Subsea Awareness Course - Field Development Planning

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GENESIS

Introduction

- A little bit about me…
- Tell us about you…
  - Name?
  - Your work area?
  - How many years of experience?

Contents

TAKE 5 : Safety/Value Moment

- Job safety analysis:
  - PPE provided and worn
    - Hard hat
    - Arms protected
    - Gloves
  - So is there a problem?

TAKE 5 : Safety/Value Moment

Setting the Frame…i.e. Mindset

- What is an Oil Company?

  A Business

- What is the Business Model of an Oil Company?

  Sell HC Products for a PROFIT

- How does an Oil Company remain in business?

  Maintain Product Lines

Blue Sky Thinking

?

Terms

- **Upstream** = Exploration and Production (E&P) of hydrocarbon resources
- **Midstream / Downstream** = Transportation, refining, and marketing of produced and refined hydrocarbon products
- **Reservoir** = A geological feature that contains hydrocarbons
  - Conventional: sandstone (clastic), carbonate
  - Unconventional: coal bed/seam methane, SHALE!

  Lead = Before discovery Prospect = Lead ready to be drilled

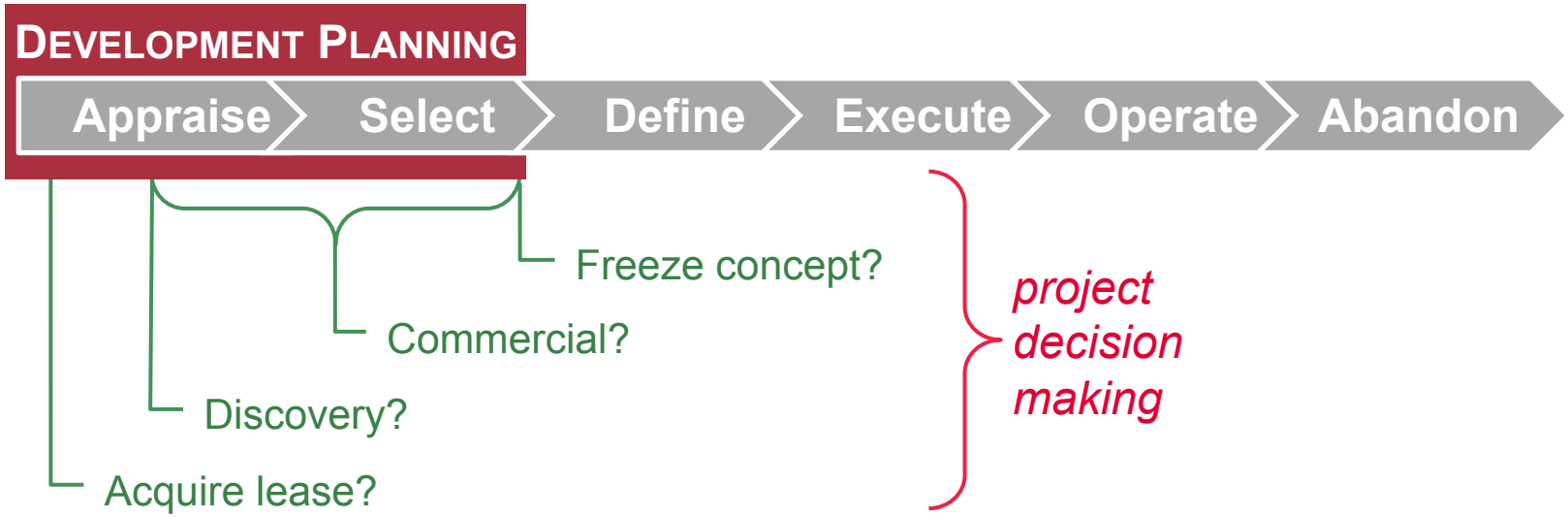
  Discovery = An exploration well that shows a potentially commercial amount of HC's
- **License** = A specific area (block or acreage) offered by a government for oil and gas exploration and production, with terms:
  - The required exploration "work" program (seismic or wildcat wells)
  - The exploration and production terms and timing (i.e. How soon after a discovery must production begin?)
  - Fiscal regime = Defines the split of revenue between the government and the oil companies. The fiscal system must be reflected in the calculation of economics.

