Breaking Gridlock with Smart Regulations

Well Integrity, Induced Seismicity and Methane Emissions

SMART REGULATIONS

Balancing the economic, environmental, and social impacts of the regulated activity

SMART REGULATIONS
= EFFECTIVE RISK MANAGEMENT

Three Steps to Effective Risk Management

1 IDENTIFY
the risks

2 ASSESS
the probability of occurrence and potential impact of each risk

Implement strategies to
3 MITIGATE
the risks

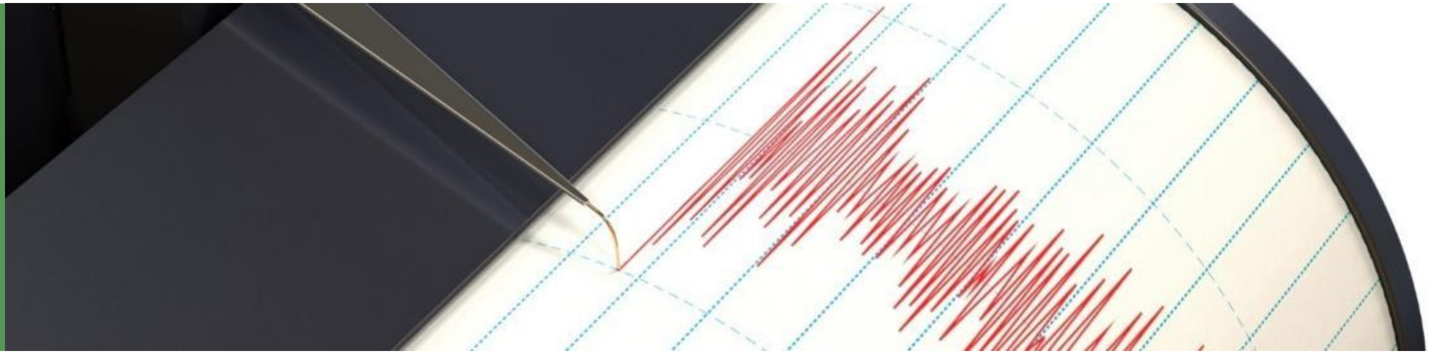
ENSURING SMART REGULATION

STRAIGHT TALK & OPEN DIALOGUE

Three Examples

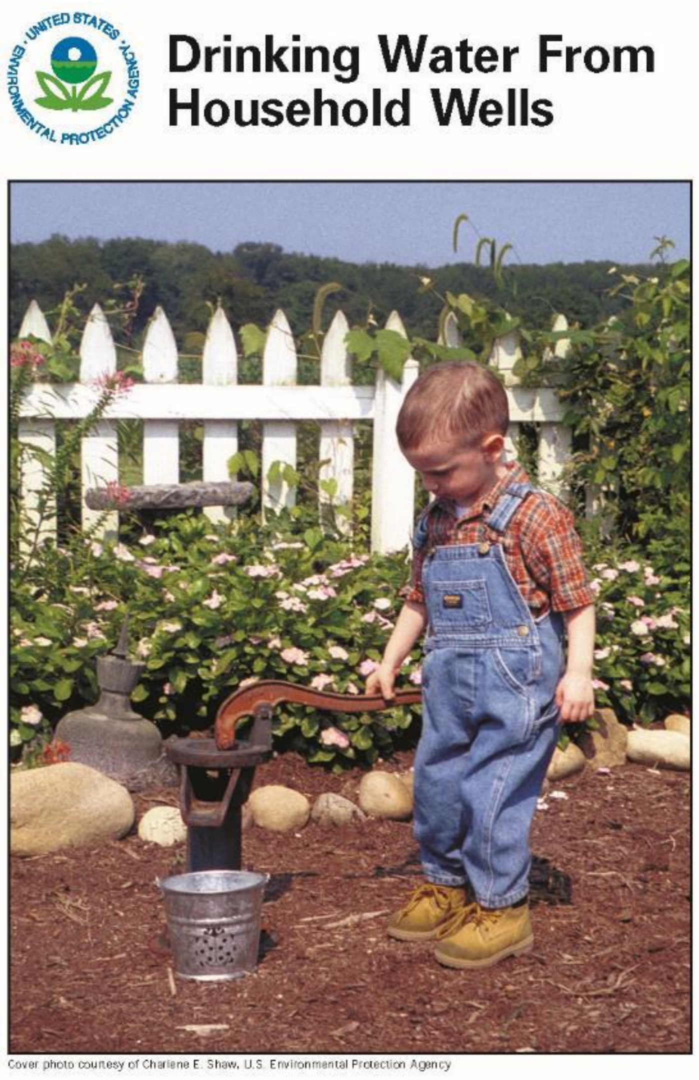
1 Protecting Underground Water Resources

2 Induced Seismicity



3 Methane Emissions

1. PROTECTING UNDERGROUND WATER RESOURCES



Well Integrity
is the Key!

