2024 GAS LIFT WORKSHOP

Disruptive S-Curves for Surface Controlled Gas Lift and ESPs

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ARTIFICIAL LIFT INTELLIGENCE

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Agenda

- Innovation Trends
  - S-Curve
  - Disruption Curve
  - Ecosystem Interactions
- Trends: Surface Controlled Gas Lift
- Trends: ICVs
- Trends: ESPs
- Conclusions

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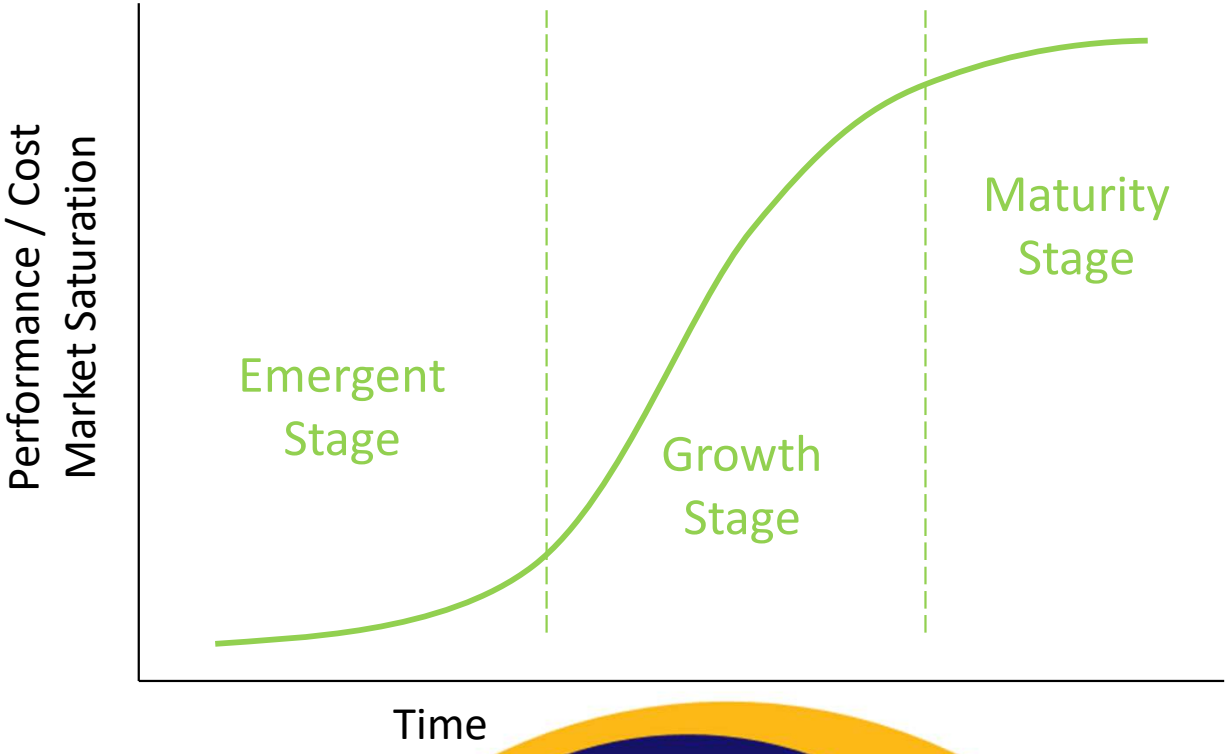
Technology S-Curve



3 Stages of S-Curve

- **Emergent Stage:** Introduction, little consistency (Betamax, VHS)
- **Growth Stage:** enabled by ***establishment of a dominant design***
  - no longer convincing customers and trying to figure out what they want
  - production and optimization
- **Maturity Stage**: sustaining innovation