Field Development Planning in the Project Life Cycle

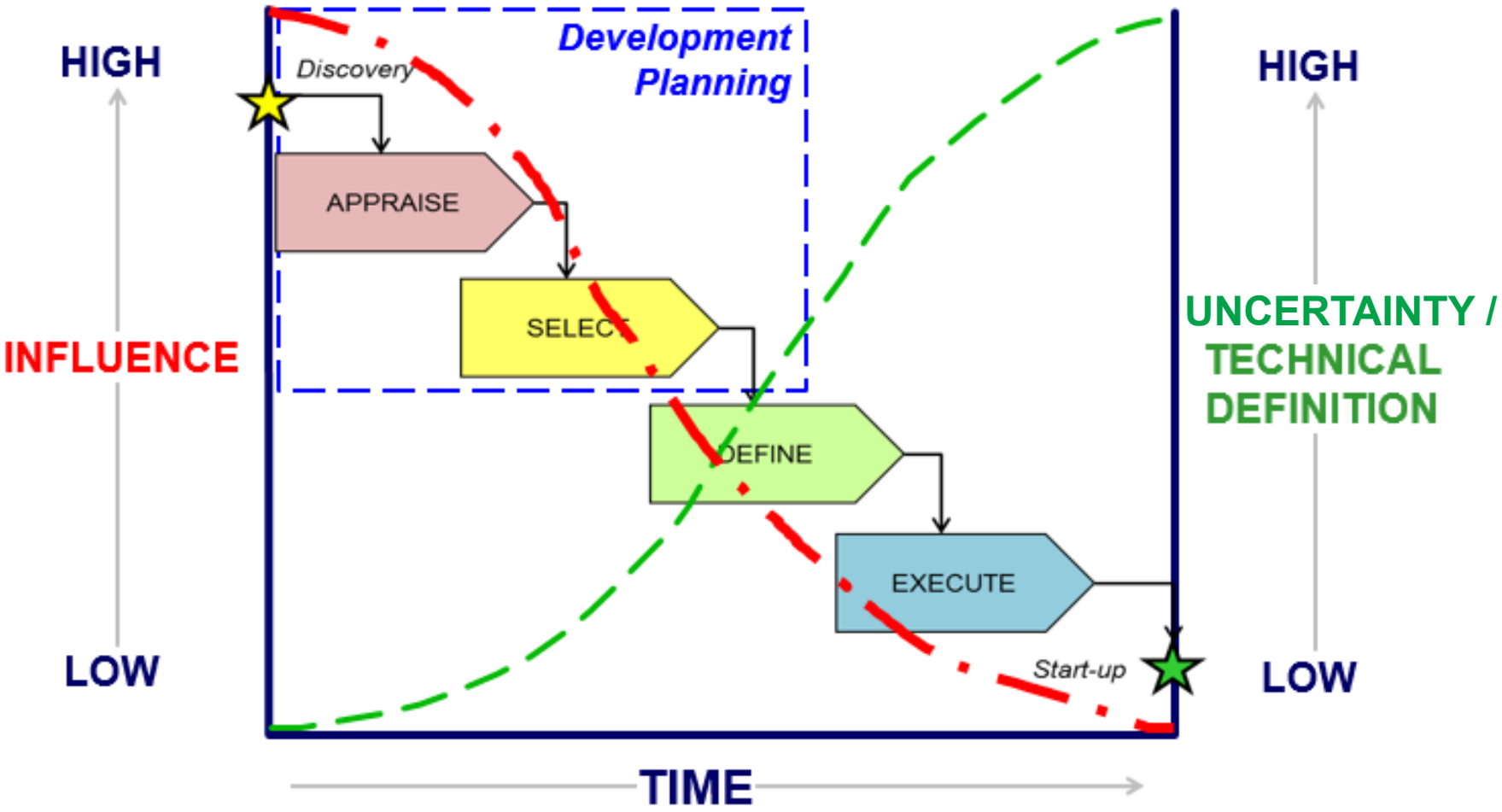
- Process used by Operators to manage project development risk:

- Hunt for ***VALUE***
- Make ***DECISIONS***, ideally ***GOOD*** ones:
  - *Is there a project* worth pursuing?
  - *What is the optimum* development?

…the front end of a *Capital Value Process*

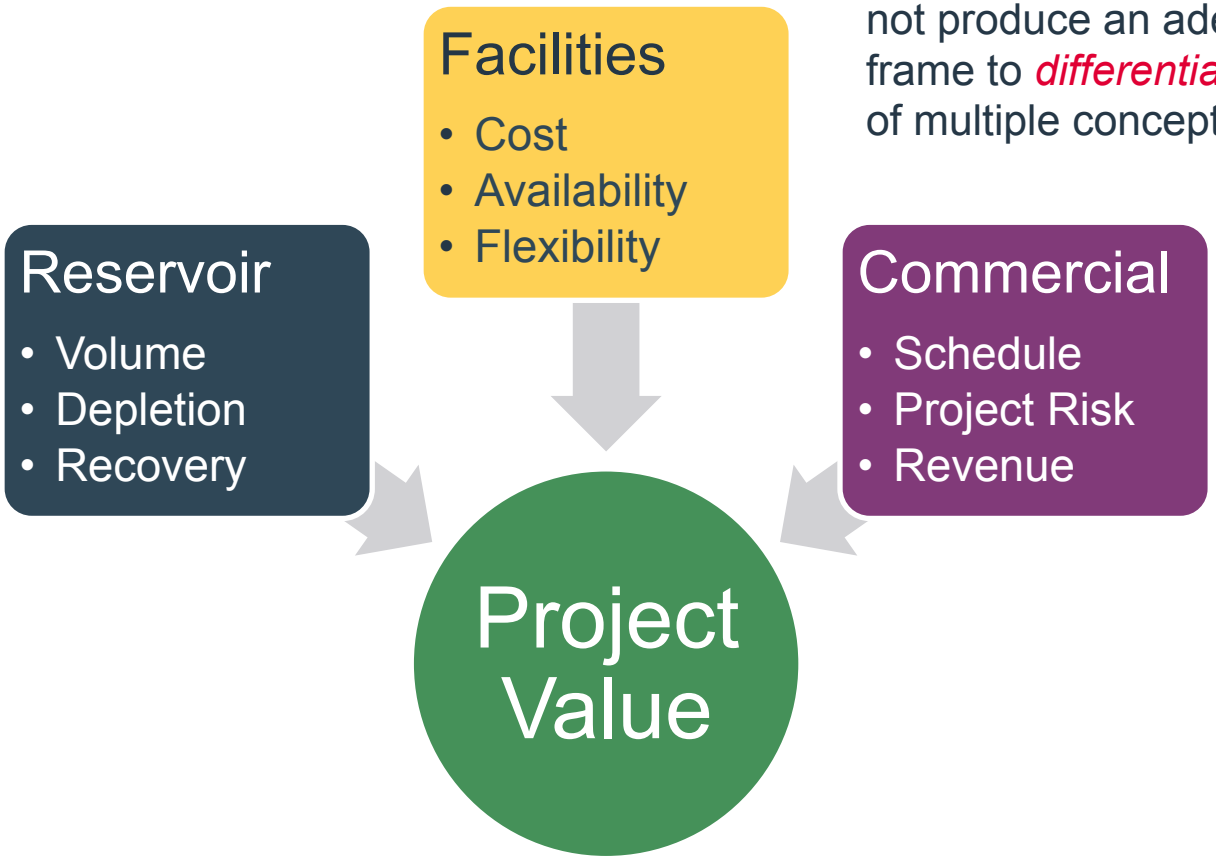


Influence vs. Time



Development concept is driven by…

Cost and schedule alone do not produce an adequate frame to *differentiate the value* of multiple concepts

