Innovation, fear and path to deployment: Thoughts for heavy oil and oil sands

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In the News

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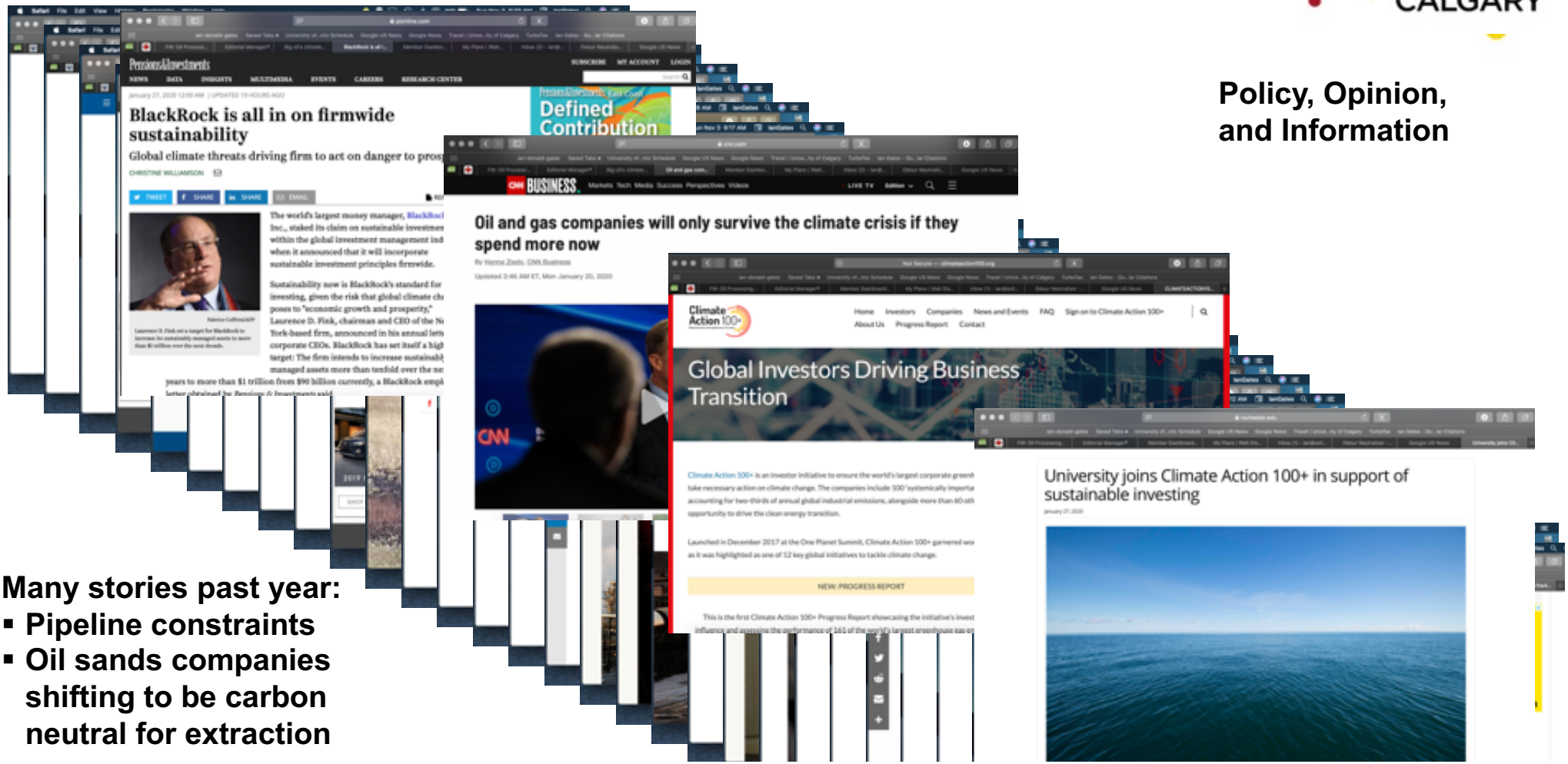
Policy, Opinion, and Information



Many stories past year:

- **Pipeline constraints**
- **Oil sands companies shifting to be carbon neutral for extraction**