ENSURING WELL INTEGRITY

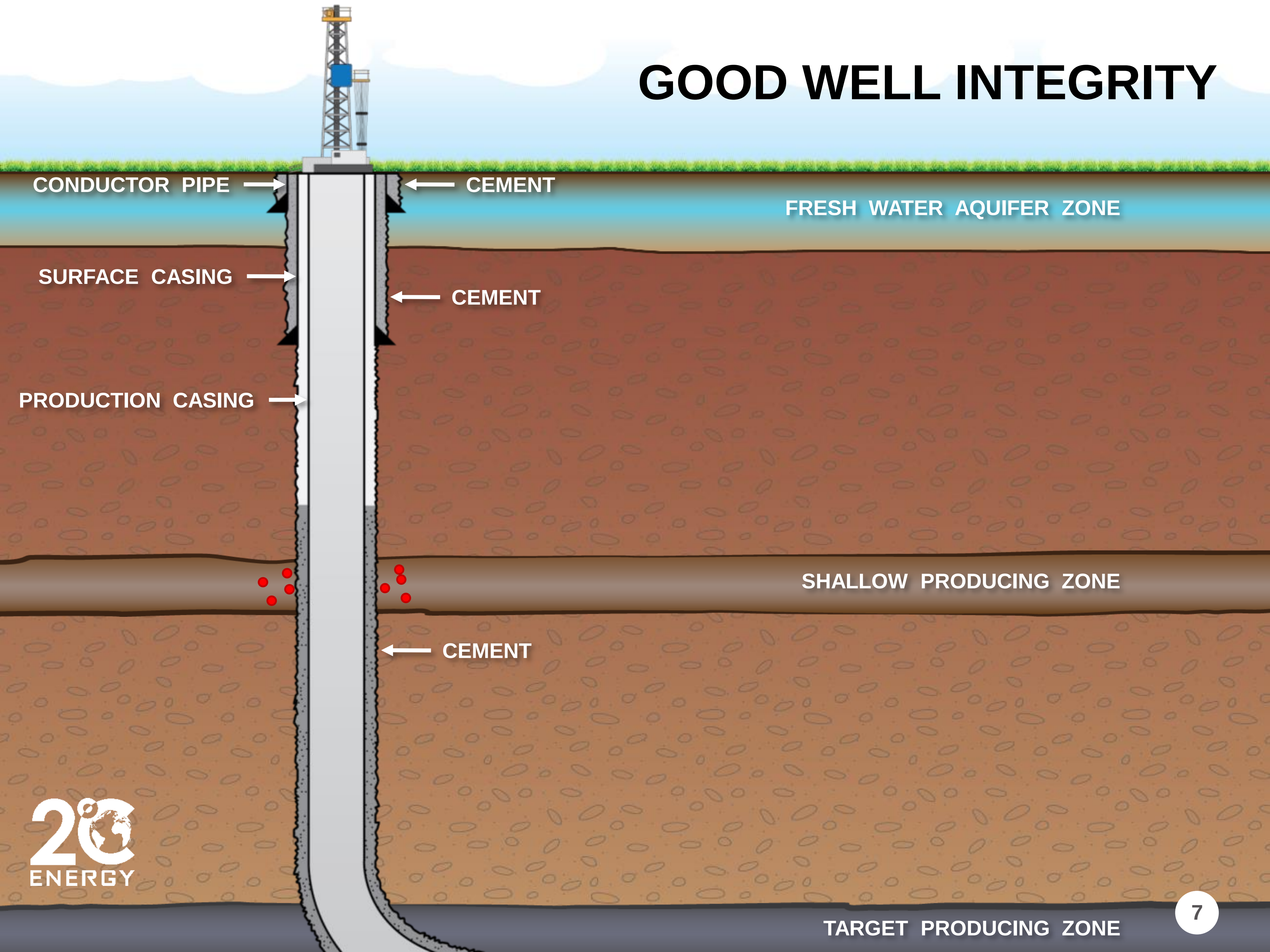
1 Evaluate Stratigraphic Confinement

2 Well Construction Standards

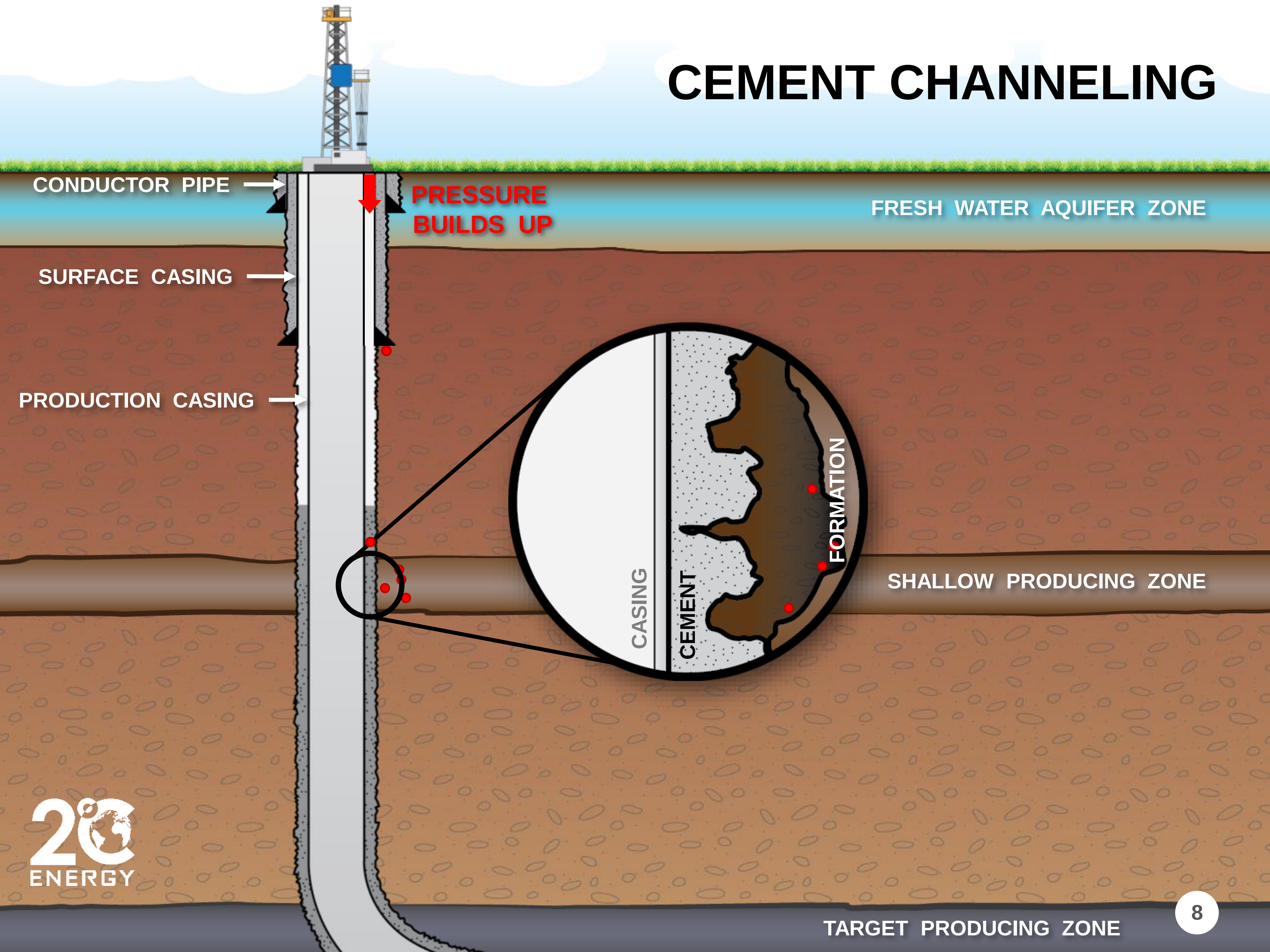
3 Evaluate Mechanical Integrity of Well

