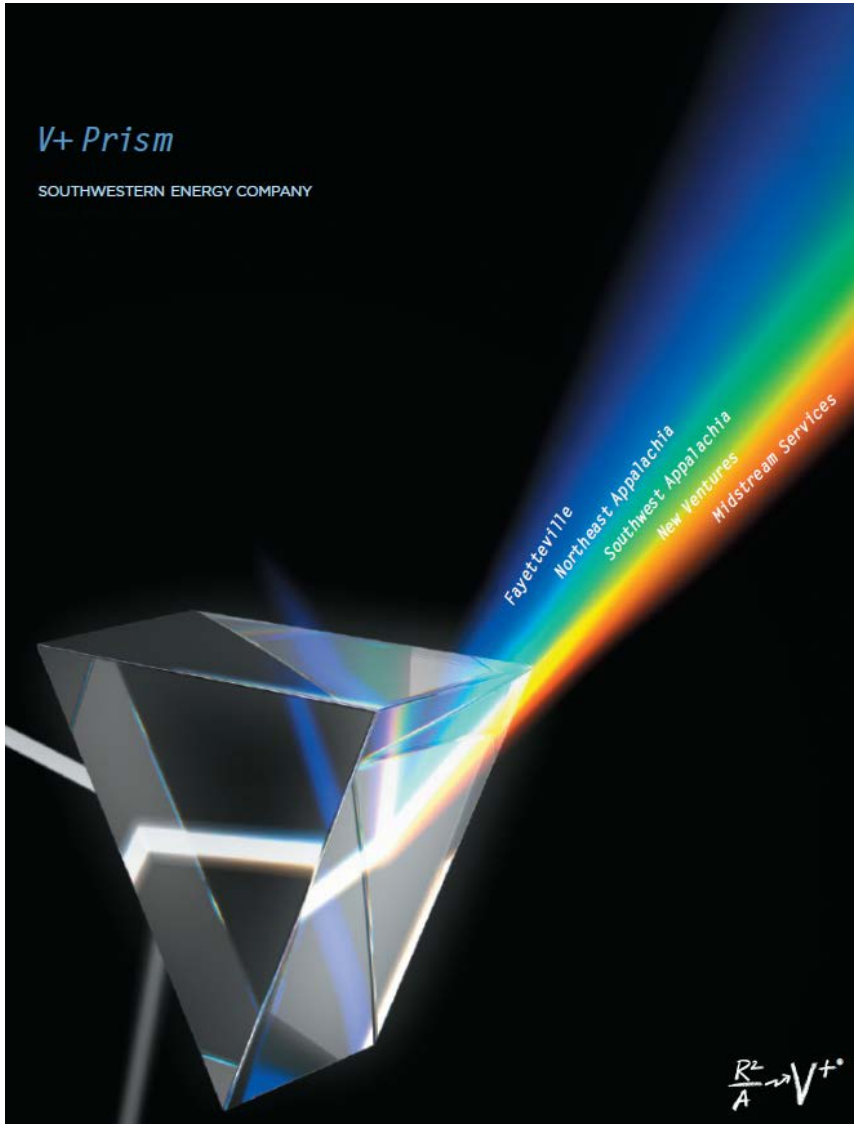

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Oil & Gas Industry Electric Power For Upstream Operations

Donald K. Sevier

Overview of Presentation

- Background on Oil & Gas Industry
- Upstream Activities
- Power Requirements
- Available Technologies
- Industry Drivers To Go To Electric Power

Three Segments of the Industry

Upstream	Midstream	Downstream
		
Wells Separation	Pipelines Compression Pump Station	Refinery Gas Plant

Drilling the Well

VIDEO

Fracking History

- 1862: Battle of Fredericksburg
- 1866: Colonel Edward Roberts, Patent 59936 “Torpedo”
- 1868: Nitroglycerin replaced black power in the Torpedo
- 1949: First hydraulic fracturing performed in Duncan Oklahoma
- 1980s: Shale developments started using hydraulic fracturing