Motivation

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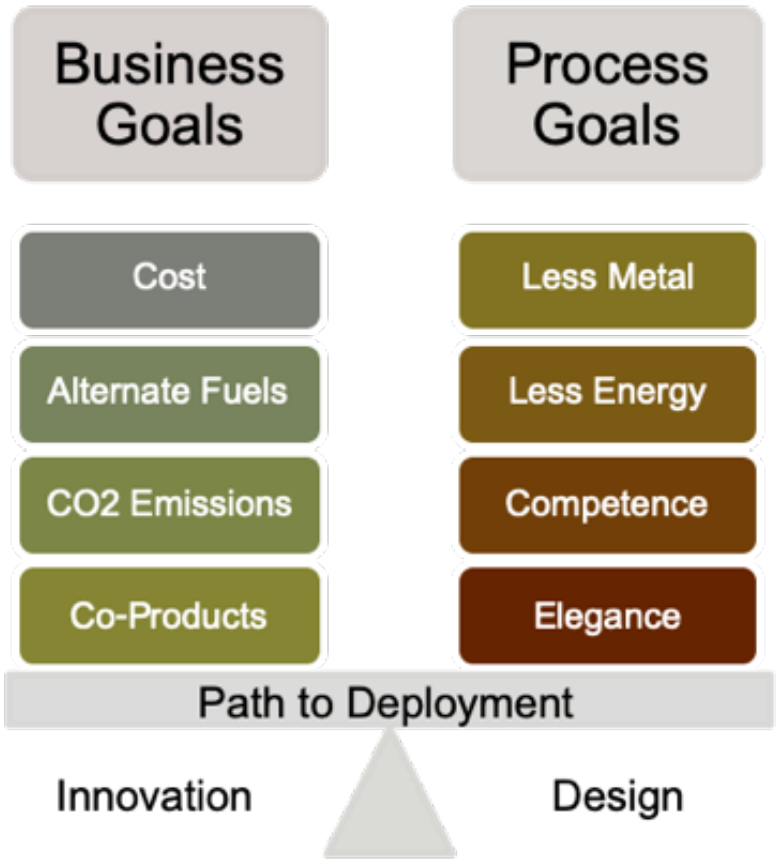
- Oil and gas industry: must find new technologies and do it rapidly
- Significant challenge to find new processes with large reductions of water and carbon dioxide emissions
- Rapid Development and Adoption is an issue



Outline

- Oil Sands Innovation – Ideas that are Useful and Relevant and Adoptable
- What prevents Innovation? Fear
- Paths to Deployment
- Path to Impact
- Final Remarks

In Situ Oil Sands Innovation

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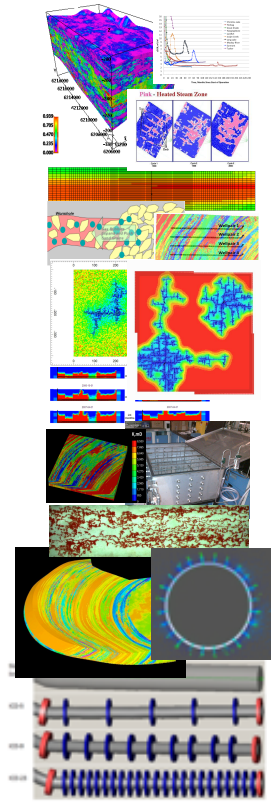
- Cyclic Steam Stimulation (CSS) and Steam-Assisted Gravity Drainage (SAGD) both invented >30 years ago
- **Operational Excellence** Achieved = Security, Low Risk, Low Costs, High Revenues, Reliable, Business Model well established, Collaborate, No Perturbations/Variations Allowed – Data drives Answers to Questions

- CSS/SAGD, both energy intensive (>7 GJ/m^3 oil), consume water (~95% recycled but ~0.2 m^3 consumed per m^3 oil), and emit GHGs (0.5-2 tCO2eq per m^3 oil)

- **Improvements must be found – environmental impact, cost, products**
- Typically, new technologies, take 10+ years to commercialize – **Improvements must be found – Discovery, Decisions, Deployment**
- Hard Tech Innovation = Metal, Machines, Energy, Environment, and Social Innovation = Ecosystem, Acceleration, Deployment, are Critical

- BUT INNOVATION MEANS Take Risk, Inspires New Visions, Create New Models and Outcomes, Perturb the System, Focus around Talent – Data creates New Questions