4 Monitor Frac Job & Producing Well

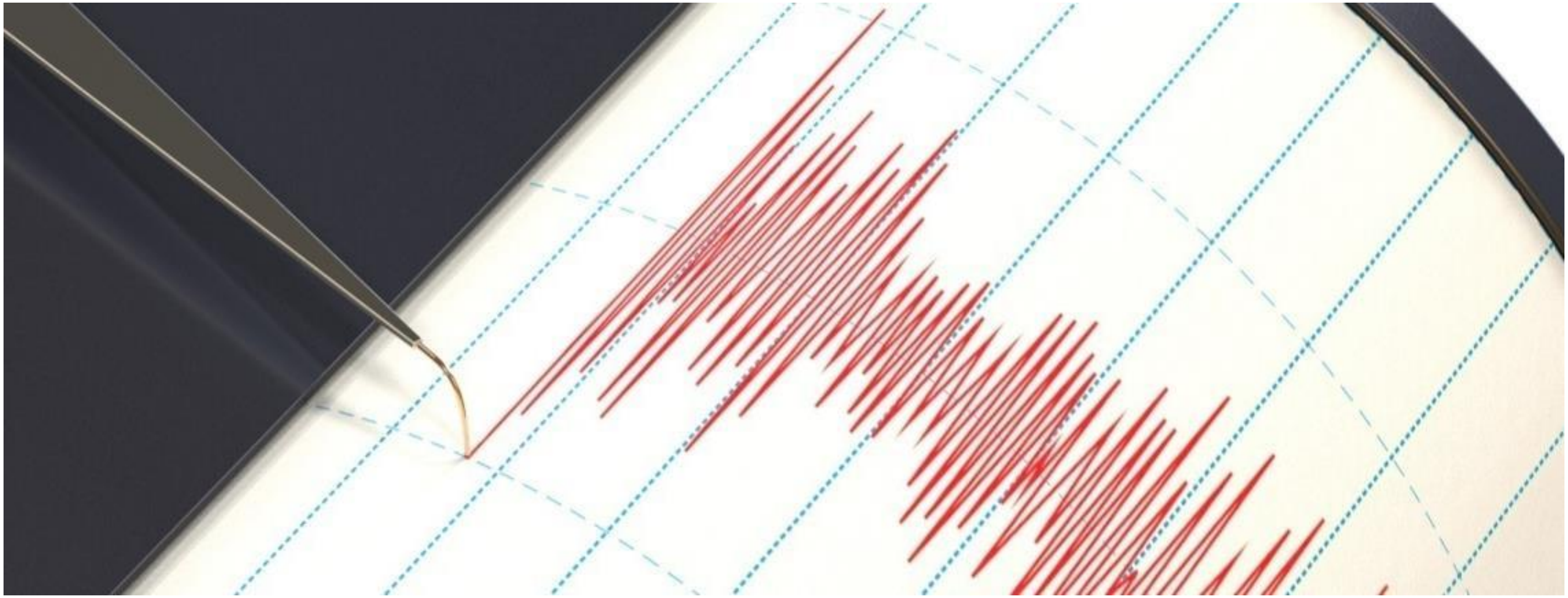
GOOD WELL INTEGRITY



CEMENT CHANNELING



2. INDUCED SEISMICITY



INDUCED SEISMICITY

What is it?