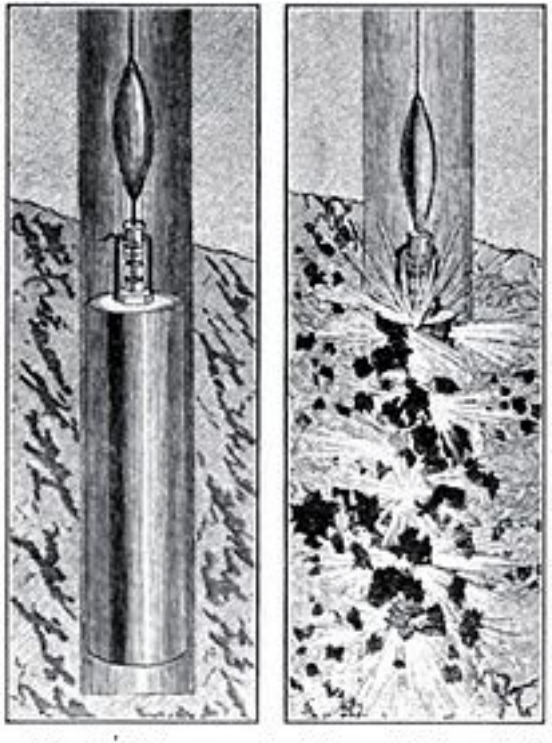
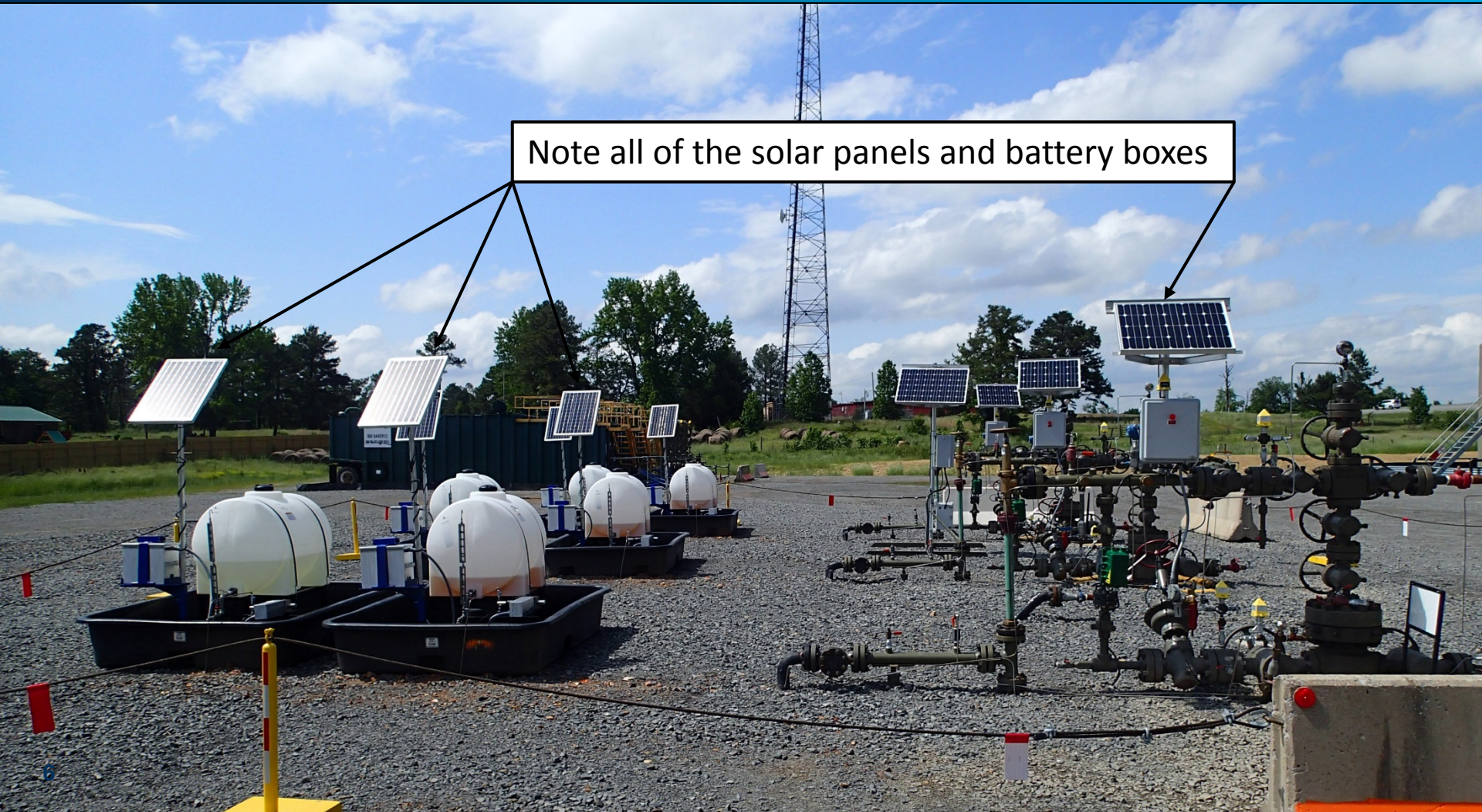