Industry Capacity

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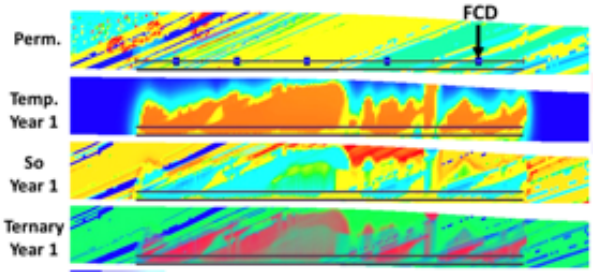
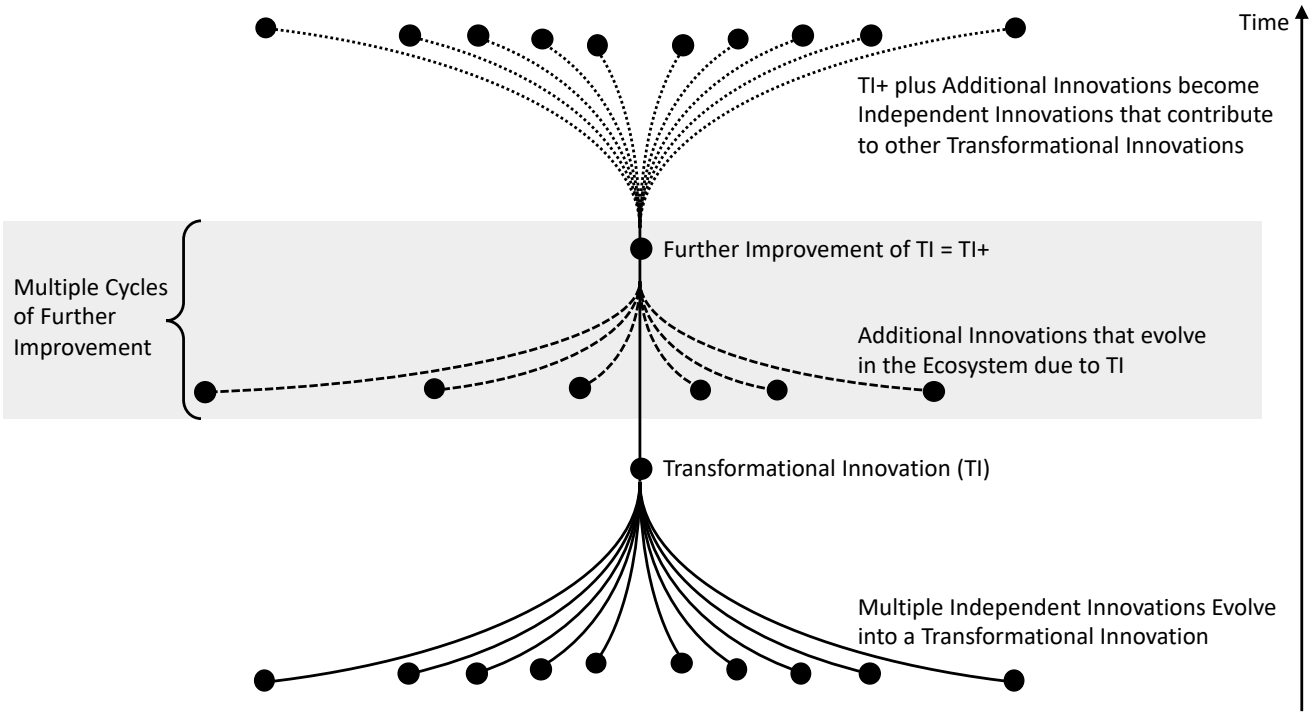
- Few companies still have oil sands research labs and permanent research staff BUT there are abundant and potentially inventive scientific, engineering and management staff and dollars
- What prevents them from developing a glut of inventions and bringing creativity to issues confronted by the oil sands industry?
- Not only a technical issue but also a social one

Observations:

- Most funding is directed at near market iterations, short term incentives (e.g. shareholder value)
- Gov't funding matched to industry activity is thus linked to market forces
- Innovation curbed by regulatory factors or internal work overload
- Organizations do not reward folks that perturb
- Culture of risk adversity (FEAR)