- Earthquakes or “seismic events” that are attributable to human activities.

- In the context of oil and gas operations, the “human activity” is the injection of fluids into, or the withdrawal of fluids from, subsurface formations.

- Current focus is on fluid injection operations.

INDUCED SEISMICITY – ASSESSING RISK

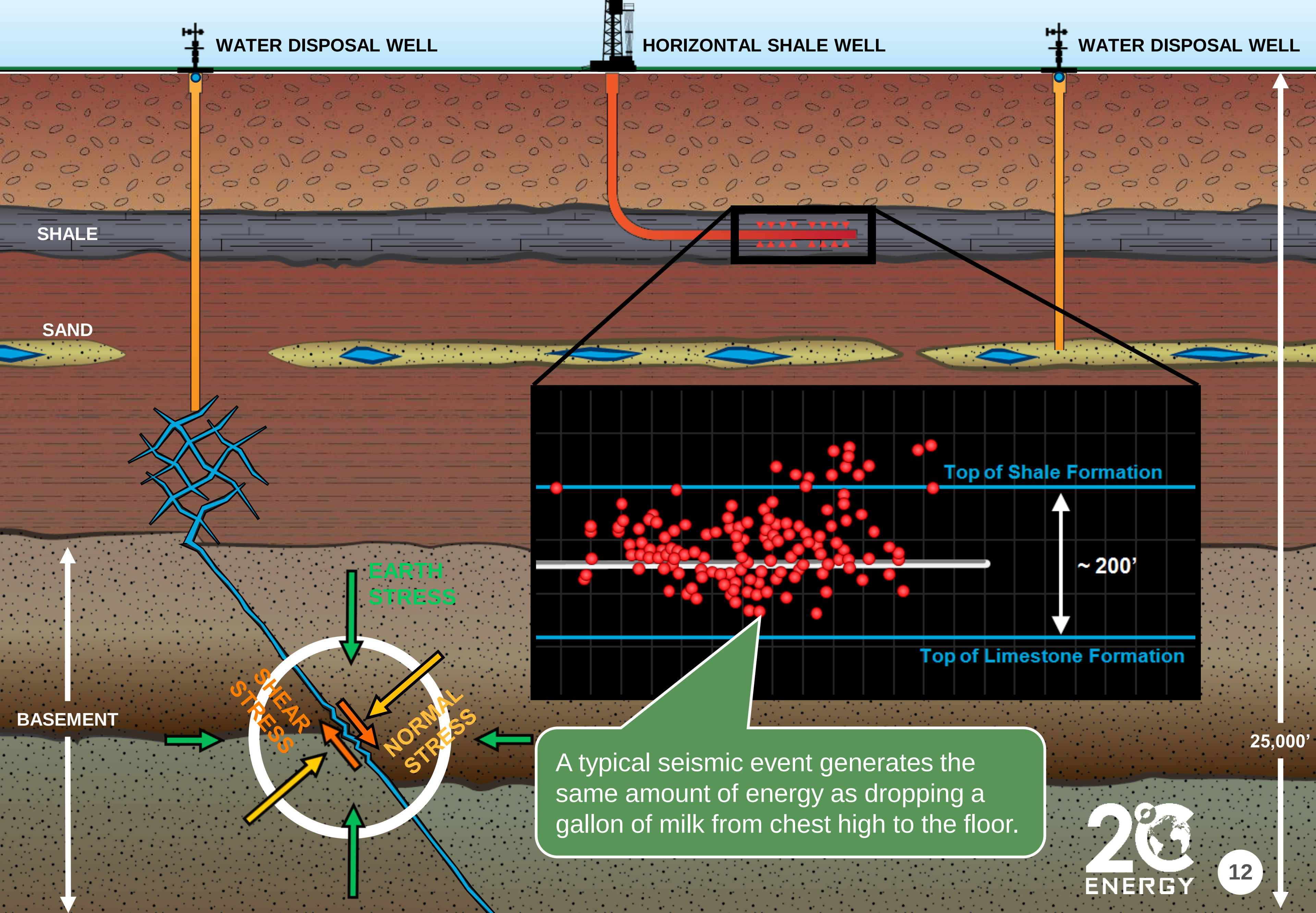
What factors are responsible for triggering the seismic event?

- Shear stress.
- Normal stress.
- Pore pressure.