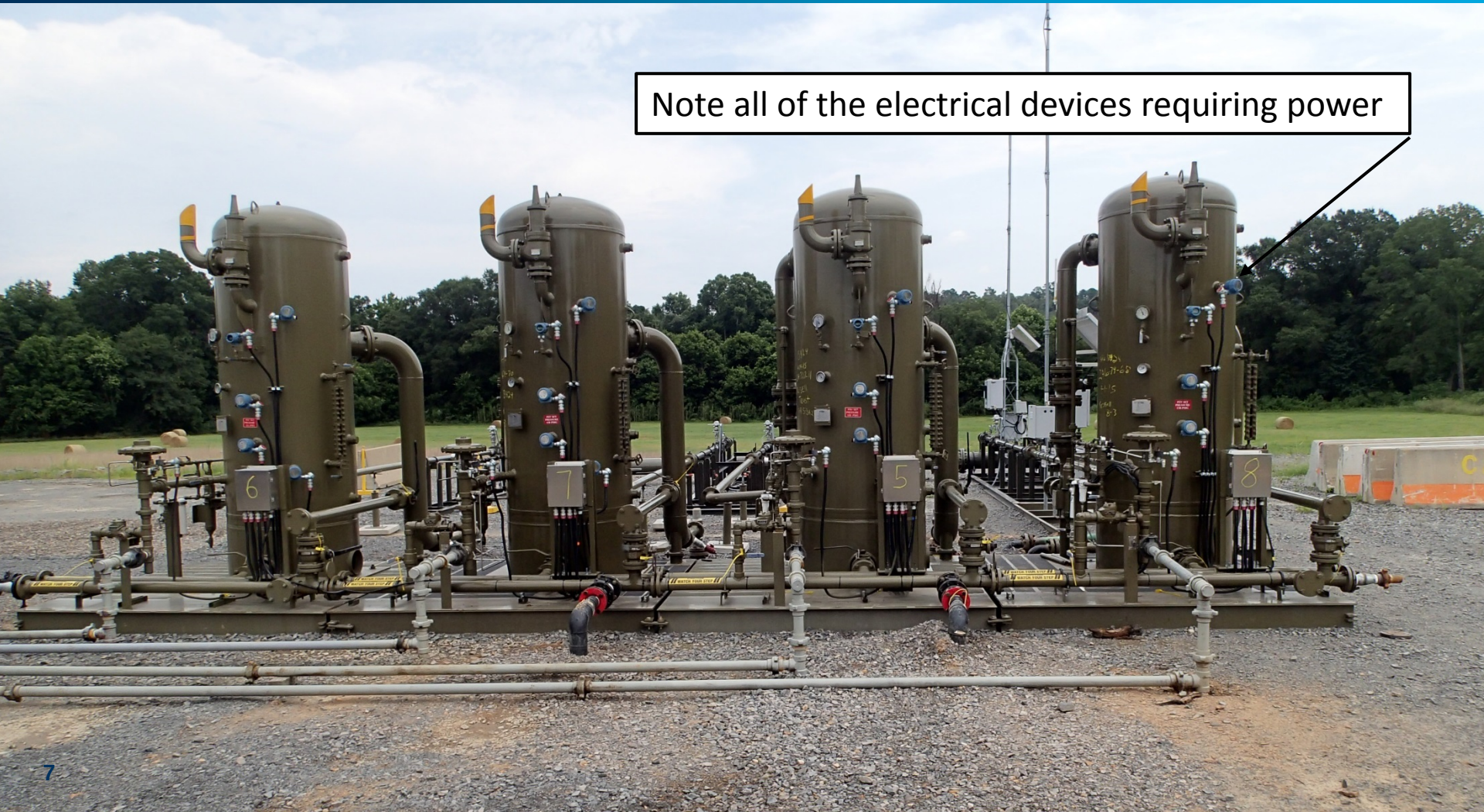