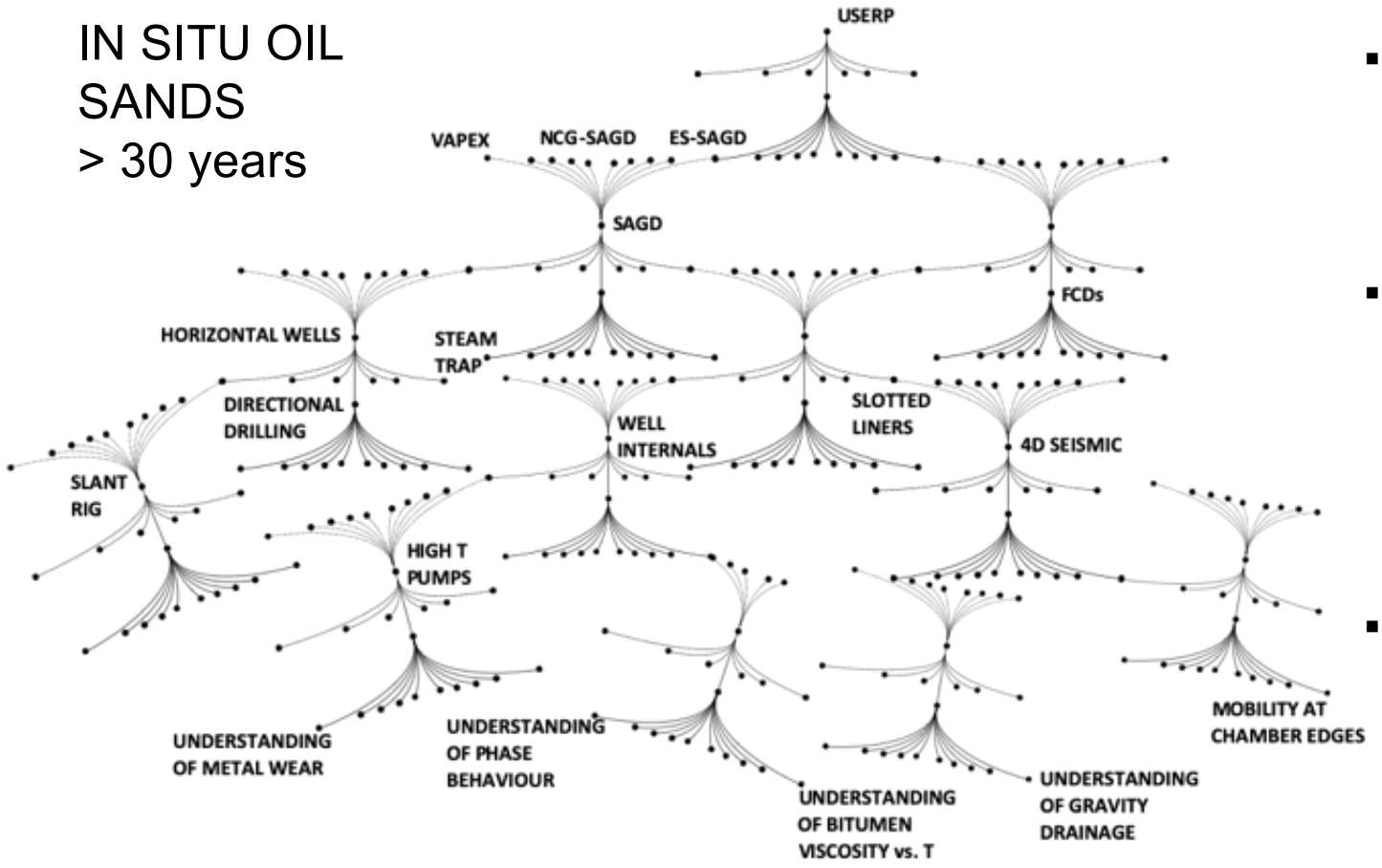
Innovation Connection Tree



- Innovations usually product of multiple, sometimes smaller-scale, innovations that reinforce each other through the development of a "platform"
- Once platform established, additional independent innovations have a context or framework to integrate into the ecosystem, allowing explosive growth in the innovative landscape
- Multiple innovations act in concert to create a new outcome that unlocks a previously-locked physical challenge

Tech. Evolution Connection Tree

IN SITU OIL SANDS
> 30 years



- Innovations reinforce each other through the development of a "platform"
  ➢ SAGD WELL CONFIG
- Established platform: independent innovations have context to integrate into ecosystem, allowing growth
  ➢ SAGD+FCDs, SOLVENTS, SEISMIC, …
- Multiple innovations create new outcome that unlocks a previously-locked physical challenge
  ➢ SOLVENT-ONLY WITH NEW WELL CONFIG

Rate of Innovation

Bunio and Gates (2013):

$$\text{Rate of Innovation to Realization} = \left(\frac{\text{Rate of Creation of Ideas}}{\text{Fear}} - \text{Rate of Loss of Ideas}\right)\left(\text{Investment in Active Innovation and R\&D}\right)\left(\frac{\text{Magnitude of Impact if New Solution Not Found}}{\text{Time scale over which New Solution Needed}}\right)$$

Net creation of new ideas

Investment – time, funding, and culture

Driving force for process of innovation to commercial realization

If fear is too large, despite creation of new ideas, net creation of ideas could be negative representing a net loss of new ideas.

Individuals/organizations are willing to put into innovation activities and development beyond the idea stage

Numerator = magnitude of impact if new solution not found (costs, revenues, environmental impact, personnel)
Denominator = desperation – if new solution required in short time scale, then desperation to get it, i.e. motivation to realize it, is higher

What Prevents Innovation?

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Bunio and Gates (2013):

$$\text{Rate of Innovation to Realization} = \left(\frac{\text{Rate of Creation of Ideas}}{\text{Fear}} - \text{Rate of Loss of Ideas}\right)\left(\text{Investment in Active Innovation and R\&D}\right)\left(\frac{\text{Magnitude of Impact if New Solution Not Found}}{\text{Time scale over which New Solution Needed}}\right)$$

Fear of loss of job, shutdown of group, divestiture, yielding a positive result, occurring at individual, group, organizational, societal, and country-wide levels (multi-scale fear)

Rate of **Loss** of ideas represents stagnation culture of organization – is it listening? does it have process to capture new ideas, screen them, and act on ones that have merit? does it have champions that move innovations?

Represents **Investment** – time, funding, and culture – that individuals and organizations are willing to put into innovation activities and development beyond the idea stage

Fear-Loss-Investment: Collisions of ideas or communication linkages that are established within/outside organizations that lead to tangible ideas/innovations ➡ **Path to Deployment**