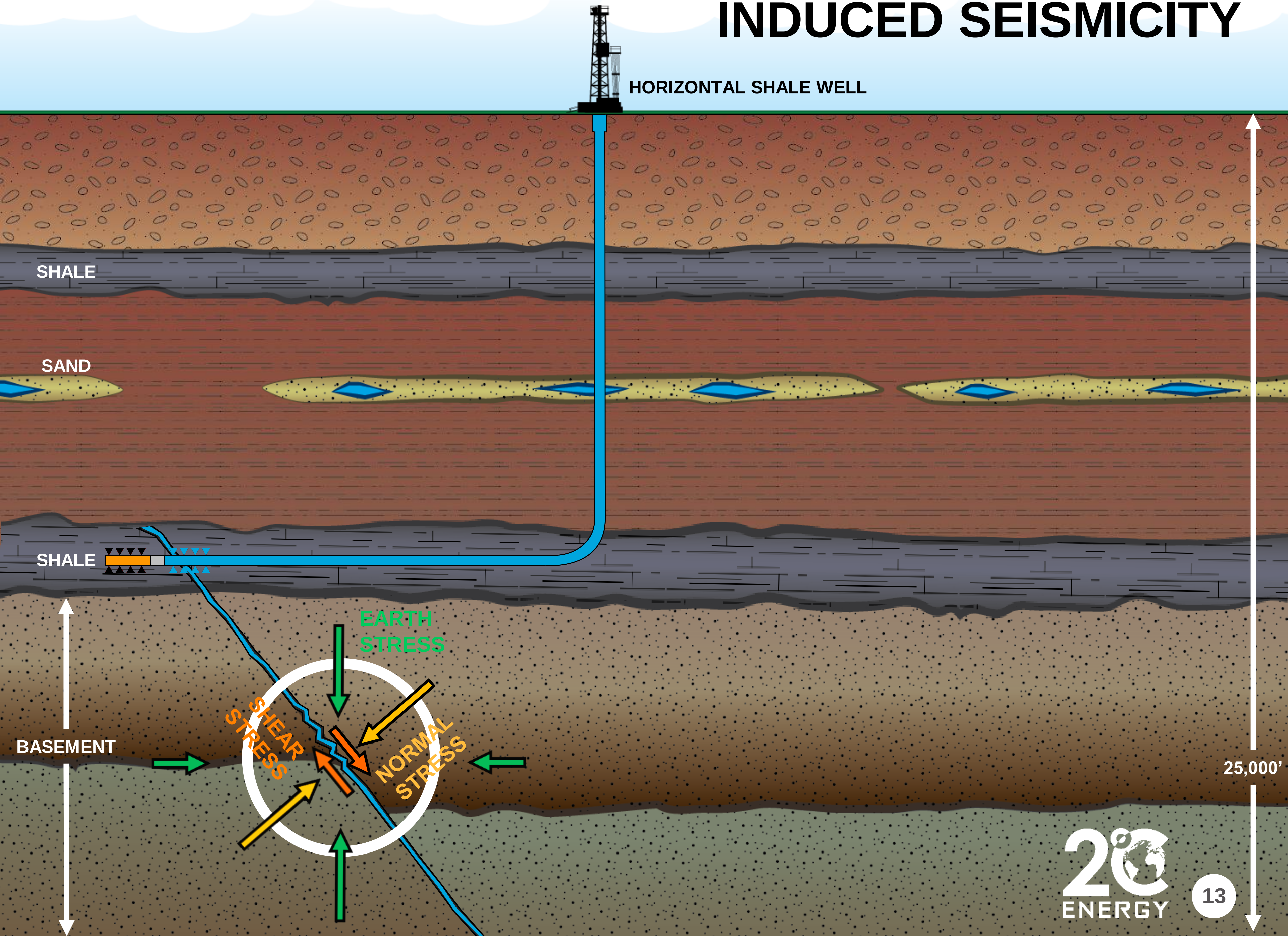
What factors determine the magnitude of the seismic event?

- Shear strength of faulted rock.
- Fault rupture area.
- Fault displacement.

INDUCED SEISMICITY



INDUCED SEISMICITY



RISK MITIGATION
Regulatory Approaches

Ohio

- New permitting requirements.

- Agency may require applicant to:
  - Conduct pressure fall-off and bottomhole pressure testing.
  - Investigate potential faulting (including seismic surveys).
  - Submit well logs, tracer and seismic monitoring plan.
  - Conduct “other tests”.

- No drilling into Precambrian basement rock.