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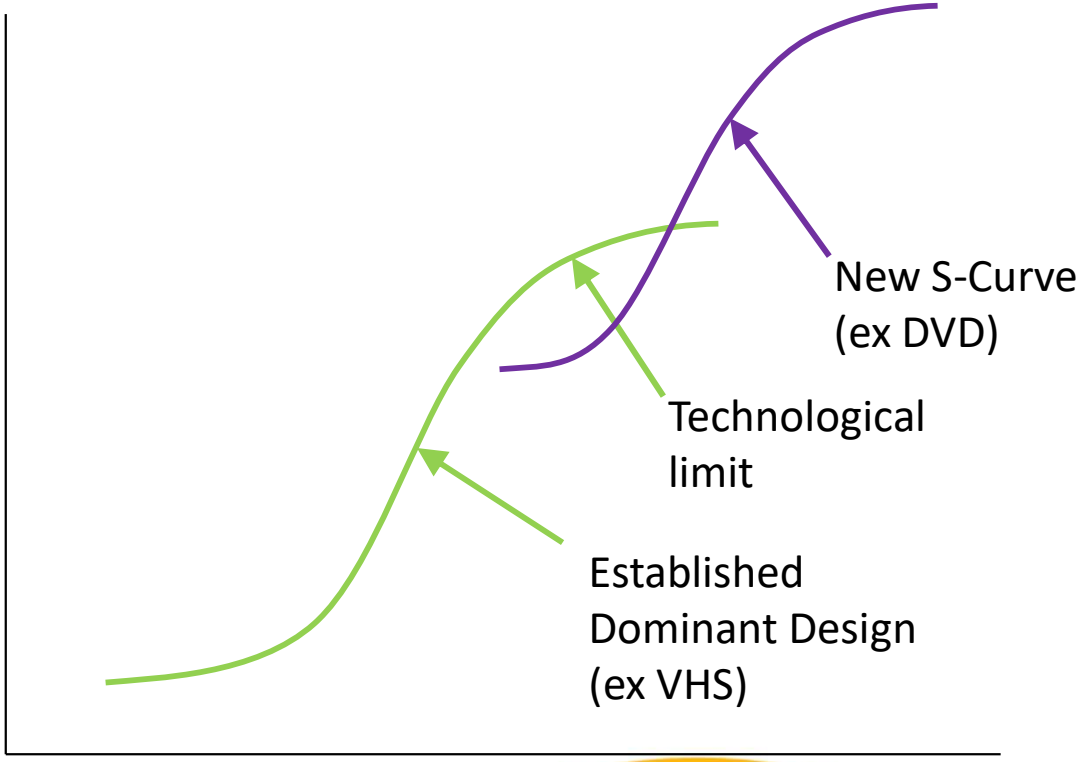
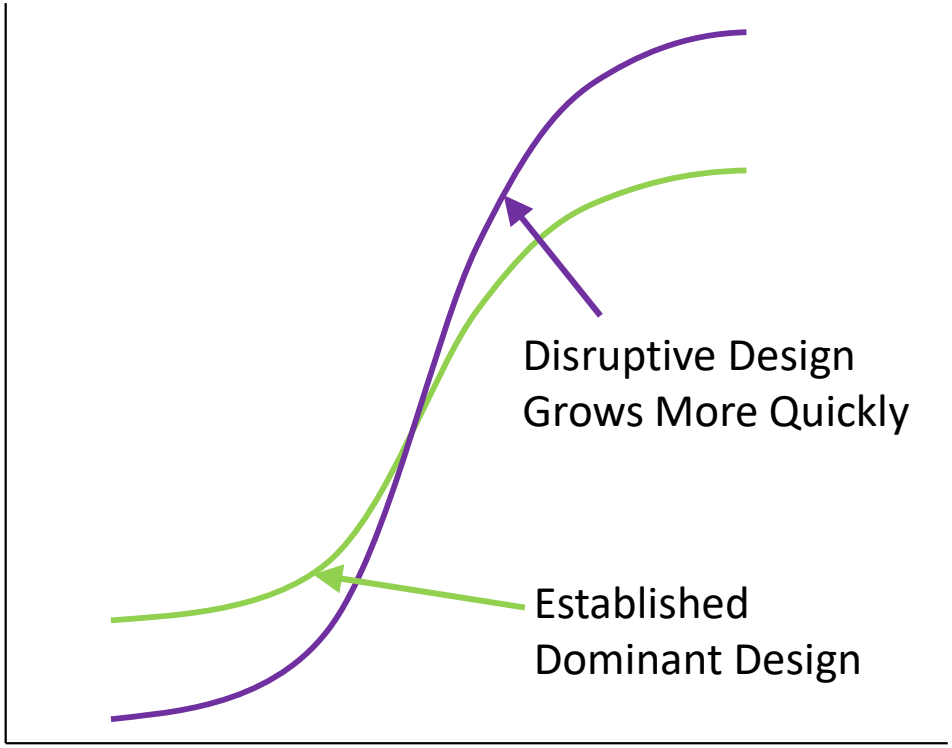
Patterns of S-Curves





Adapted from Christensen's
"The Innovators Dilemma"

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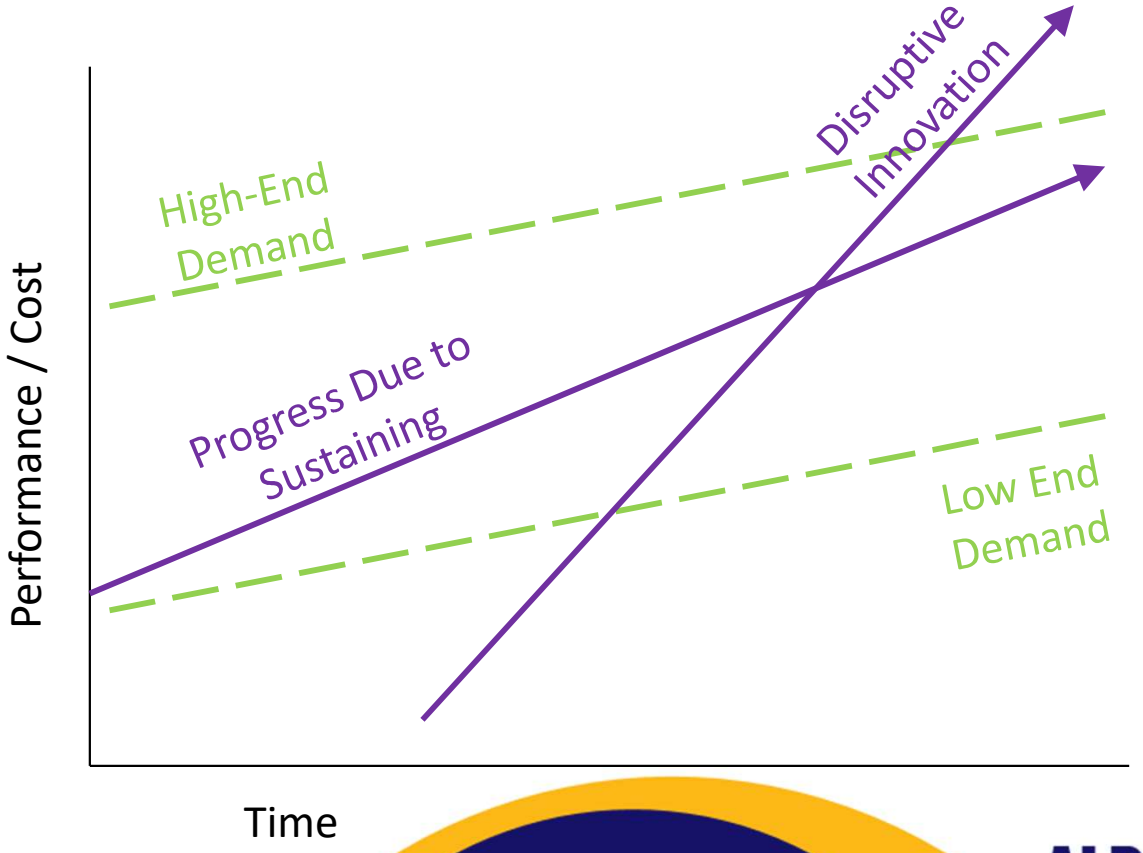
Disruptive Technology Change