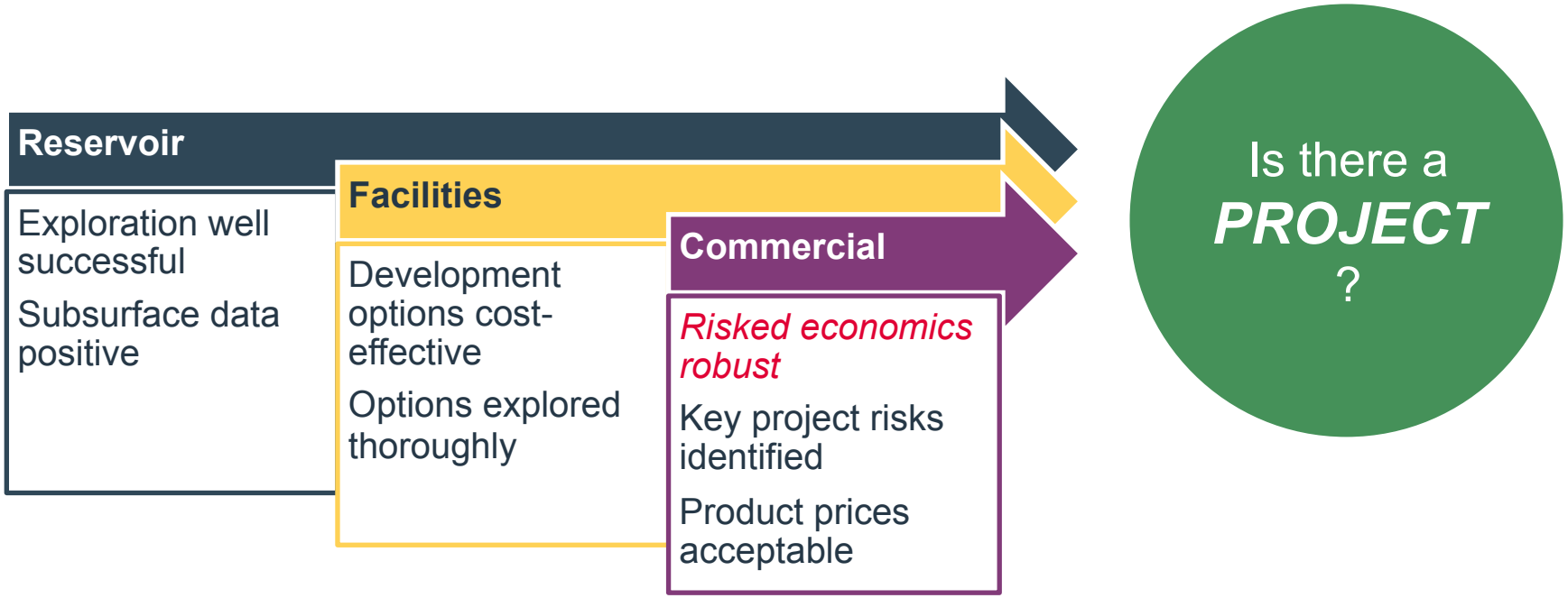


"Under-performance is attributed largely to ….
inaccurate evaluation of the ***economic impacts*** *of uncertainty*."

Source: Begg, S, Bratvold, R and Campbell, J. (2002, October). *The Value of Flexibility in Managing Uncertainty in Oil and Gas Investments*. SPE 77586. SPE Annual Technical Conference & Exhibition, Texas.

Making *GOOD DECISIONS*

Focus on *key decisions* rather than every decision



Looking at sensitivities that are not really important wastes time, money…
Floater selection or subsea architecture is moot ***if you don't have a commercial prospect.***

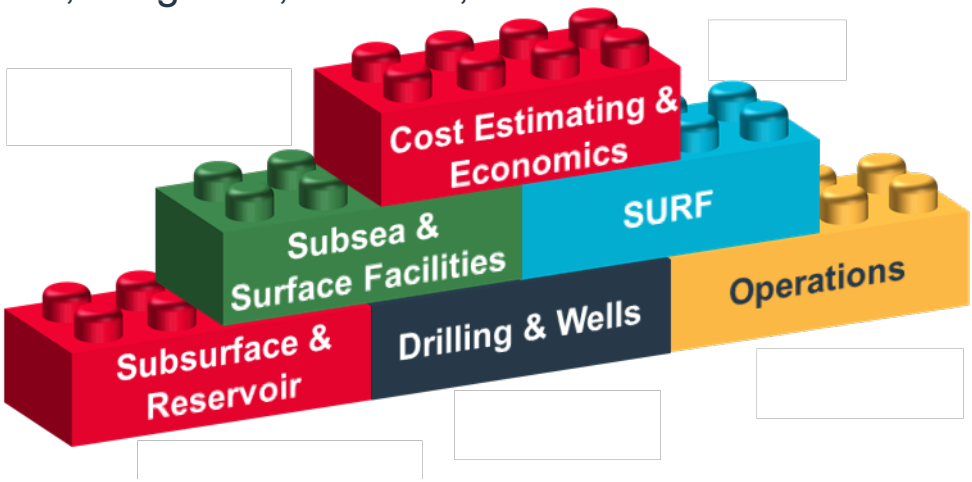
What is the optimum development ?