Fig. 134.—The Roberts torpedo, before and during explosion.

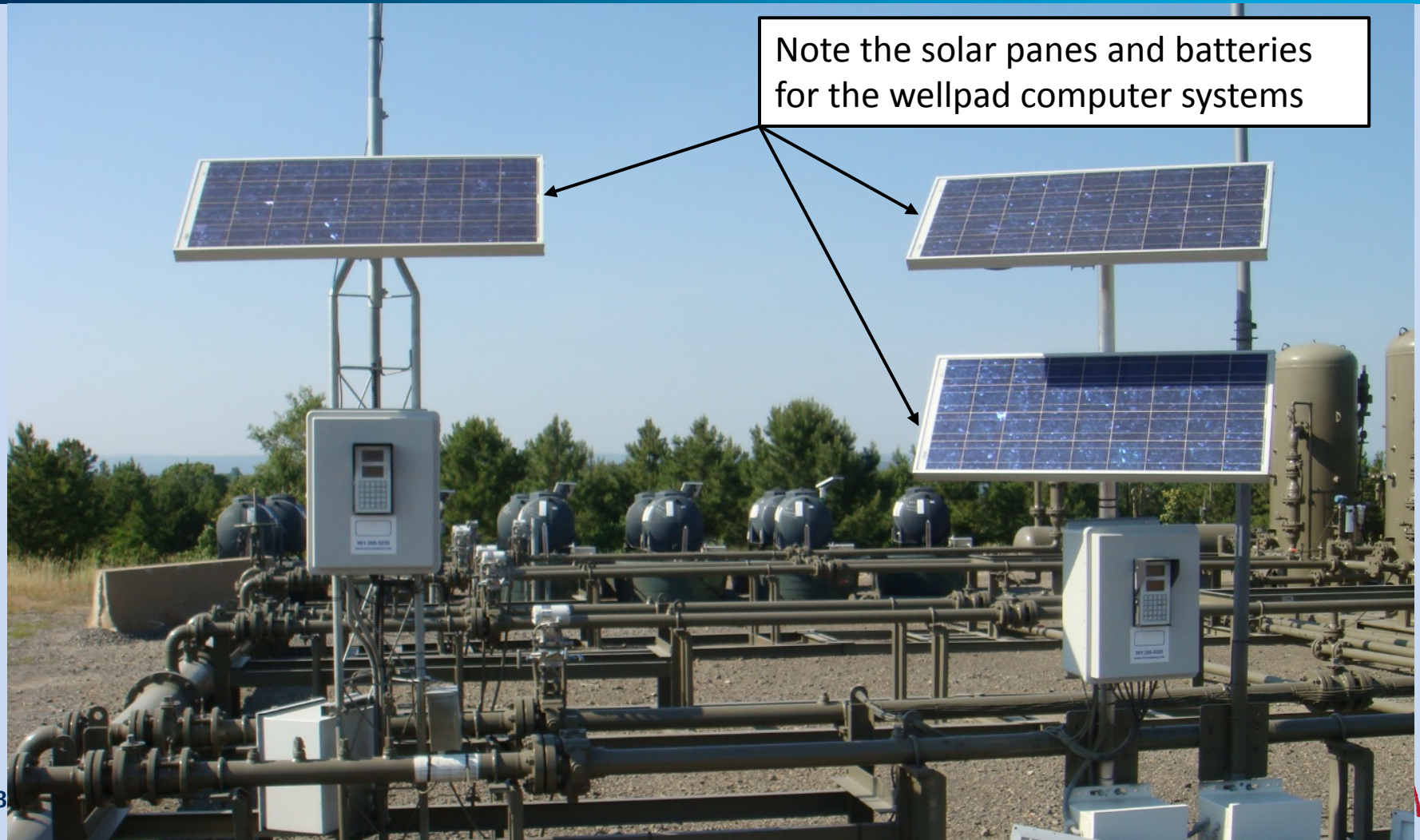
Upstream Facilities – Typical 3 Well Wellpad