Disruptive Innovation:

1. Start at a low customer value
2. Rate of progress much steeper than trajectory of incumbent technology

Adapted from Christensen, Mcdonald, Altman, Palmer "Disruptive Innovation: An Intellectual History and Directions for Future Research"

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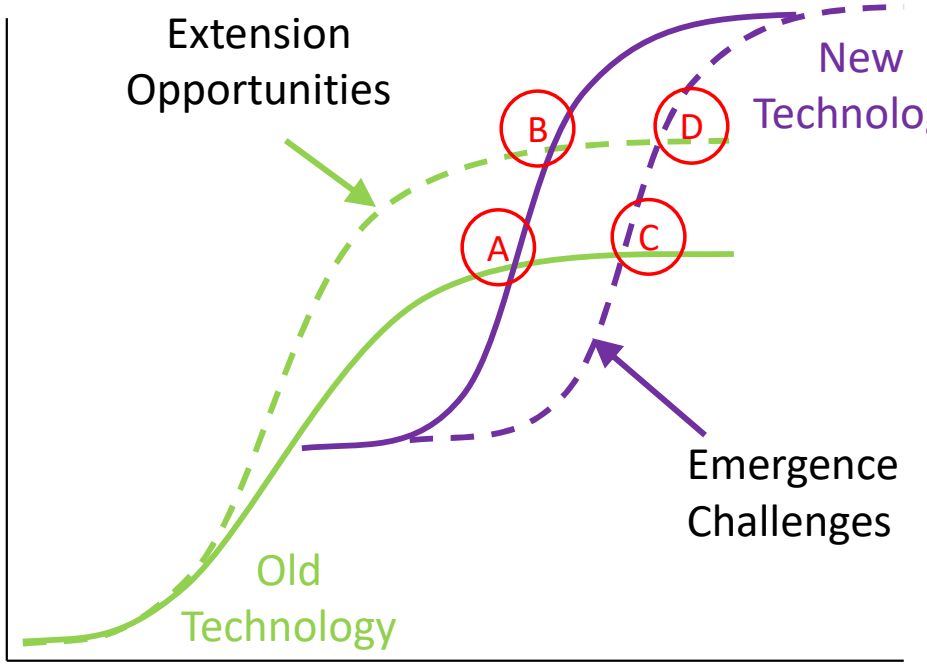
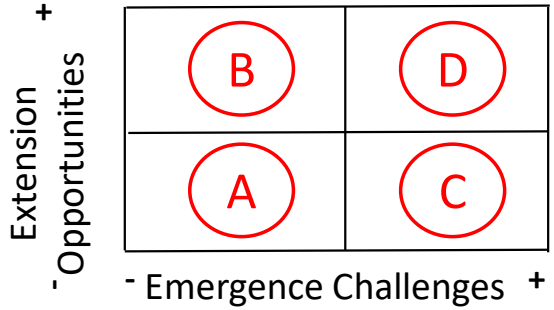
Ecosystem Disruption Framework



Source: Ron Adner and Rahul Kapoor, *"Right Tech, Wrong Tech,"* Harvard Business Review VOLUME (2018)



A **Creative Destruction:** Classic and fastest substitution; new ecosystem is ready to go and the old can't be significantly improved

B **Robust Coexistence:** New technology is compatible with the existing ecosystem and the old ecosystem can be improved

C **Illusion of Resilience:** New ecosystem needs considerable development and the old ecosystem has little room for improvement.

D **Robust Resilience:** The new ecosystem needs considerable development and there are abundant opportunities to improve the old ecosystem

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Surface Controlled Gas Lift: Innovation Curves