To converge on a 'robust' development concept that maximizes value across a range of uncertainties and best manages risk

- Uncertainties – What might happen? How big or small could it be?
- Risk = Likelihood x consequence → What is the likely or expected impact?
  - Subsurface Uncertainties
    - Deepwater and Arctic wells are costly and take a long time to drill
    - Frontier regions lack basic design data and analogs
  - Technology uncertainties and risk
  - Execution uncertainties and risk
    - Drilling rig availability and day rate
    - Global fabrication and installation market uncertainties
    - Force majeure – labor strikes, weather, etc.
    - Regulatory risk
  - Geopolitical risk
  - Oil and gas price uncertainties

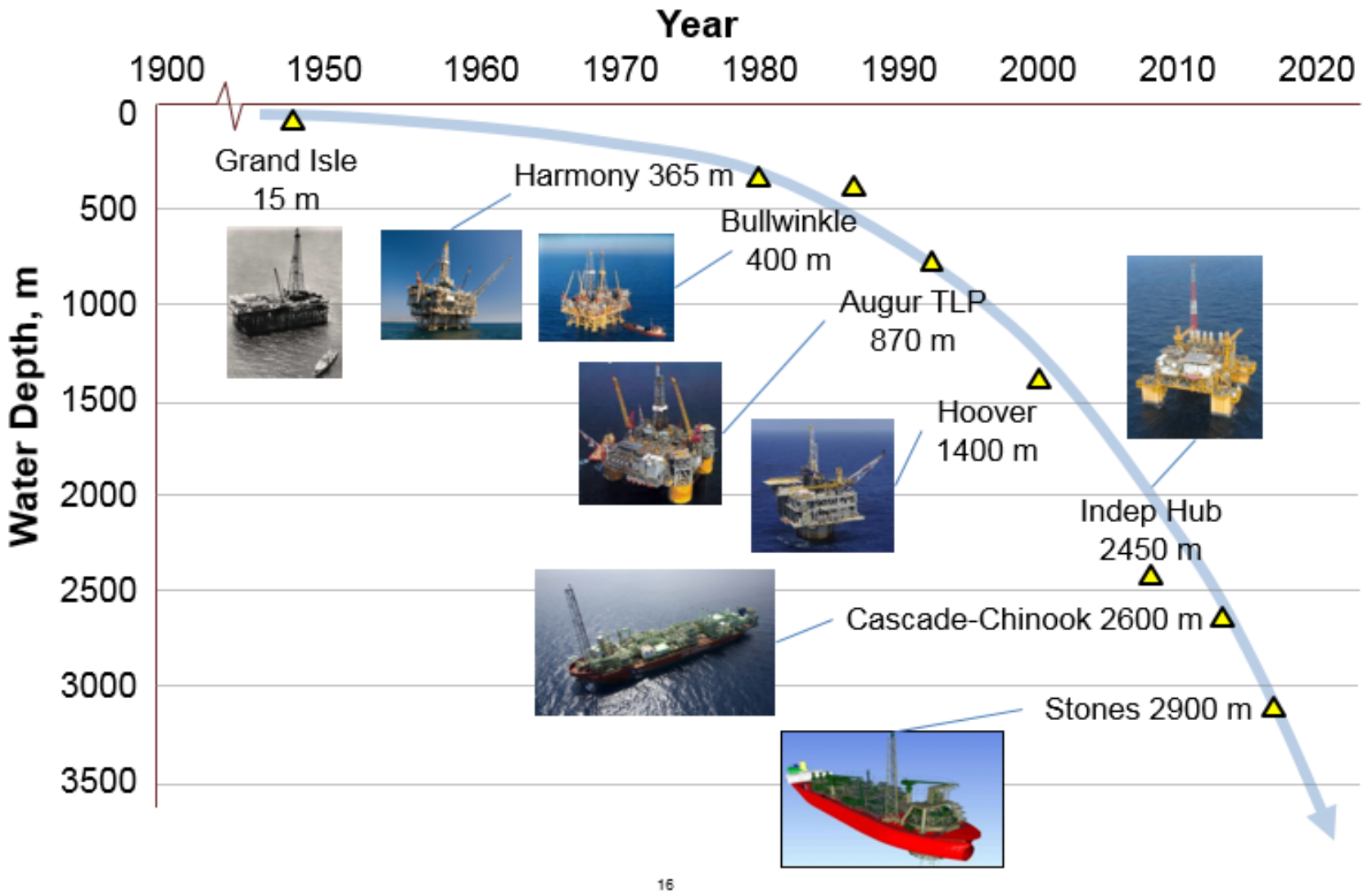
Development Planning Is…

- The integration of multiple disciplines and factors
  - ***Subsurface*** – Geological description, uncertainties and reservoir depletion plans
  - ***Drilling*** – well and completions designs
  - ***Facilities*** – trees, flowlines, risers, substructure, export system
  - ***Technology*** – are new drilling or facilities technologies needed?
  - ***License terms*** – acreage relinquishment; timing constraints
  - ***Commercial*** – agreements with government, partners, marketing
  - ***Execution approach*** – where built, integrated, installed, local content
  - ***Fiscal terms & economics***
  - ***Budget constraints***
  - ***Project risks***