Upstream Facilities – 4 Gas Separators



Upstream Facilities – Metering Computers



Upstream Facilities – Typical Tank Battery

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Upstream Facilities – 12 Well Gas Facility

Upstream Facilities – 24 Well Condensate Facility

Upstream Facilities – 2 Well Oil Facility

Average Power Requirements

- Instrumentation
  - 1 well — 35 W
  - 5 wells — 175 W
  - 10 wells — 270 W
- Air Compressor — 330 W
- Chemical Pump — 7 W
- Downhole Pump (10 hp) — 7460 W
- Electric Actuator — 2 W

Fuel System For Fuel Cell

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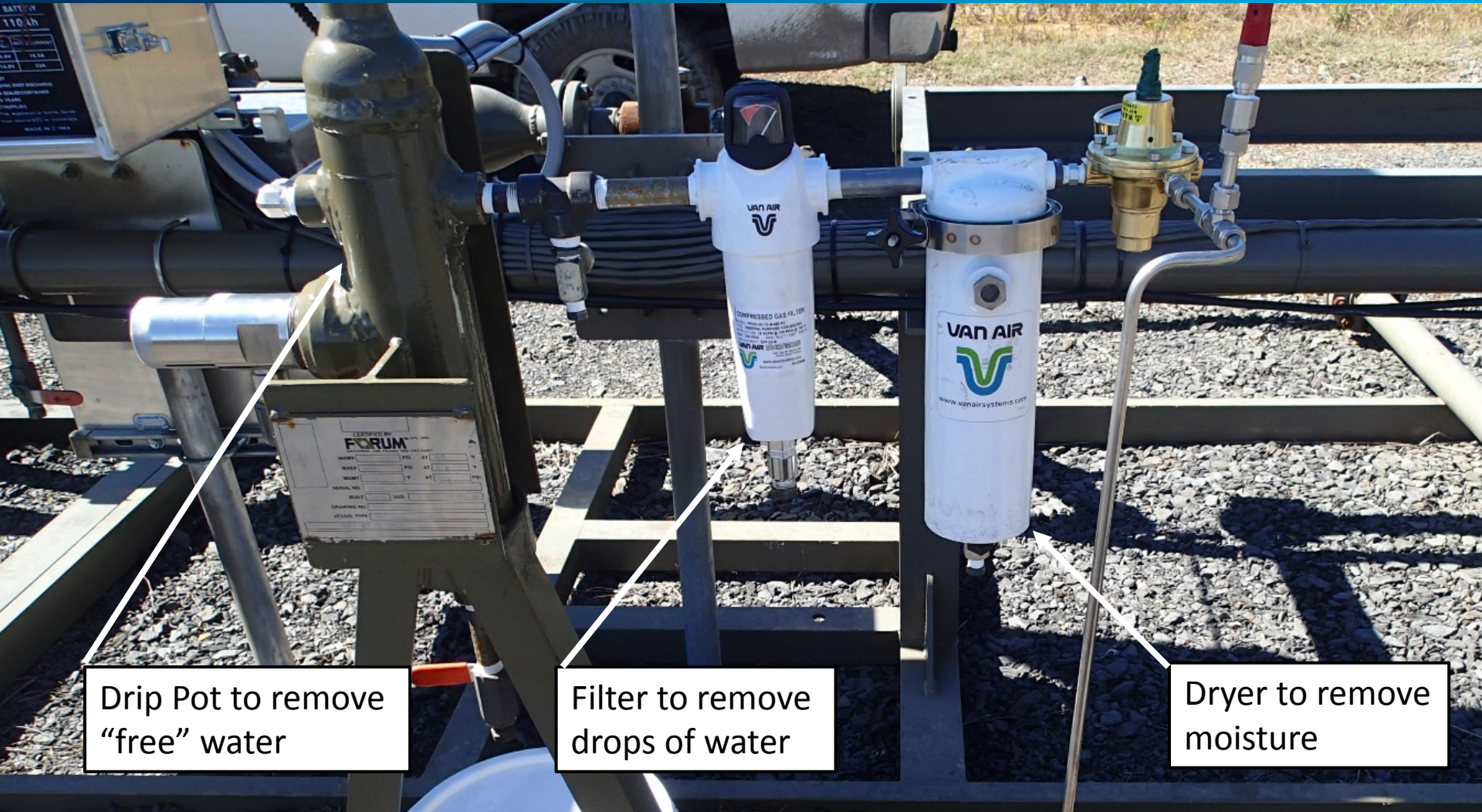