Path to Deployment

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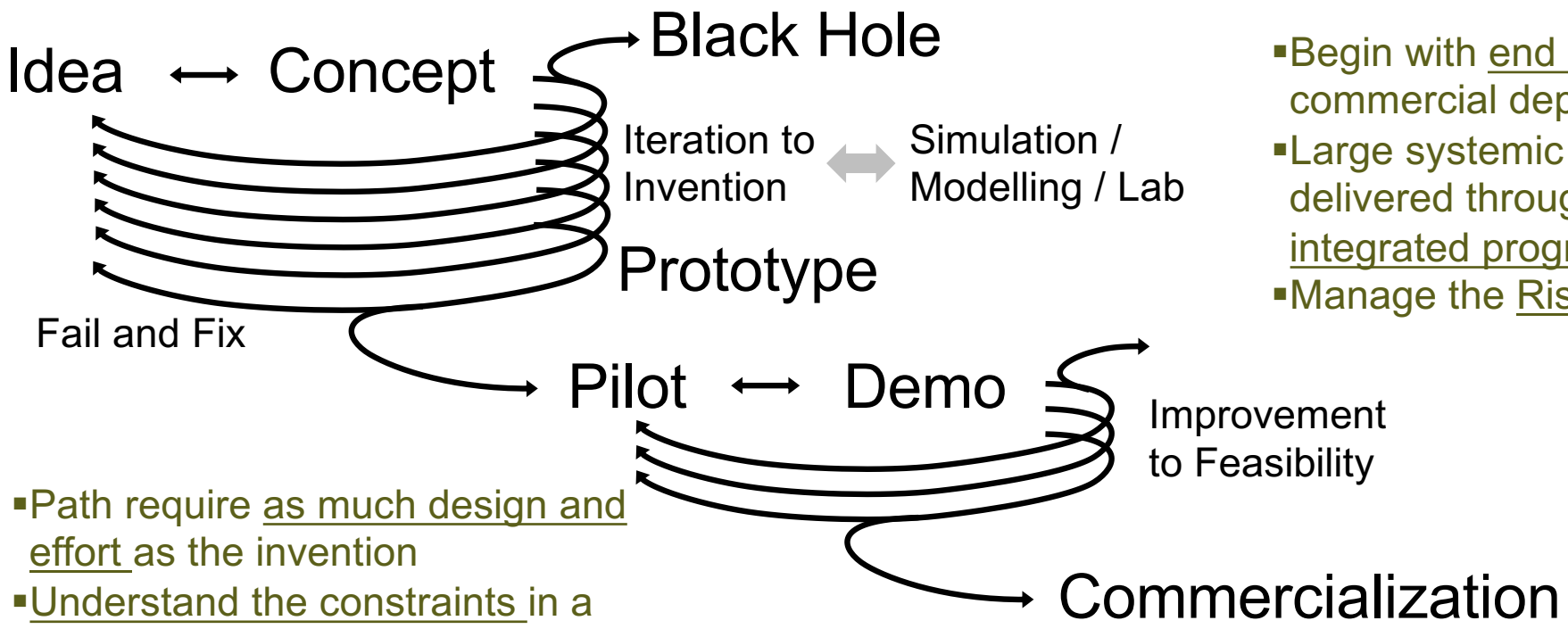
Idea → Concept → Pilot → Demo → Commercialization



- Begin with end in mind – commercial deployment
- Large systemic innovations delivered through integrated programs
- Manage the Risk profile

- Path require as much design and effort as the invention
- Understand the constraints in a Path to Deployment