- **Alignment with:** (1) management, (2) technical and business functions, (3) partners, (4) government, (5) NGOs, (6) contractors

Historical Overview of Offshore/ Deepwater



Deepwater Drilling

- **Deeper Water**
  - ***More costly to stay on station*** – Move moored rigs to dynamically positioned rigs
  - ***Longer times*** to run the drilling riser and BOP and to change out bits
  - ***Narrows the margin*** between fluid pressure in the rock (pore pressure) and the pressure at which the rocks will fracture (frac gradient) – adds complexity and cost.
- **Deeper Wells**
  - ***Very high hook load*** (suspended weight) rigs
  - ***Long drilling times***
  - ***More complex well designs*** (more casings, etc.)
  - ***High pressure/ high temperature***
- **Costs for drilling in deepwater ~ $1+ Million/ day**
  - Semi or Drillship ~ $350-650 k/ day
  - Above rig spread ~ $500 k/ day
- **Time for drilling in deepwater ~ 50 to 300 days**
  - Some wells in the US Gulf of Mexico have been drilled to a total depth in excess of 30,000 ft.

Deepwater Drilling

Getting Hydrocarbons out of the ground

Reservoir engineering: Once I make a discovery, how do I get the hydrocarbons out ?

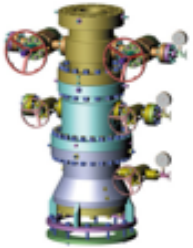
- ***Oil / gas in place*** = Porosity (open space pores) x rock volume
- ***Recoverable oil / gas*** = Recover factor (RF%) x oil / gas in place
  - A key is permeability = How well the oil and gas flows?
  - Typical **oil** recovery factors:
    - Primary recovery/ depletion = 10-20% - limited by pressure decline
    - Secondary recover = 35-45% - with pressure maintenance from water or gas injection wells and artificial lift (gas lift, pumps, etc.)
  - **Gas** recovery factors: 50-90%; typically, gas reservoirs are produced by depletion or primary recovery; gas expands much more than oil as pressure declines and is much more mobile than oil
- Fluid properties affect recovery: e.g., oil viscosity, gas in the oil (gas-oil ratio), amount of condensate in gas.

Surface Trees vs. Subsea Trees

What is a tree?

- Assembly of valves & fittings to control production out of (or injection into) a well

Dry or Surface Tree



Well head and tree are above the water, easy to reach

Why dry trees?

- Reservoir is compact → 1 drill center
- Multiple well interventions are planned
- Flow assurance issues

Issues

- Requires a platform rig; topsides and vessel must be larger to accommodate the well bay and rig
- Difficult in deep water, as dual-barrier risers become increasingly heavy and expensive

Subsea Tree

Well head and tree are on sea bottom, require a floating rig to reach

Why subsea trees?

- Reservoir is spread out → multiple drill centers
- Flow assurance can be managed
- Surface wells / risers are too expensive