Fuel Cell Installation

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Inside The Fuel Cell

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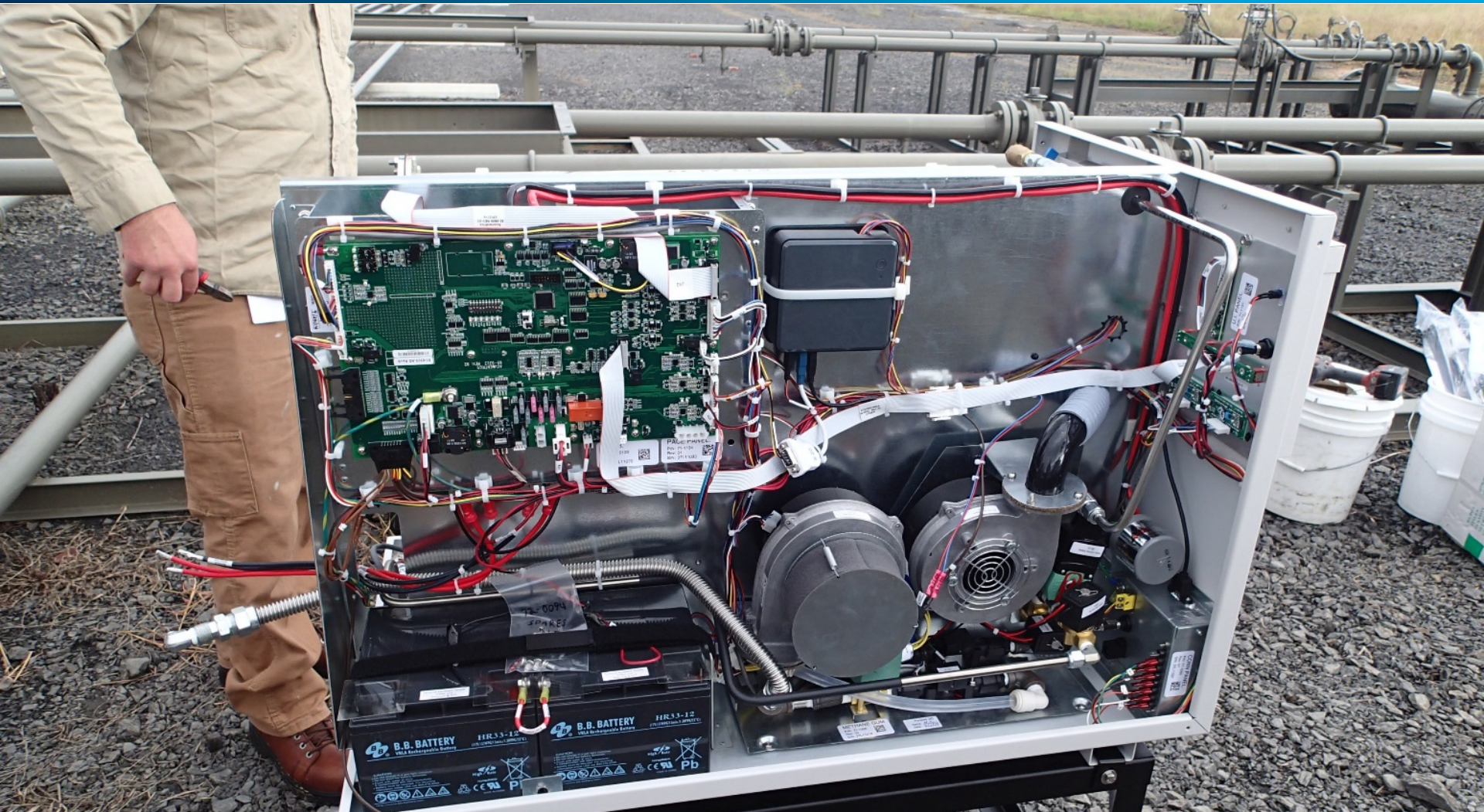