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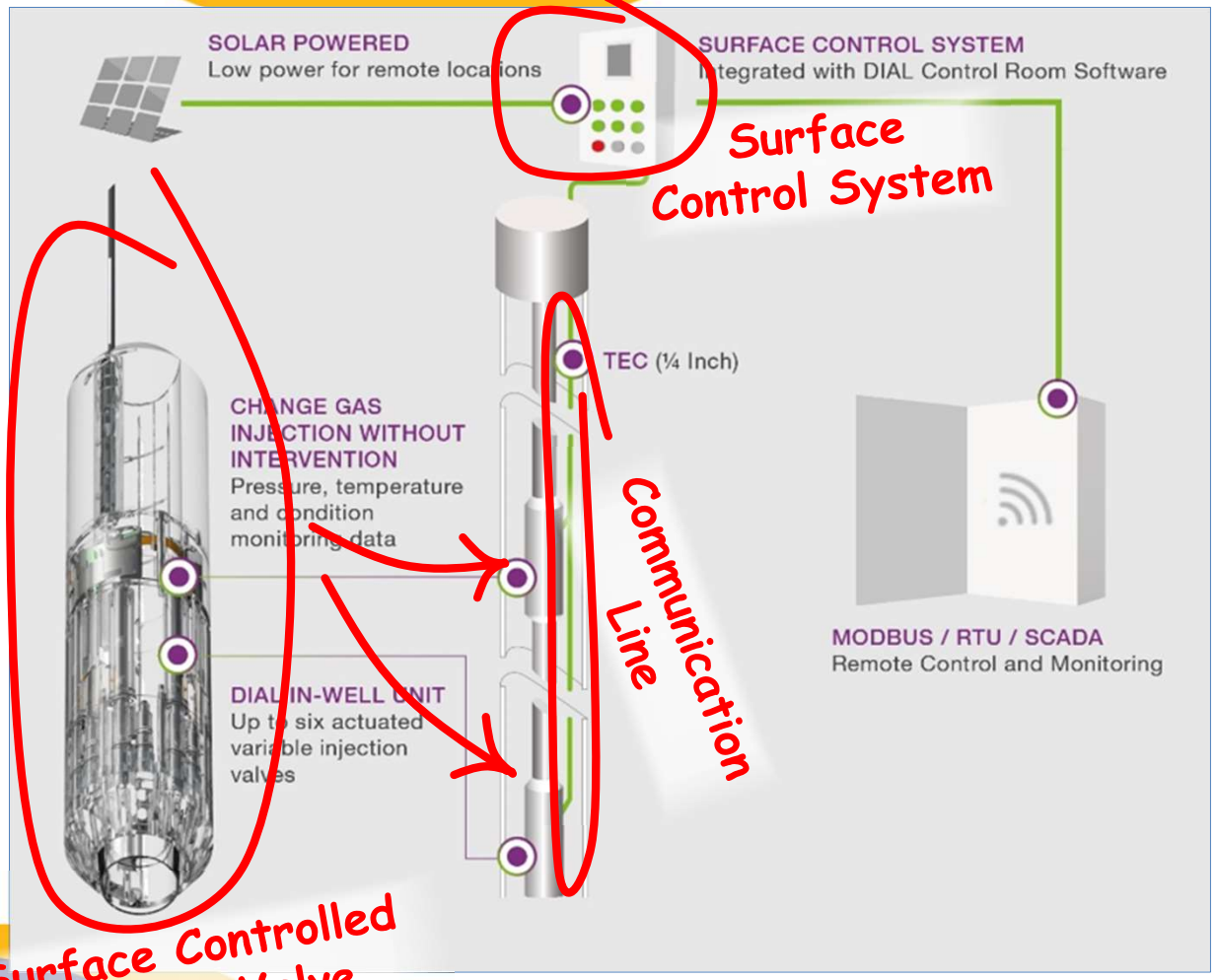
Surface Controlled Gas Lift: Essential Components:

- Surface Controlled Gas Lift Valve
- Surface Control System
- Communication Line (Hydraulic or Electric)



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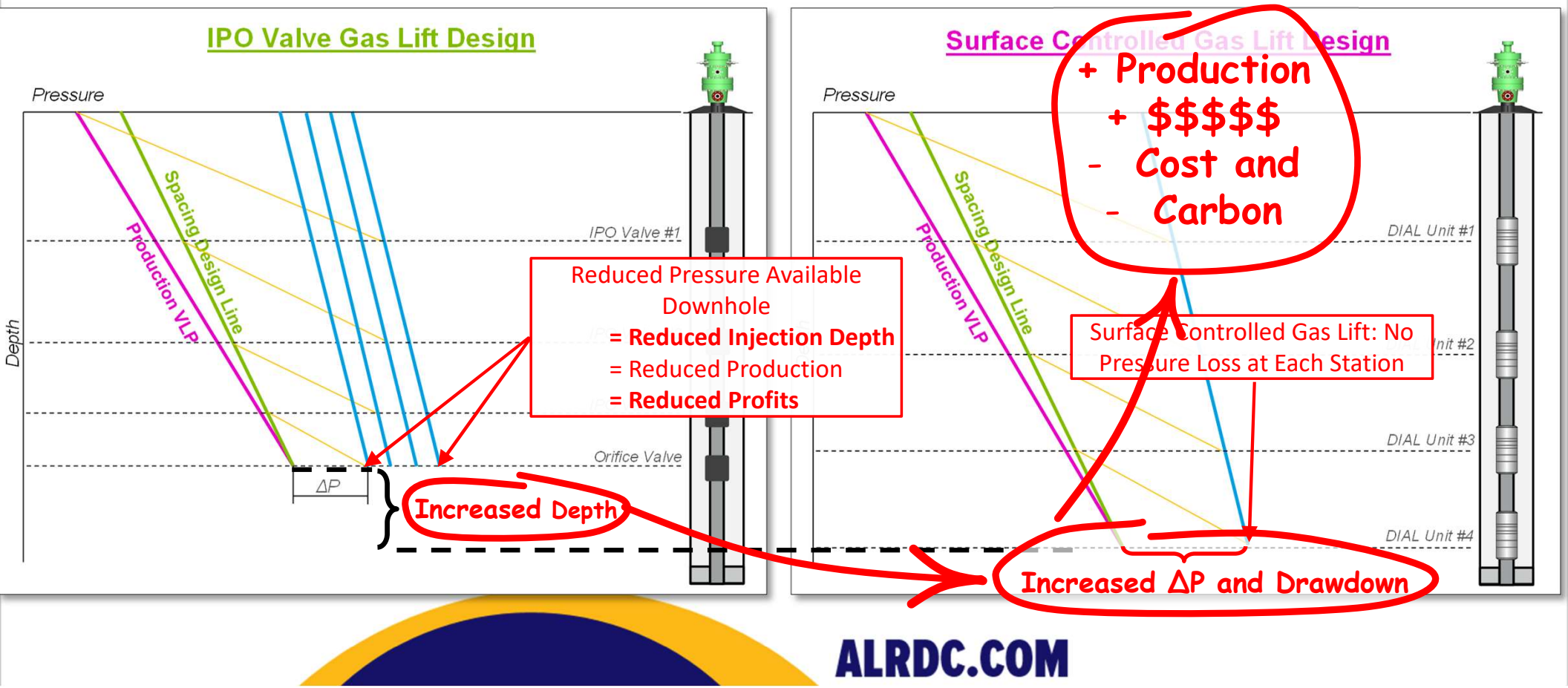
Surface Controlled vs IPO Design



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Surface Controlled Gas Lift Innovation Path

THEN

"PUSH" Innovation – initially a "solution looking for problem"

- Innovative actuator
- Found home in automotive, medical, aerospace, oilfield

Business Cases Developed Around Gas Lift

- Much more costly than conventional; Initially unproven

-BUT-

- Rapid payback;
- Reduced OPEX, intervention, carbon intensity, hazard……..