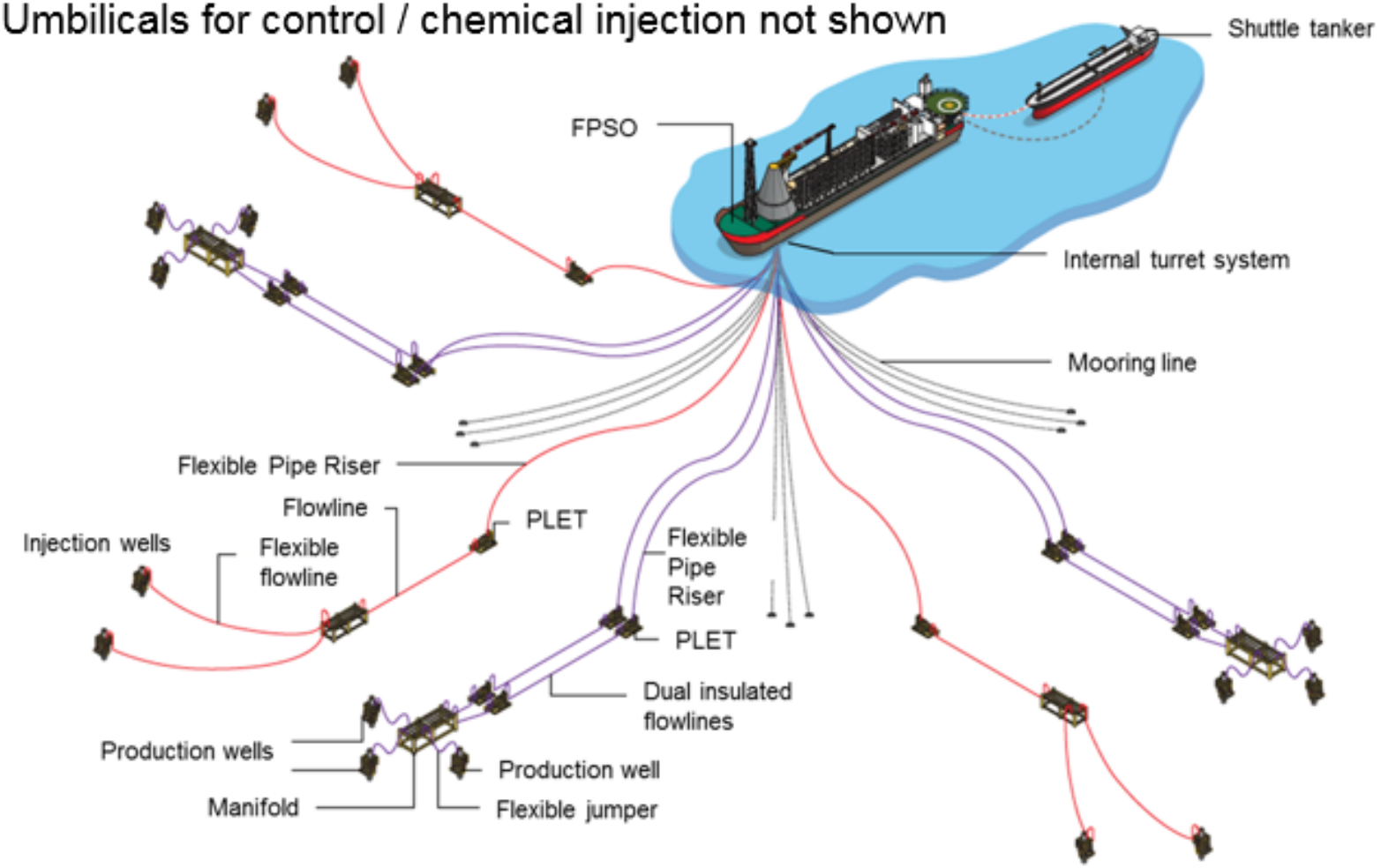
Issues

- Expensive deepwater drilling rig (MODU)
- Subsea reliability – no longer a major issue

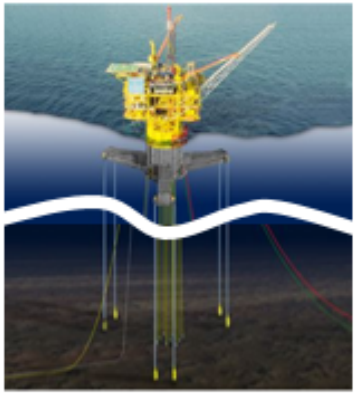
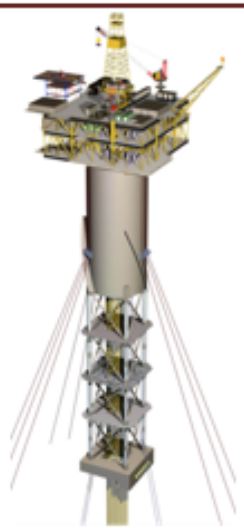
Subsea System Architecture

Subsea wells → manifold → flowlines → risers → FPSO

Umbilicals for control / chemical injection not shown



Deepwater Floating Production

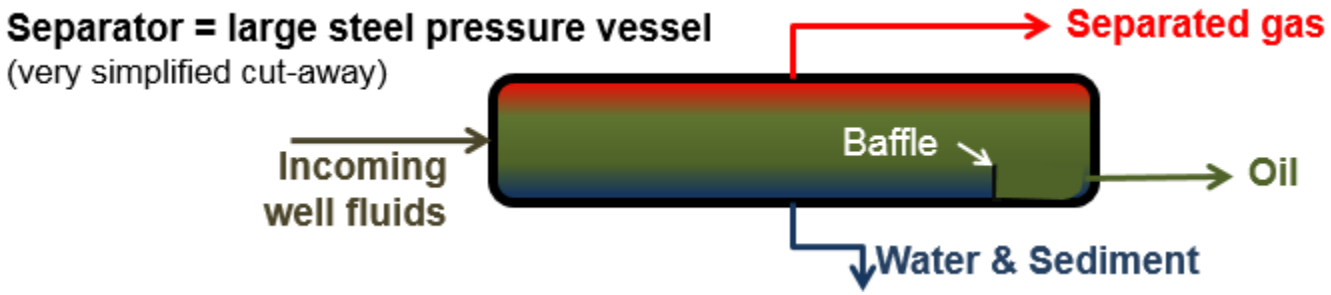
Structure	Technical / Development	Industry Experience
TLP (Tension Leg Platform) 	• Lowest-motion for surface trees; some w/ subsea wells • Tendons (specially designed steel tubes) • Use of steel catenary risers (SCRs) • No oil storage • Installation / removal complicated	• 1st installed in 1984 (Hutton, 147 m) • Heidrun (1985) is largest at 255 kboed • Big Foot @ 1580 m is deepest (2014) • < 30 installed
Spar 	• Low motion for surface trees; some w/ subsea wells • Mooring lines • Use of steel catenary risers (SCRs) • 1 with condensate storage (Aasta Hansteen, 2016) • Installation / removal complicated	• 1st installed in 1997 (Neptune, 590 m) • Holstein (2004) is largest at 140 kboed • Perdido @ 2380 m is deepest (2010) • < 25 installed

Deepwater Floating Production

Structure	Technical / Development	Industry Experience
Semisubmersible 	• Solely subsea wells to date; can have drill rig • Mooring lines • Use of steel catenary risers (SCRs) • No oil storage • Installation / removal easier	• 1st installed in 1975 (Argyll, 75 m) • Thunderhorse (2008) is largest at 285 kboed • Independence Hub @ 2440 m is deepest (2007) • ~ 50 installed
FPSO (Floating Production, Storage & Offloading)  **FLNG** = Floating LNG Huge, Prelude (2017)	• Subsea wells only • Usually flexible pipe or hybrid risers; smaller SCRs • Conversion / newbuild • Mooring lines • Spread moored; external turret; internal turret • Storage • Installation / removal easier	• 1st installed in 1977 (Castellon, 115 m) • Agbami (2008) is largest at 325 kboed • Stones @ 2900 m is deepest (~2016) • > 200 installed