Paths to Deployment

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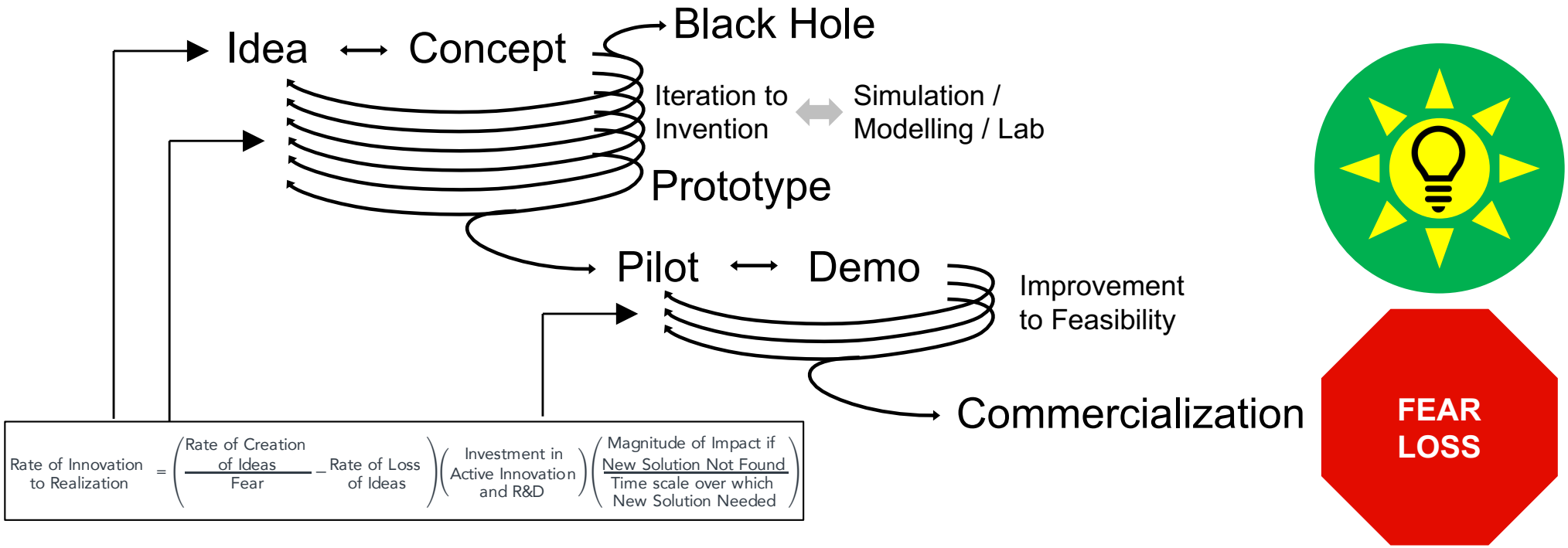
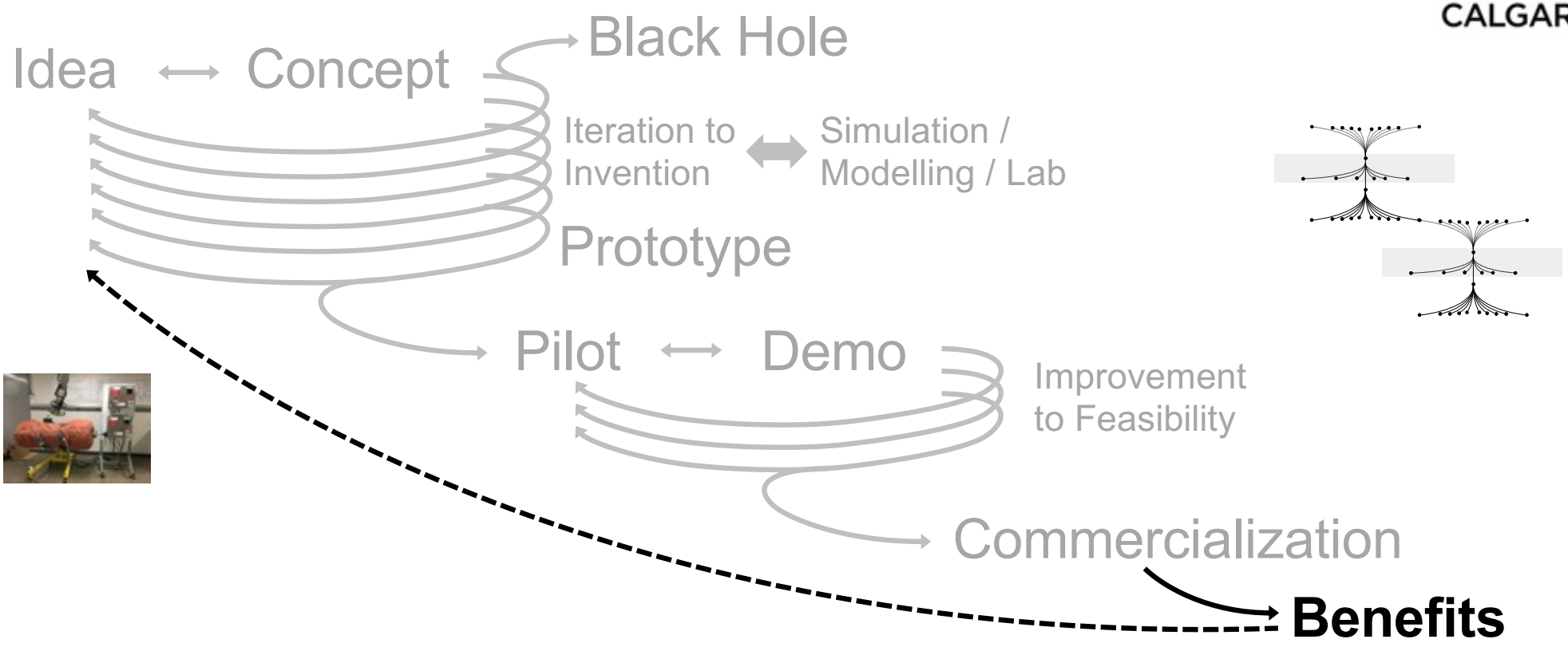
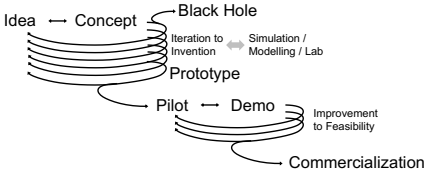
- Address the blocks/cliffs in “your” path to deployment – Technical, Social, …
- Must have a Social Path to Deployment as well as a Technical One



Path to Impact



- Jobs, New Revenues, Lower Costs, Lives/Communities Improved/Saved, Environment/Ecosystem Improved/Saved, New Industries, New Innovation, …, and the Cycle Continues



Ecosystem

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Spirit

Culture

Markets

People

Beer

Resources

Financing

Investors

Industry/End Users

Min Bureaucracy

Social Networks

Government

Universities

Risk

Wine

Business Infrastructure

Time Scale

Sharing/Communication

Nascent Entrepreneurs
Mentors
Role Models
Dealmakers

Recognition/Reward

Competition

Cooperation

Markets

Tolerance

Dense Actions

The Hard Stuff

Cheese

History

TRUST

Positivity

Freedom

The Refocusing of Oil Sands

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Oil Sands are an Immense Resource for Alberta and Canada

If World Demands Zero Carbon Energy, then Hydrocarbon Fuels Cannot be the End Product