NOW

"PULL" Innovation

- Operations WANT solutions
- Entrants to the Market
- BUT, other actuators might be better suited for some applications

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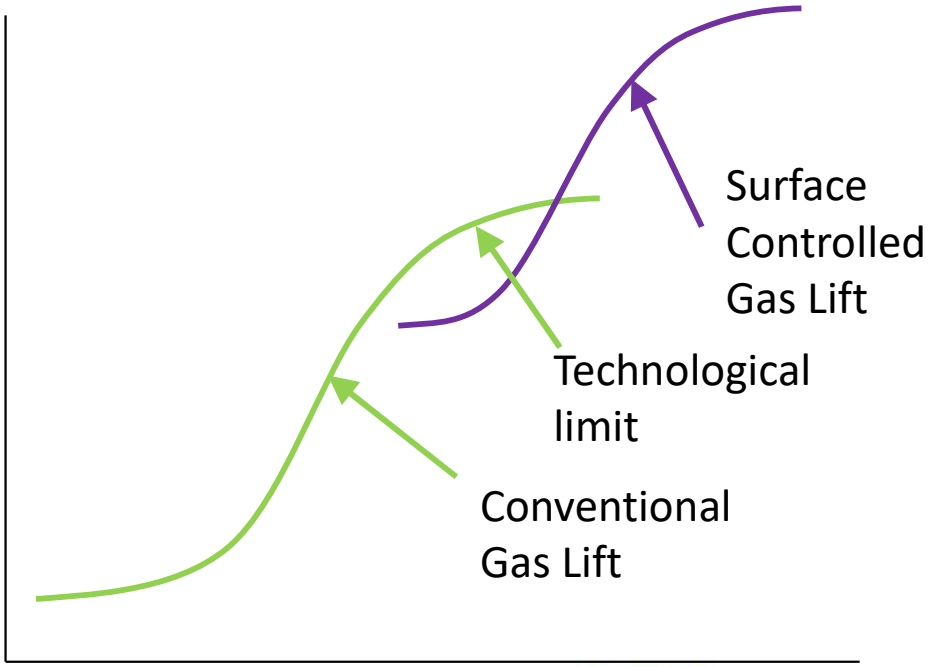
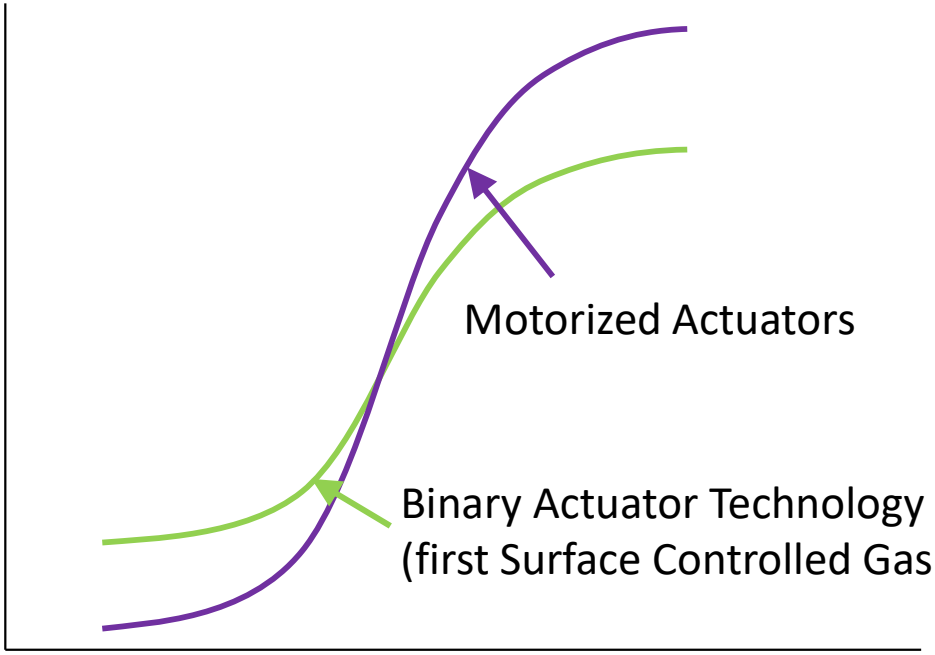
Surface Controlled Gas Lift S-Curves

S-Curve Interactions: Surface Controlled Gas Lift and Conventional Gas Lift



S-Curve Interactions: Electric Surface Controlled Gas Lift Actuator Types



Adapted from Christensen's "The Innovators Dilemma"