RISK MITIGATION

Regulatory Approaches

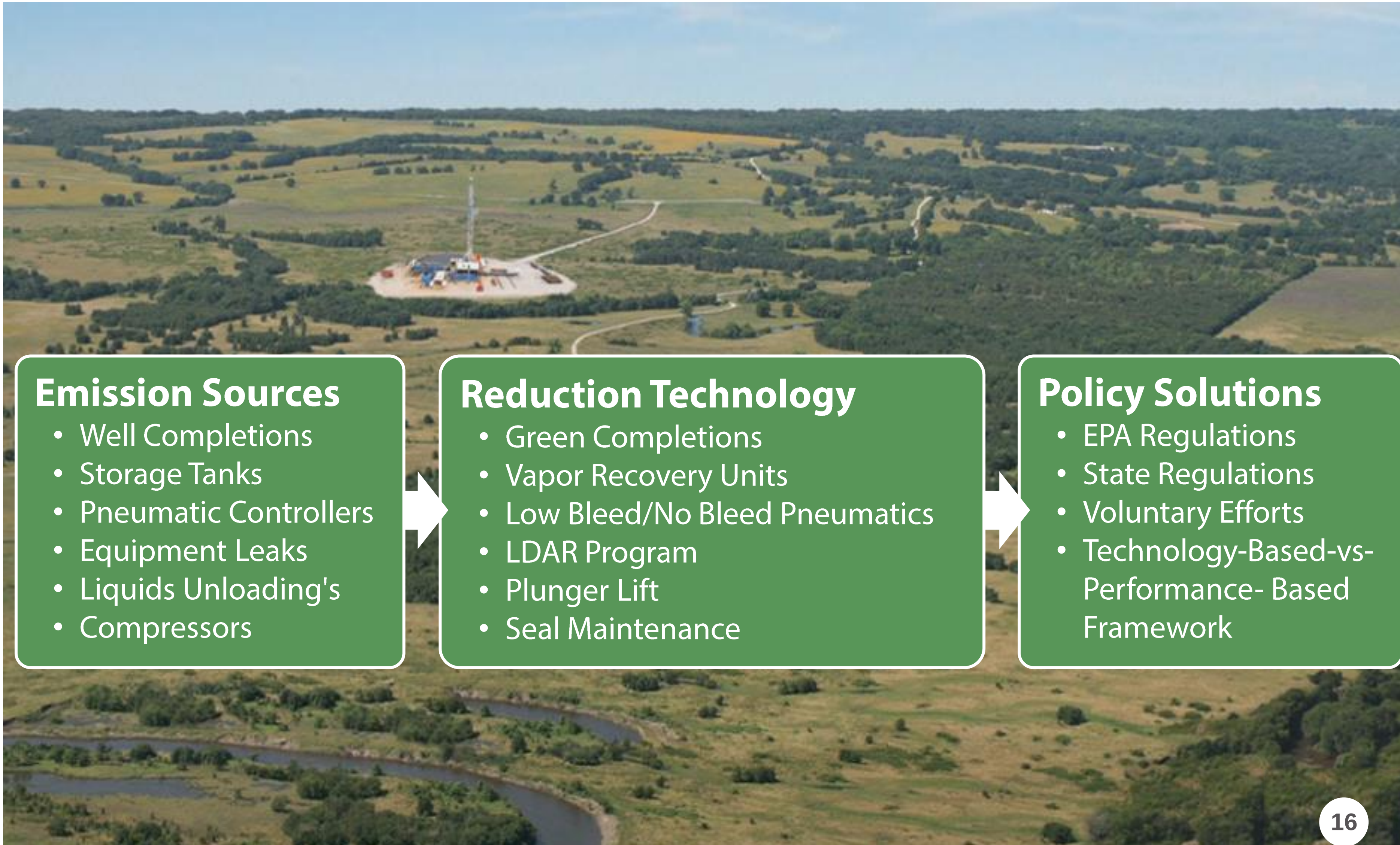
Texas

- Applicant must survey 100 square mile area around well location for "historical seismic events" (USGS data).

- Commission may require applicant to provide well logs, cross sections, structure maps and/or pressure front boundary calculations if the disposal well is located in area of increased risk that injected fluids will not be confined to injection interval.

- "Increased risk" areas – complex geology, injection interval is close to basement rock, presence of transmissive faults, and/or history of seismic events.

3. METHANE EMISSIONS



Emission Sources

- Well Completions
- Storage Tanks
- Pneumatic Controllers
- Equipment Leaks
- Liquids Unloading's
- Compressors

Reduction Technology

- Green Completions
- Vapor Recovery Units
- Low Bleed/No Bleed Pneumatics
- LDAR Program
- Plunger Lift
- Seal Maintenance

Policy Solutions

- EPA Regulations
- State Regulations
- Voluntary Efforts
- Technology-Based-vs-Performance- Based Framework

NATURAL GAS SUPPLY CHAIN

Natural gas systems encompass wells, gas gathering and processing facilities, storage, and transmission and distribution pipelines.