We can still produce Bitumen, but this must go to Products

Represents Huge $$, Energy, and Chemical Feedstock Value

If for Fuel, the only Zero CO_2 Option is Hydrogen

Simplified Innovation Tree for H2

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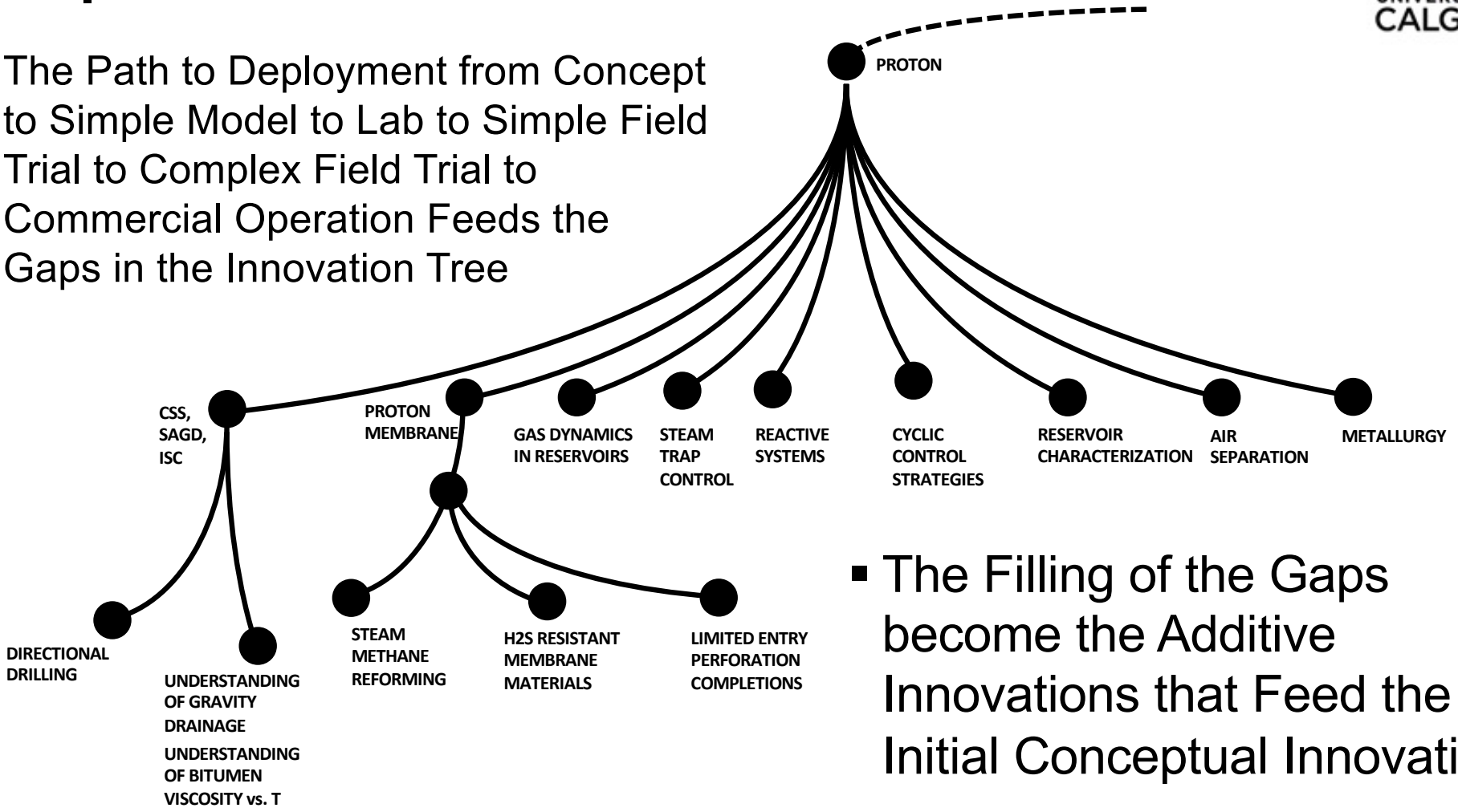
- The Path to Deployment from Concept to Simple Model to Lab to Simple Field Trial to Complex Field Trial to Commercial Operation Feeds the Gaps in the Innovation Tree



- The Filling of the Gaps become the Additive Innovations that Feed the Initial Conceptual Innovation

Proton Commercial Field Operation – Energetics

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- 5.7 m^3H_2/day per 24 cm membrane (half lab/field trial rates)
- 12 Production Vertical Well Operation
- 6 membrane bundles, 80% membranes in Well
- 100,000 m3/day Air, 4 MPa Injection Pressure
- 10% Decline on H2 Production expected per year
- Compressor Efficiency 80%, *powered by Produced Hydrogen*

- Initial H2 Production 8400 kg/day (~3.75 million scf / day)
- Initial Energy Return on Energy Invested = 18 GJ Out / GJ In
- *That is, Per Unit Energy Invested in the Process, We Get 18 Times the Energy Back as Hydrogen*

And Zero CO2 to Surface

- SAGD: SOR 3, Energy Return per Unit Energy Invested is about 7 GJ/GJ (to Get Bitumen at Surface)

Proton Commercial Field Operation – Post SAGD

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- 5.7 m^3H_2/day per 24 cm membrane (half lab/field trial rates)
- 800 m SAGD wellpair
- 6 bundle membrane, 50% along production well

- Hydrogen Production ~17,500 kg/day (~7.8 million scf H2 / day)
- At H2 sale price of $2/kg H2, revenue is $35,000 / day