Processing Facilities

- **Oil and gas** typically don't come out of the ground ready to be sold
  - Oil usually comes with gas, water and small amounts of sediment
  - A major cost for an oil and gas project is the facilities needed to separate the oil, water and gas
    - Separators use gravity and residence time to split the oil, gas and water



    - Multiple stages of separation are usually needed to get the oil to sales quality
    - Gas is compressed for export via pipeline or for gas injection
    - Water is cleaned and disposed overboard or injected
- Processing facilities must also: operate reliably; generate power; take in seawater, filter & inject it; deal with slugs & emulsions; separate & dispose of H_2S & CO_2, if present

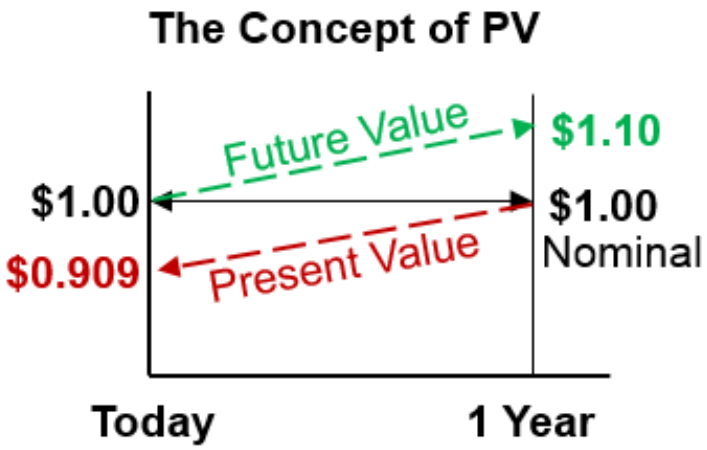
Economics – Present Value

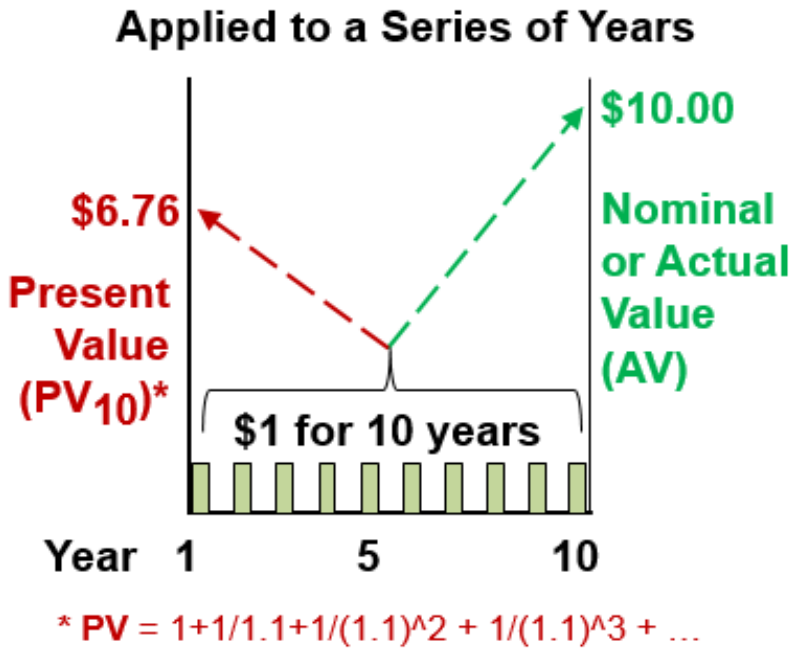
- What is ***Present Value***?

Today's actual or nominal value (AV) = $1 today or in any given year

Future value of $1 a year from now = $1 x (1+ return) = $1 x 1.1 = $1.10

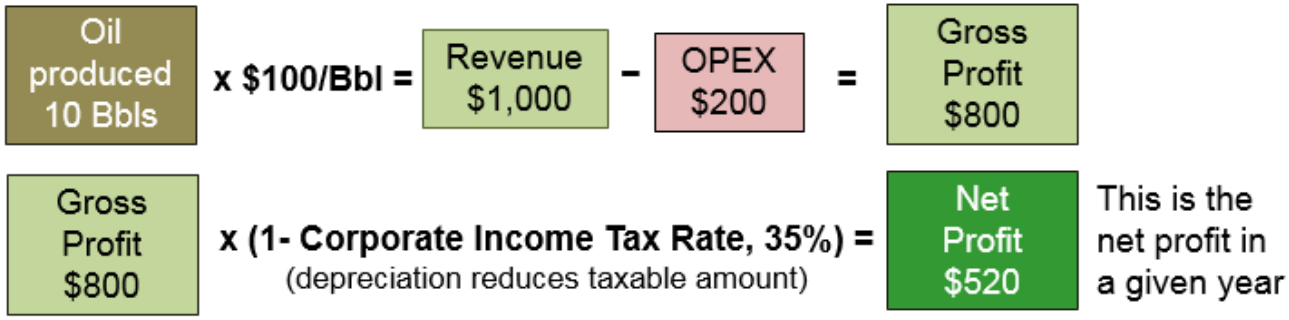
Present value (PV_{10}) = value today of $1 next year = $1/1.1 = $0.909