Production and Gathering

1. Drilling and Well Completion
2. Producing Wells
3. Gathering Lines
4. Gathering and Boosting Stations

Gas Processing

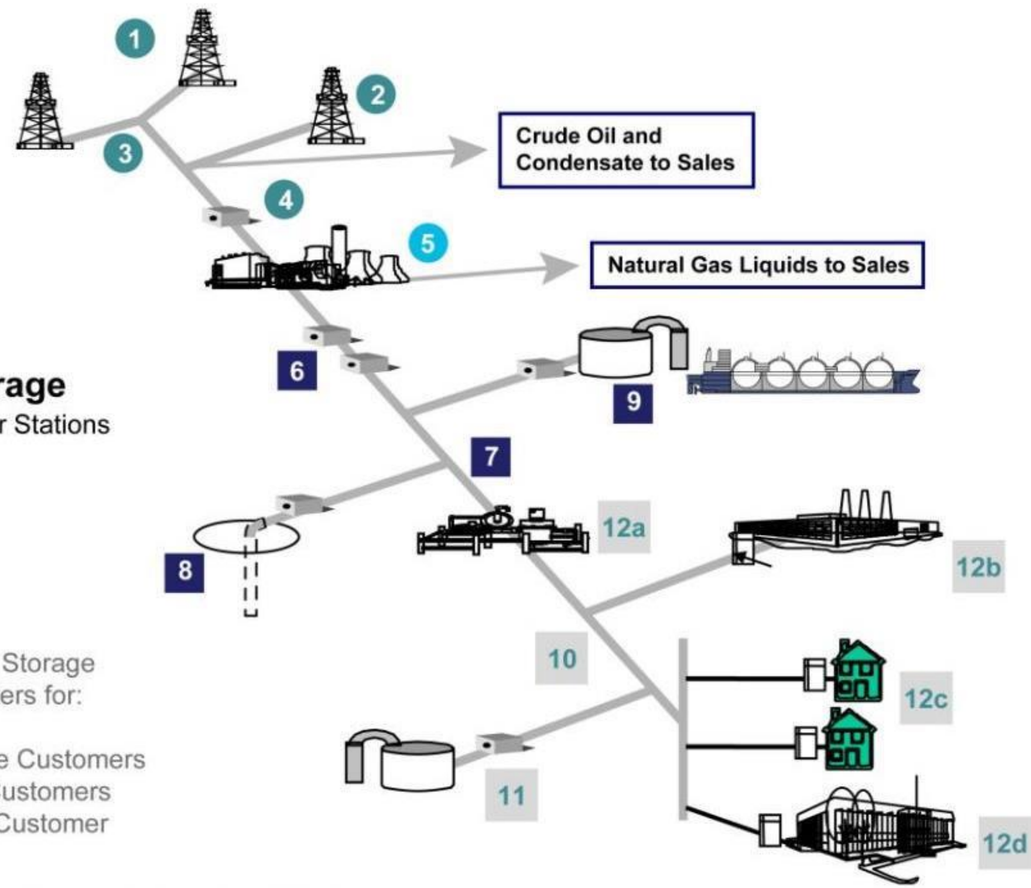
5. Gas Processing Plant

Transmission & Storage

6. Transmission Compressor Stations
7. Transmission Pipeline
8. Underground Storage
9. LNG Import/Export

Distribution

10. Distribution Mains
11. LNG Peak Shaving Storage
12. Regulators and Meters for:
    a. City Gate
    b. Large Volume Customers
    c. Residential Customers
    d. Commercial Customer



Source: Adapted from American Gas Association and EPA Natural Gas STAR Program

METHANE EMISSIONS PROFILE

Emission Levels

- Measurements at the source ("bottoms-up") indicate emissions are close to inventory estimates.
- Measurements using aircraft ("top-down") indicate emissions are higher than inventory estimates.

Regional Variations

- There are significant regional variations among emission sources.
- Differences likely attributable to (i) type of natural gas production (i.e. wet gas-vs-dry gas) and (ii) the age, number and type of infrastructure.

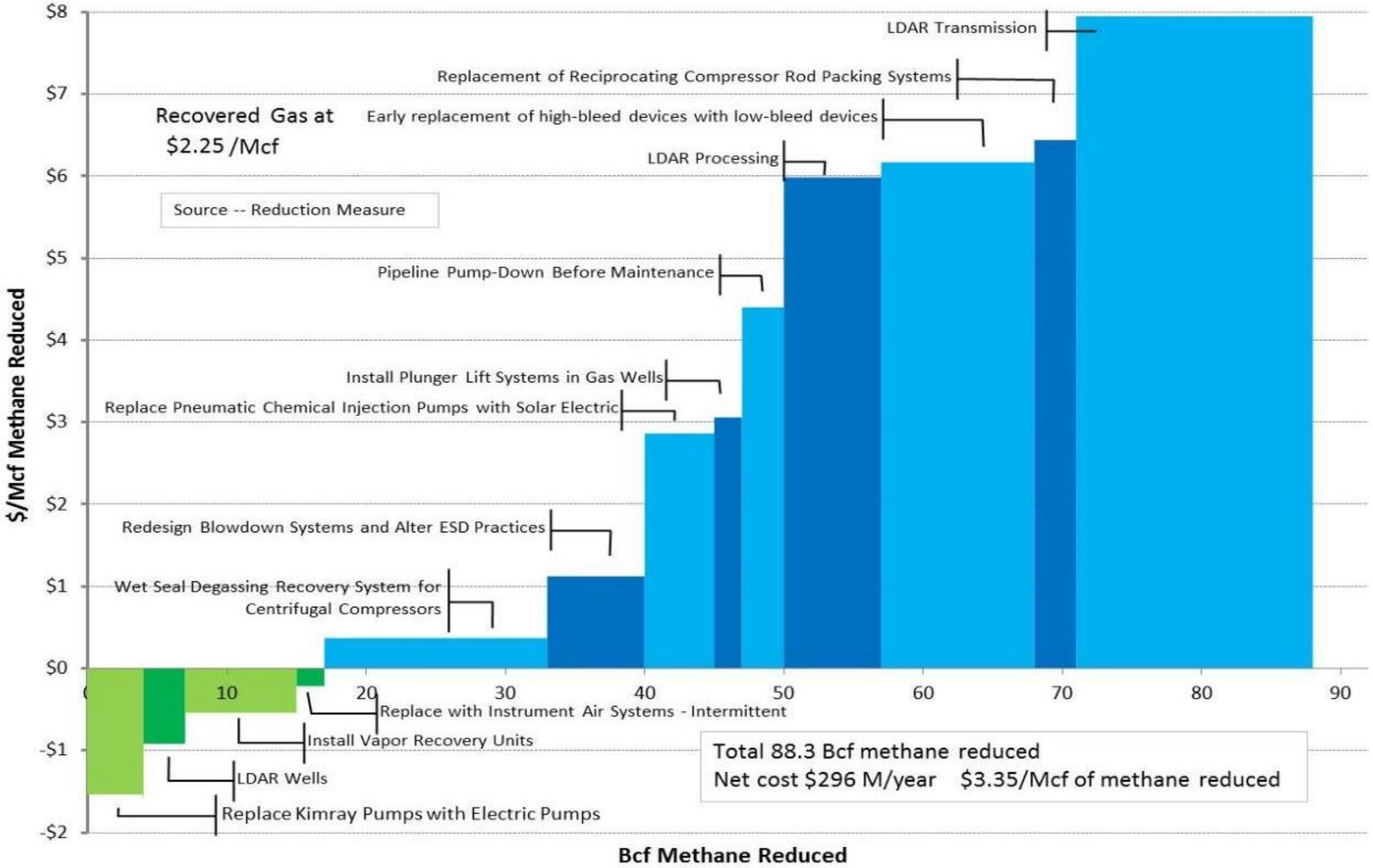
Super Emitter Phenomenon

- A relatively small number of emission sources are responsible for a disproportionately large number of emissions.
- Important to recognize there are three (3) types of super-emitter: chronic, episodic and malfunctioning.