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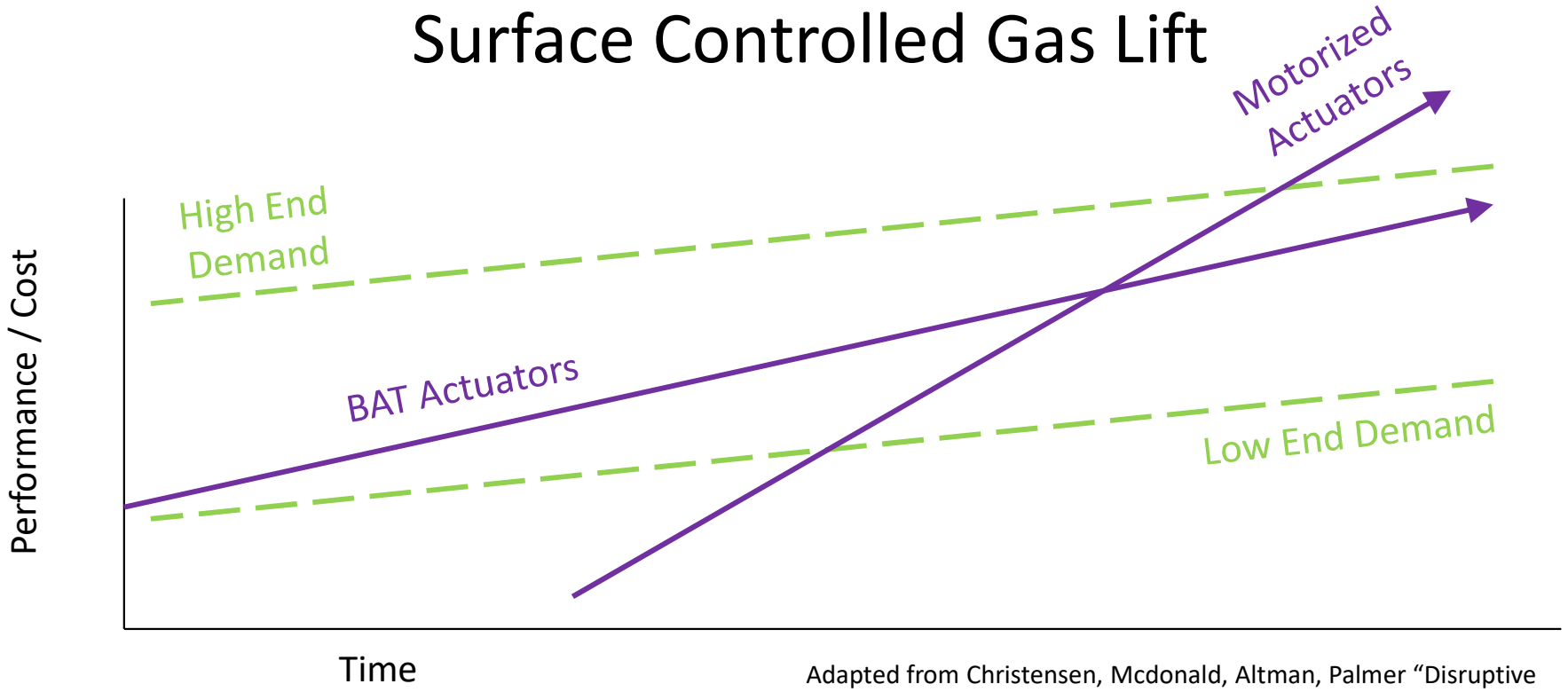
Disruptive Technology Change: Surface Controlled Gas Lift



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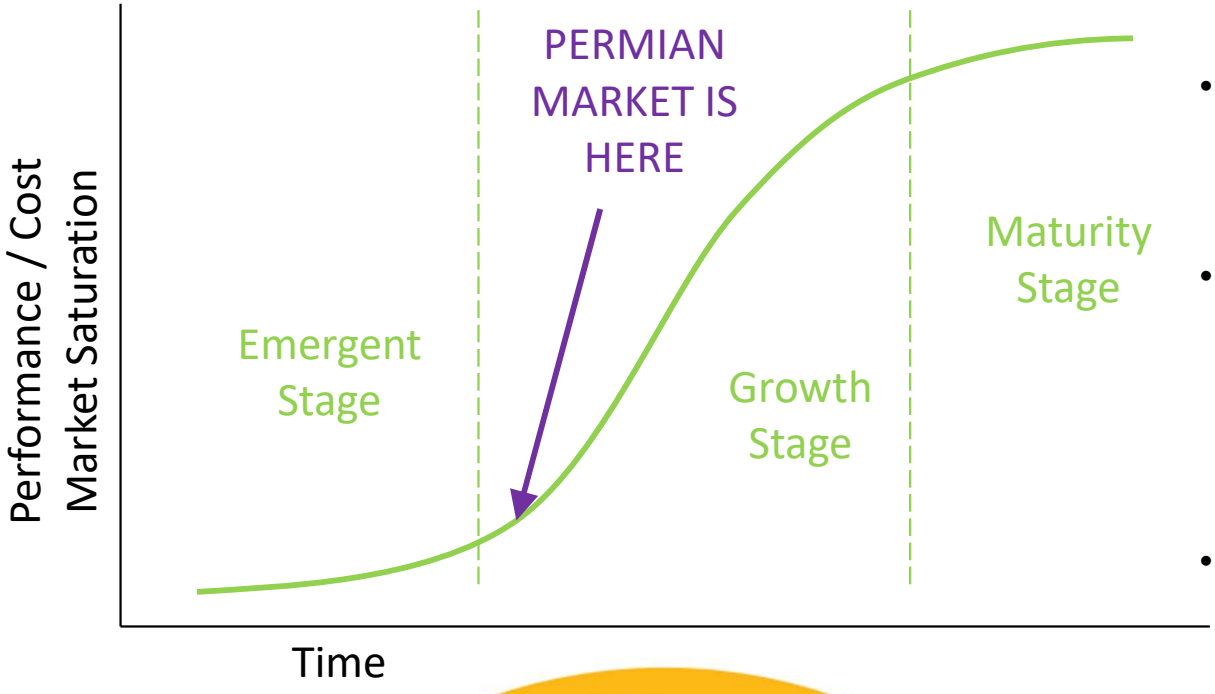
S-Curve: Permian Unconventional Surface Controlled Gas Lift Technology