Fuel Cell Costs (Test Unit)

• Fuel Cell w/ Stand	$19,820
• Fuel Gas System	$1,977
• Battery System	$822
• Total Installed Cost	$22,797

Fuel Cell Positives

- Initial Operation Has Been Excellent
- Good Remote Tracking By Manufacturer
- Great Help From Manufacturer With Initial Setup
- Very Low Fuel Consumption
  (137 scfd for 500 W unit)
- Using Fuel Cell As Battery Charger Is The Right Approach To Handle “Startup” Power Spikes
- Can Run 24-hours Per Day

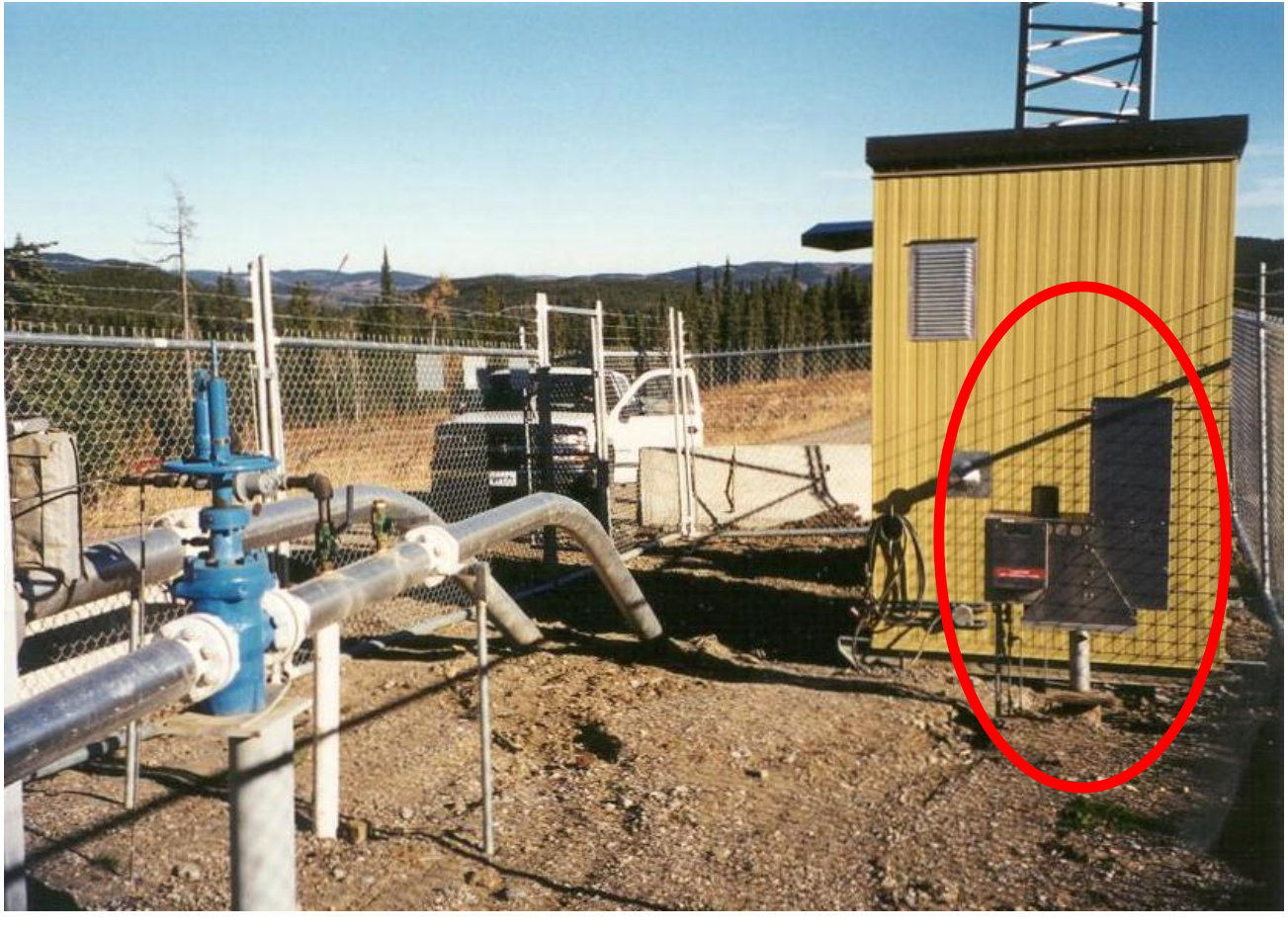
Fuel Cell Negatives

- High Initial Cost
- High Annual Cost
- One Producer Has Approximately 50 Fuel Cells
  - They Are Replacing Fuel Cells When They Have Issues
  - Difficult To Repair
  - Operators Can Not Perform Field Repairs
  - Yearly Maintenance Is High
  - Catalyst Bundle Replacement Is High (12-18 mo)

Thermoelectric Generator (TEG)

- Typically Used For:
  - Low Power Service
  - Remote Locations Where Grid Power Is Not Available
- Low Fuel Emissions (If Run On Natural Gas)
- Zero Fuel Emissions (If Run On Waste Heat Alone)
- Can Be Run:
  - Directly Power Load
  - Battery Charging Mode

Thermoelectric Generator – Typical Installation



Thermoelectric Generator – Exterior Picture

Thermoelectric Generator – Interior Picture