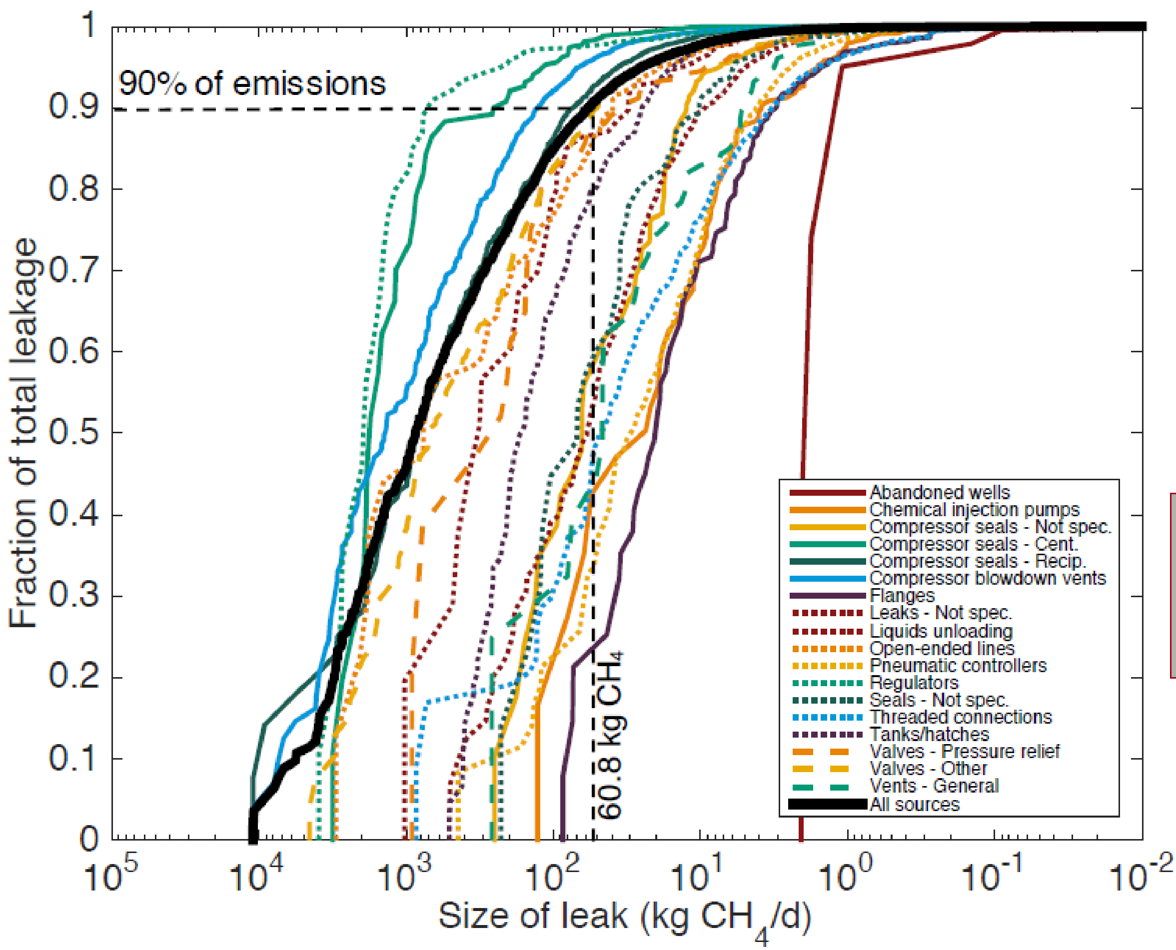
Cost-Effective Reduction Opportunities

- There are a number of cost-effective emission control technologies that can be employed today.
- Advances in emissions detection/monitoring technologies should follow reduction opportunities.

REDUCTION OPPORTUNITIES



MAXIMIZING THE REDUCTION OPPORTUNITIES



90% of volume leak size > 61 kg/d

ARPA-E target leak size = 2.7 kg/d

Source: Brandt et al. (2016)

POLICY OPTIONS FOR ADDRESSING METHANE EMISSIONS

TECHNOLOGY-BASED DESIGN

- Pre-defined emission control technologies are applied to all “affected sources”.
- Application of control technology is required regardless of the actual emission profile of the source.
- Technology-based design is more appropriate for a smaller population of homogenous emission sources.
- Monitoring, recordkeeping and reporting requirements are burdensome due to large number of emission sources.

PERFORMANCE-BASED DESIGN

- Performance-based design allows companies to focus on “super emitter/fat-tail” emission sources.
- Each company optimizes emission reductions by focusing capital deployment on its highest emitting sources.
- Technology-neutral approach encourages development of new technologies to achieve emission reduction goals.
- Intensity-based metrics enable bench-marking between companies, regardless of size.

KEY POLICY DESIGN QUESTIONS

Does the policy match the science of methane emissions?

Does the policy optimize emission reductions by deploying capital on the highest emitting sources?

Does the policy encourage development of new emission *reduction* technologies?

Does the policy encourage development of new emission *detection* technologies?

Does the policy provide “reasonable assurance of compliance”?

Can the policy be “enforced in a reasonable manner”?