- **Emergent Stage:**
  Initial Installations (SPE 201140-MS) and (SPE 214939-MS)
- **Growth Stage:**
  Enabled by establishment of a dominant application design (bidirectional flow for annulus / tubing lift / production; ability to swap between them)
- **Maturity Stage:**
  Sustaining innovation and incremental improvements

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Interval Control Valves: S-Curve Interactions

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ICV Technology

THEN

Initial Electric and Electric/Hydraulic ICVs

- Complex
- Expensive

Hydraulic ICVs

- Less expensive
- Less complex / More reliable
- Less functionality

More Advanced Hydraulic ICVs

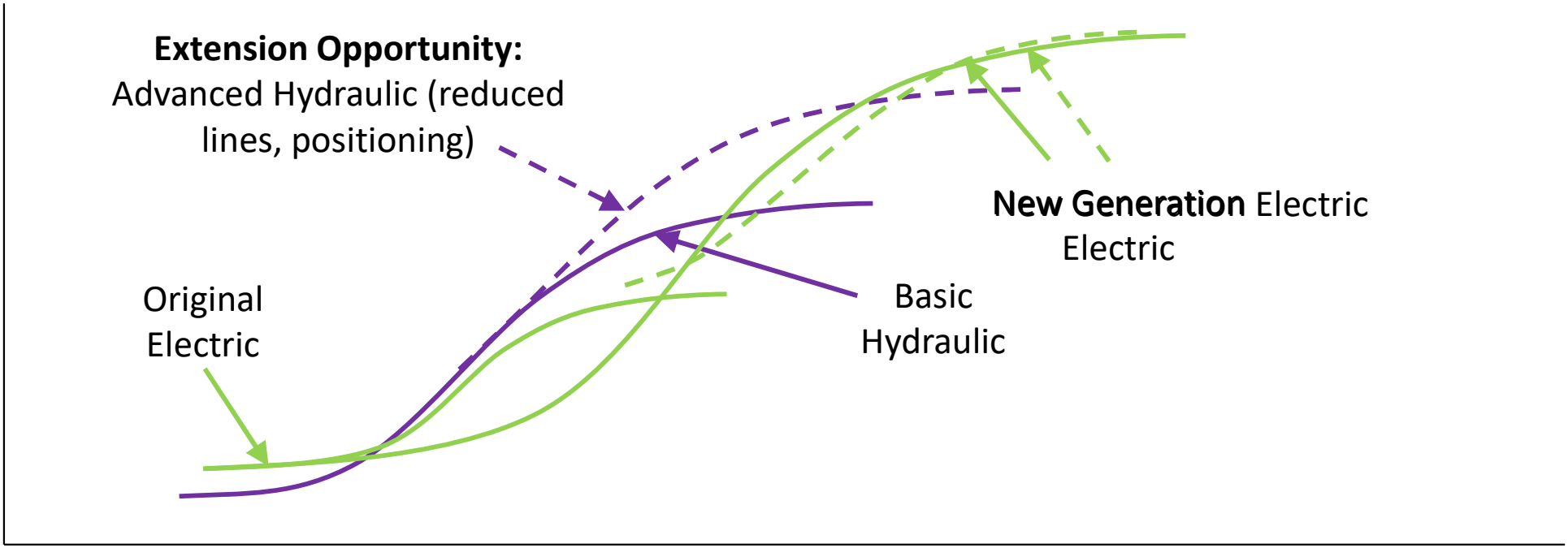
- Multiple position options (j-latch, hydraulic stepping)
- Line minimization strategies (Single Lien Switch, Digital Hydraulic, etc)

NOW

New Generation Electric and Electric / Hydraulic

- Downhole electronics have advanced
- Much better understood and more experience

ICV S-Curve Interactions



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ESP S-Curves

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ESP Technology

THEN

Basic ESP: Electric Submergible [SIC] Pumps

- 1930's
- Widely accepted

VFD: Variable Frequency Drive

- Wider operating Range
- More efficient

Sensing (downhole pressures, motor performance)

- Improved control of ESPs
- Better understanding of reservoir
- Preventative maintenance