And Zero CO2 to Surface

- SAGD: End of life wellpair 500 bpd production
  If raw bitumen price = $30/bbl, revenue is $15,000 / day

And >0.5 t CO2 per m3 bitumen produced at Surface

- Price of steam, water handling and treatment, emissions to atmosphere is greater than that of air separation/compression

Final Remarks

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- Need to build, from individual, family, group, team, to multinational corp. and governments, a feeling of creative belonging as guiding force for evolution of individuals, groups, and beyond – this means positive action, open communication, and forgiveness
- Consortia between Oil Sands Operators and Government can provide one model:
  - Canada's Oil Sands Innovation Alliance (COSIA), Canada's Clean Resources Innovation Network (CRIN), Crowd-sourced innovation

But Competition is also Good

- Make sure the Path to Deployment is Clear and Obvious
- **For acceleration, this requires:**
  - **positive, trusting and evolving relationships – both collaborative and competitive**
  - **seeking to understand, alignment of vision, coordination of effort,**
  - **Reward perturbative innovative thinking,**
  - **focus on priorities,**
  - **recognition of success and failure**
- Finally, there are people who are intrinsically motivated to find the next answer – they will continue to innovate and persevere – we must remove barriers and enable them

Thank you for listening

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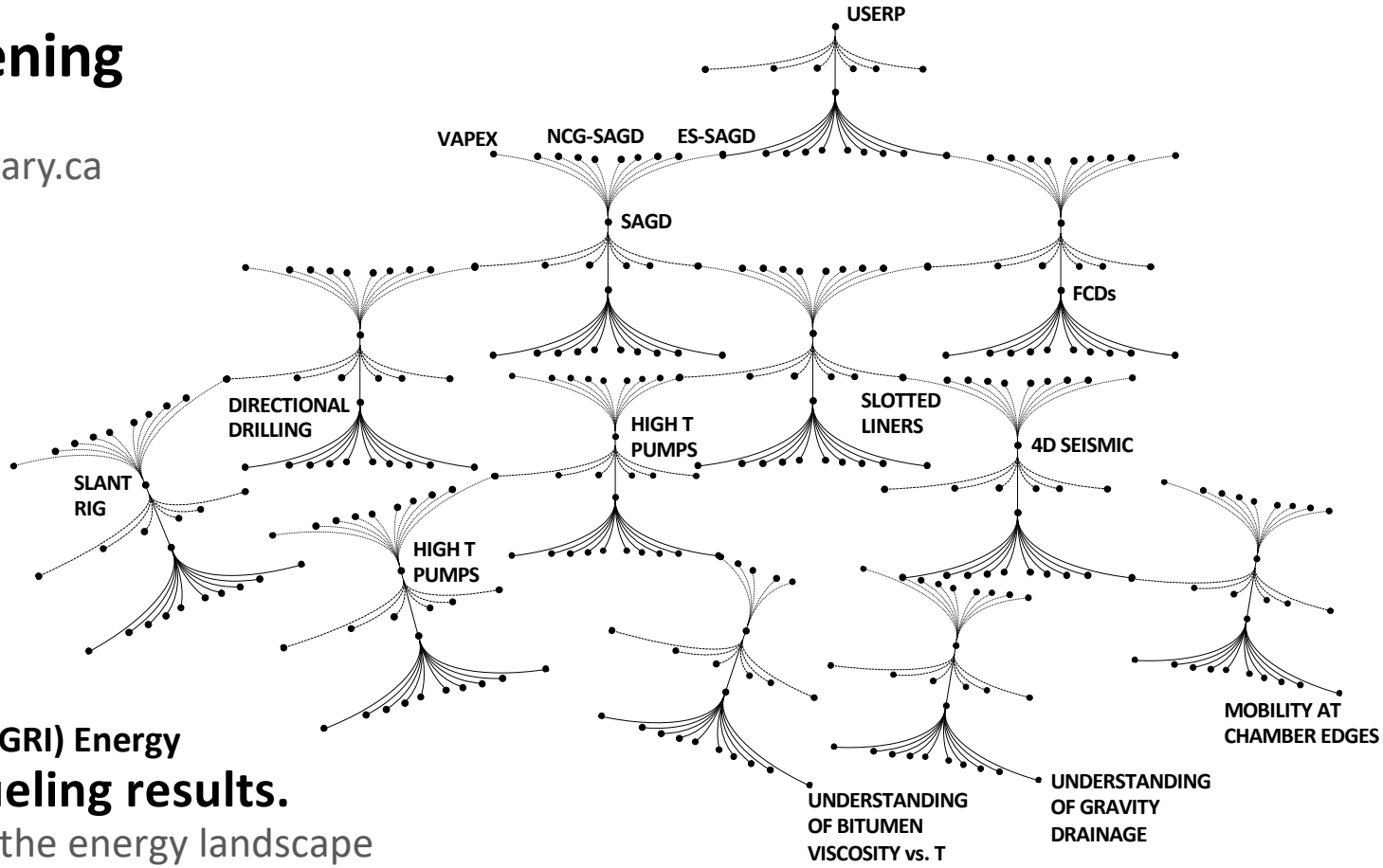

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