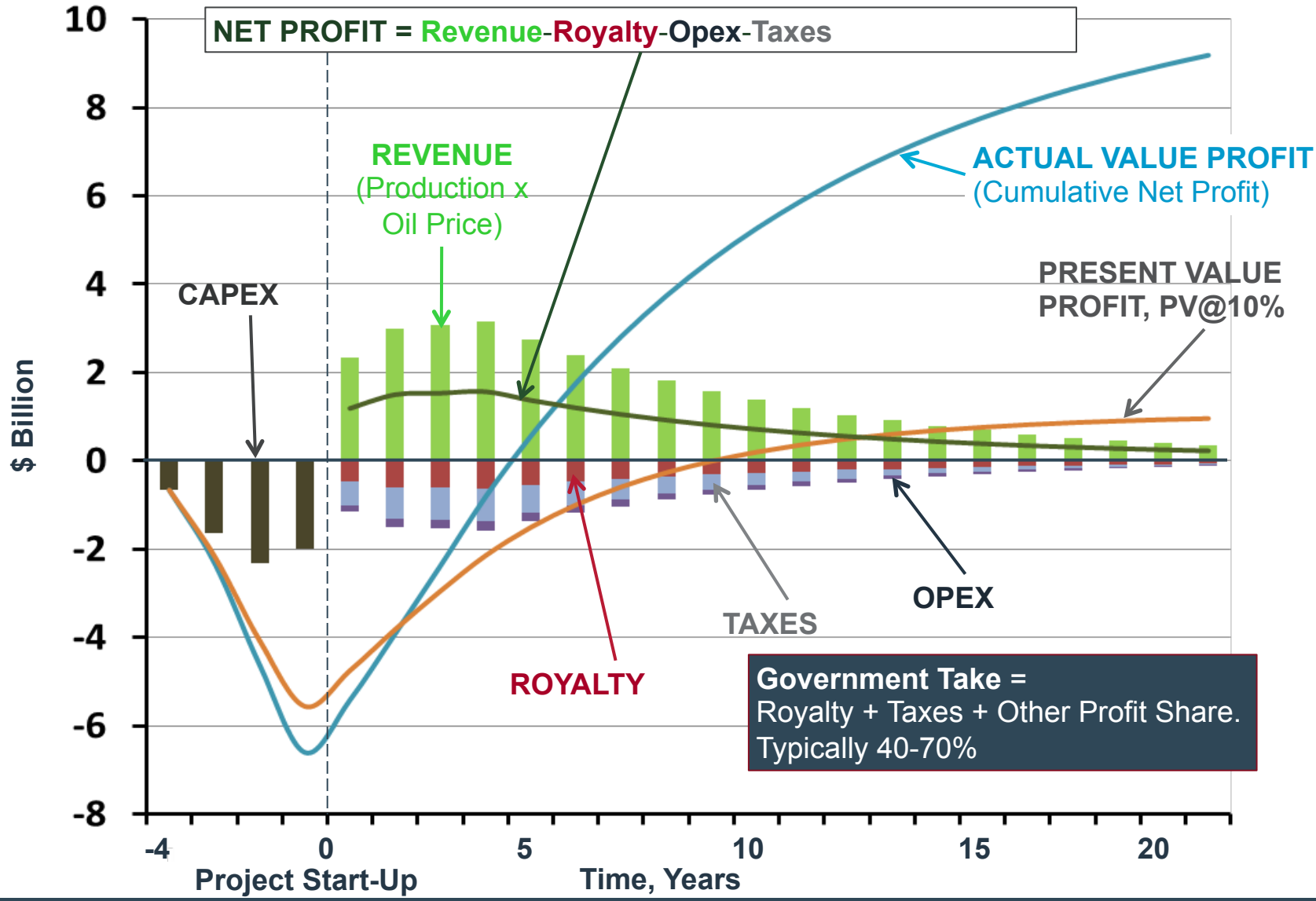
Economics – Basic Terms

- **CAPEX** = capital expenditure (cost of drilling and facilities)
- **OPEX** = operating expenditure (personnel, maintenance, tariffs)
- **Cost metrics**: Capex $/ BOE; Opex $/BOE
  - If Capex $/BOE + Opex $/BOE ≥ 50% oil price, economics will be challenged
- **Net profit** = revenue from oil & gas production - operating costs + cost recovery or depreciation - government take (royalty, taxes & profit share



- **Price assumption** – the oil/ gas price used, often < current price and/or a range
- **AVP** (actual value profit) = the sum of actual, nominal, "dollars of the day" cash flow profit = earnings
- **PV** = present value profit at a given discount rate. Discount rate typically 8-12%
- **IRR** = internal rate of return (the return on investment)

Economics for a Project



Concept Selection Drivers and Constraints

- ***Safety*** – Construction, installation, operation
- ***Environmental Protection*** - No loss of containment; special considerations for protected species and environmentally sensitive areas
- ***Maximum recovery*** – for the government and oil companies
- ***Book reserves*** – if the oil company doesn't replace reserves, it will shrink
- ***Capital expenditure limits*** – a budget that the oil company has decided it will spend on ALL its projects
  - ***Higher-risk, lower profit projects may be delayed or dropped***
- ***Economics*** – is the project…
  - ***Profitable*** = ↑ IRR
  - **Material** (big enough) = ↑ AVP and NPV
  - **Affordable** = ↓ maximum spend (CAPEX)
  - ***Faster payout*** = faster time to start-up; higher early production rate
- ***1st Production*** – In addition to economics, may want early start-up to satisfy license terms, government or partners (Early Production Systems)
- ***Technology*** – 1st of a kind? Some precedent? Time, $ and risk to deliver?
  If achievable, can be a competitive advantage

Summary:

- ***Development Planning***…
  - Is the early planning of oil and gas projects to manage uncertainty risk for making good project decisions
  - Requires the integration of multiple disciplines and factors to converge on a ‘robust’ development concept that maximizes value across a range of uncertainties and best manages risk
  - Sets new projects on the path to assure:
    1. Safety
    2. Environmental protection
    3. Profitability

THANK YOU

Contact us
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