NOW

PMM: Permanent Magnet Motor

- Better control
- More efficient

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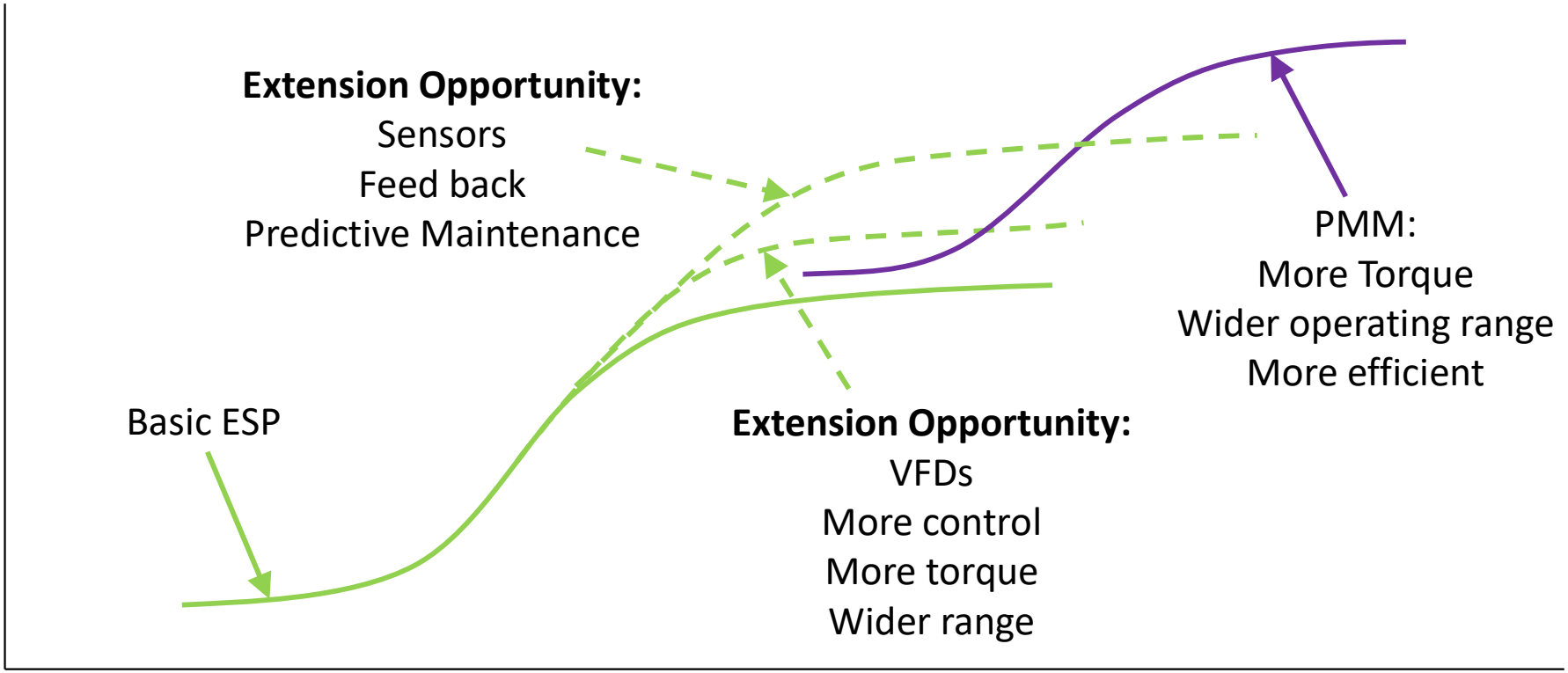
ESP S-Curve Interactions



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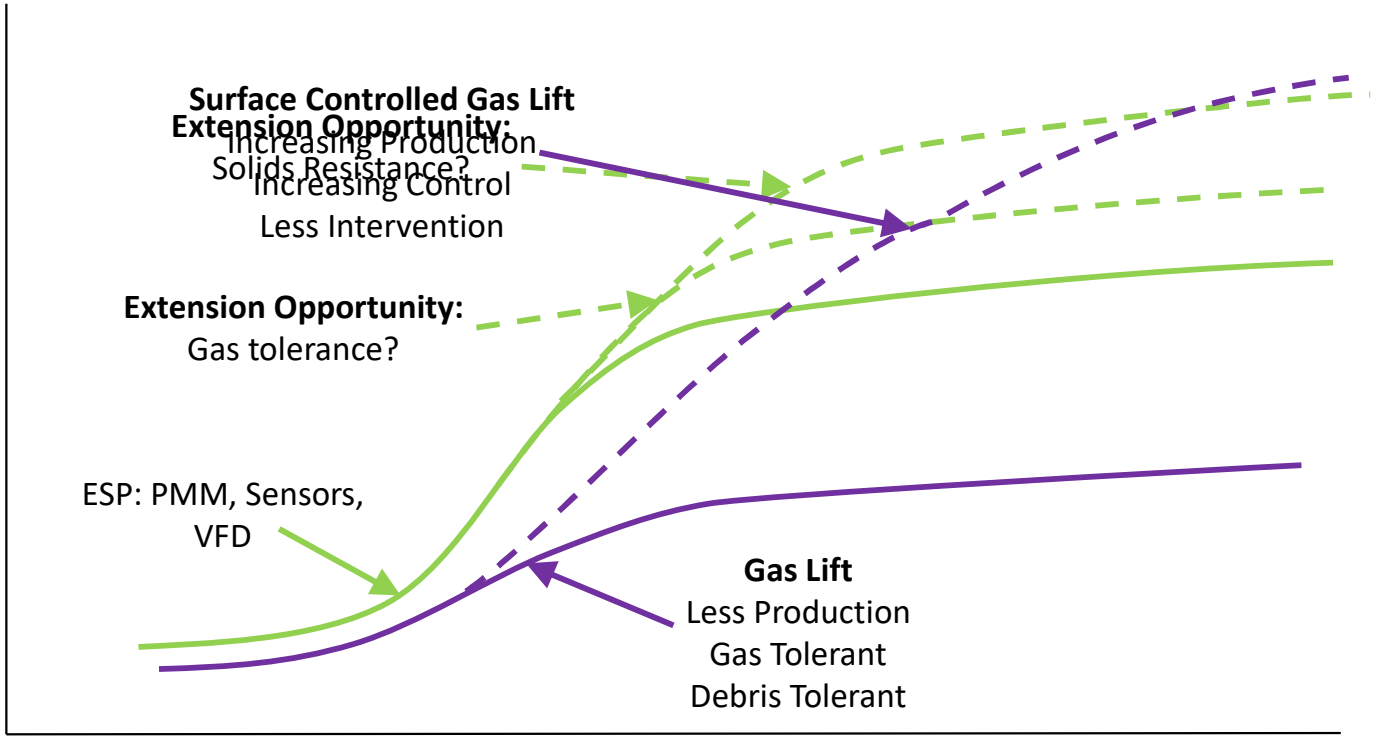
ESP: What's Next?



Unconventionals:

- Gas Production
- Solids (proppant)
- High initial production
- Production quickly drops

ESP Shortcomings:

- Debris tolerance
- Gas tolerance
- Lift up annulus?

Summary / Conclusions

- Innovation follows trends across markets and industries
- Offers insight into the path of new technologies
- Comparing trends can help decide where new technologies might lead
- Discussion topics:
  - Is Surface Controlled Gas Lift finding a niche?
  - What is the future of ESPS in the Unconventional Market? Gas Lift?
  - Where do we see Extension Opportunities? Or resistance?

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Question Time

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