Thermoelectric Generator Positives

- These Units Have Extensive Field Applications In The Oil & Gas Industry:
  - Using Some To Supplement Solar
  - Using Hundreds Of TEGs
- Easy To Maintain/Fix By Field Operators
- Low Initial Cost
- Low Annual Cost
- Can Run 24-hours Per Day

Thermoelectric Generator Negatives

- TEGs Consume A Medium Amount Of Fuel When Powered By Natural Gas (Approximately 10 Times That Of A Comparably Rated Fuel Cell)

Solar Package

- Typically Used For:
  - Low Power Service
  - Remote Locations Where Grid Power Is Not Available
- Zero Hydrocarbon Emissions
- Can Be Run:
  - Battery Charging Mode

Solar Package – ROC

Power Options

- Grid
- Engine Driven Generator (Natural Gas)
- Micro Turbine (Pressure Drop or Natural Gas)
- Fuel Cell (Natural Gas)
- Thermoelectric Generator (Natural Gas)
- Wind Generator
- Solar

Waste Heat Recovery

- Weather
  - Freezing Weather
- Pressure Drop
  - Joule-Thomson Valve
  - Turboexpander
- General Heating
  - Line Heater
  - Heater Treater

Waste Heat Recovery

Environmental Issues – Green House Gas

Burning or Emitting Fossil Fuels

VS

Clean Electric Power

Environmental Issues – Noise

Diesel or Natural Gas Engines

VS

Electric Motors

Questions?