc.
  o Liquids: HF, acids, bases, POCl$_3$, P$_2$O$_5$, B$_2$O$_3$
  o Pastes: B and P containing
  o Solids: Pb, slurries from wire-saws
• Equipment
  o Conveyers
  o High temperature
  o Casting process
• Key Issues
  o PECVD of SiN layer
  o Bulk Si processing
PV Fabrication Controls

- Restricted flow orifices
- Gas cabinets and gas bunkers
- Ventilated tubeways
- All welded tubing
- Excess flow valves
- Scrubbers
- Minimum quantities
- Purge cycling
- Redundant regulators
- Pressure transducers
- Automatic control valves NFC
- Gas detection
- H-5 occupancy construction
- Exhaust ventilation N+1 and standby
- Extensive work control/authorization
Residential Photovoltaic Installation

Photo by John Prieto
The Denver Post 9/18/11
Wind Energy

- Raw material extraction only occurs once during life cycle (20-30 yrs): 1 time event
- Risk of catastrophic event limited
- Some hazards, such as working at heights, also found in fossil fuel
- Maintenance accidents most likely to occur
- Electricity distribution risks similar to fossil fuel
- ExternE Project indicated injury costs for complete wind cycle compare favorably with coal and oil power cycles
What’s Inside The Nacelle

- Rotor
- Gearbox
- Disc Brake
- Generator
- High Speed Shaft
- Low Speed Shaft
- Pitch Drive
- Yaw Drive
Hazards & Prevention

**Hazards**
- Electrical (up to 13,200 VAC)
- Climbing/ working at height (300-450 ft)
- Falling/ flung objects
- Noise
- High pressure (hydraulics, compressed gas)
- Burns/ fire (overheating, welding)
- Heavy lifting, hoisting & rigging
- Rotating machinery
- Torque and Tensioning tools (Bolting)
- Confined spaces
- Environmental - lightning, snakes, extreme winds...
- Heavy equipment operation
Hazard Control

**Engineering Controls**
- Elevators & Service Lifts
  - Eliminate Climbing & Fall Hazards
  - Reduce Fatigue
- Climb Assist Systems
  - Reduce Fatigue
- Turbine Safety Systems
  - Pitch Control & Yaw System / Regulate Speed
  - High Speed Cut Out / Prevent Over Speed
  - Arc Flash Detection Systems
  - Extinguishing Systems (Proposed)
  - Lightning Protection Systems
- NREL Lightning Detection Systems
- Live Weather Displays (wind speed, wind chill, etc.)
Hazard Control

- **Methods and Work Practices**

- Competent, experienced workers with demonstrated proficiency
- Mentoring & training
- Vested interest in safety, supportive safety culture
- Trained eyes – work activities, inspection & maintenance
- Dedicated team of experts
- Well-defined assignment of roles and responsibilities
- Practical safety procedures
- Pre-Task safety meetings
- Critique of completed tasks to ID improvement opportunities.
- Incorporate Lessons Learned
- Hazard ID and Control Process
On average extraction activities in oil and gas account for 100 deaths annually.

Coal extraction account for more than 30 deaths annually.

Elimination of fossil fuel extraction phase may avert 1300 worker deaths next decade.
1. Make occupational safety and health a priority by leveraging the purchasing power that government and industry already have, be it via contracts or grant authority.

2. Integrate occupational safety and health data collection and monitoring into codes and standards of practice that already have wide support, so that improved safety and health protections also become standard practice.

3. Improve the data collection process to identify and understand safety and health risks and use those data to promote occupational safety and health investment more effectively.

4. Create better methods and better standard references that can be used by occupational safety and health professionals to better protect workers.

5. Invest more time and resources to train exposed populations and to increase awareness by those who may be unaware that they are being exposed to controllable risks.

6. Fix broken regulations—i.e., those where there are gaps in safety and health coverage mandates.

7. Conduct market research to create new motivators that will inspire owners, employers, and workers to make occupational safety and health a priority that cannot be ignored.
Integrated Safety Management System
• **LINE MANAGEMENT RESPONSIBILITY FOR SAFETY.** Line management is directly responsible for the protection of the public, the workers, and the environment.

• **CLEAR ROLES AND RESPONSIBILITIES.** Clear and unambiguous lines of authority and responsibility for ensuring safety shall be established and maintained at all organizational levels.

• **COMPETENCE COMMENSURATE WITH RESPONSIBILITIES.** Personnel shall possess the experience, knowledge, skills, and abilities that are necessary to discharge their responsibilities.

• **BALANCED PRIORITIES.** Resources shall be effectively allocated to address safety, programmatic, and operational considerations. Protecting the public, the workers, and the environment shall be a priority whenever activities are planned and performed.

• **IDENTIFICATION OF SAFETY STANDARDS AND REQUIREMENTS.** Before work is performed, the associated hazards shall be evaluated and an agreed-upon set of safety standards and requirements shall be established which, if properly implemented, will provide adequate assurance that the public, the workers, and the environment are protected from adverse consequences.

• **HAZARD CONTROLS TAILORED TO WORK BEING PERFORMED.** Administrative and engineering controls to prevent and mitigate hazards shall be tailored to the work being performed and associated hazards.

• **OPERATIONS AUTHORIZATION.** The conditions and requirements to be satisfied for operations to be initiated and conducted shall be clearly established and agreed upon.
Hierarchy of Controls

1. Eliminate hazard or substitute with lesser
2. Engineering Controls
3. Administrative Controls
4. PPE
“Whereas many health benefits associated with a reduction in high carbon dioxide emission energy production may be perceived by some as distant or uncertain, prevention of deaths of energy workers as a result of an improved occupational safety profile of renewable technologies has the potential to be immediate, obvious and sizeable.”

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Questions?

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