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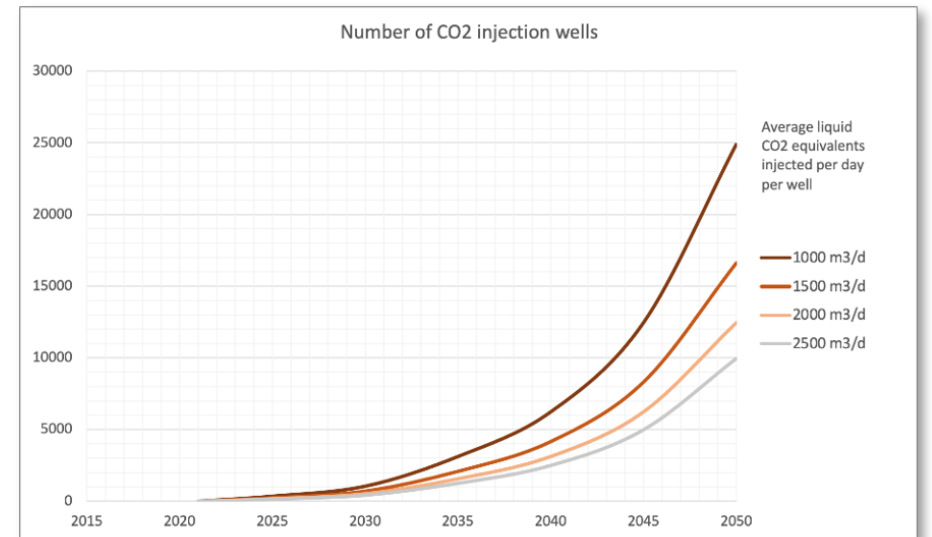
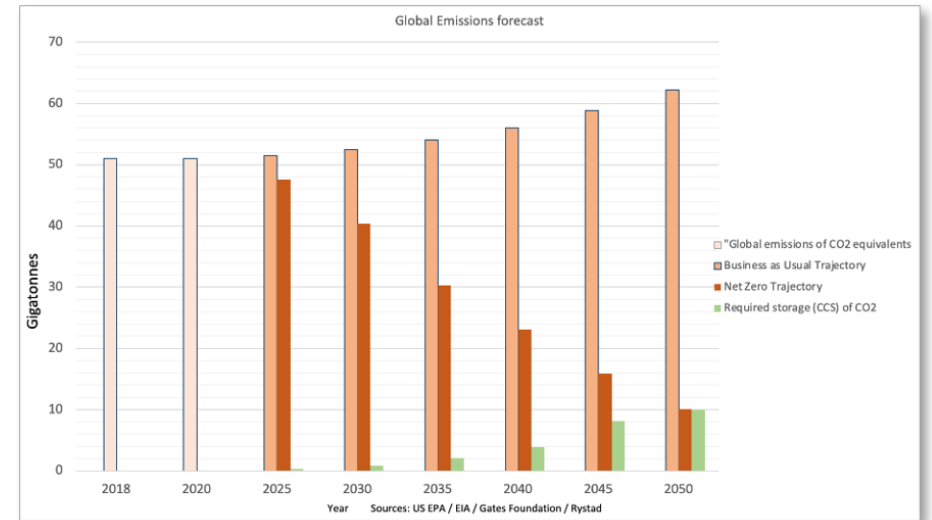
CARBON CAPTURE AND STORAGE (CCS) WELL DESIGN USING CLOUD SOFTWARE

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CCUS – The context

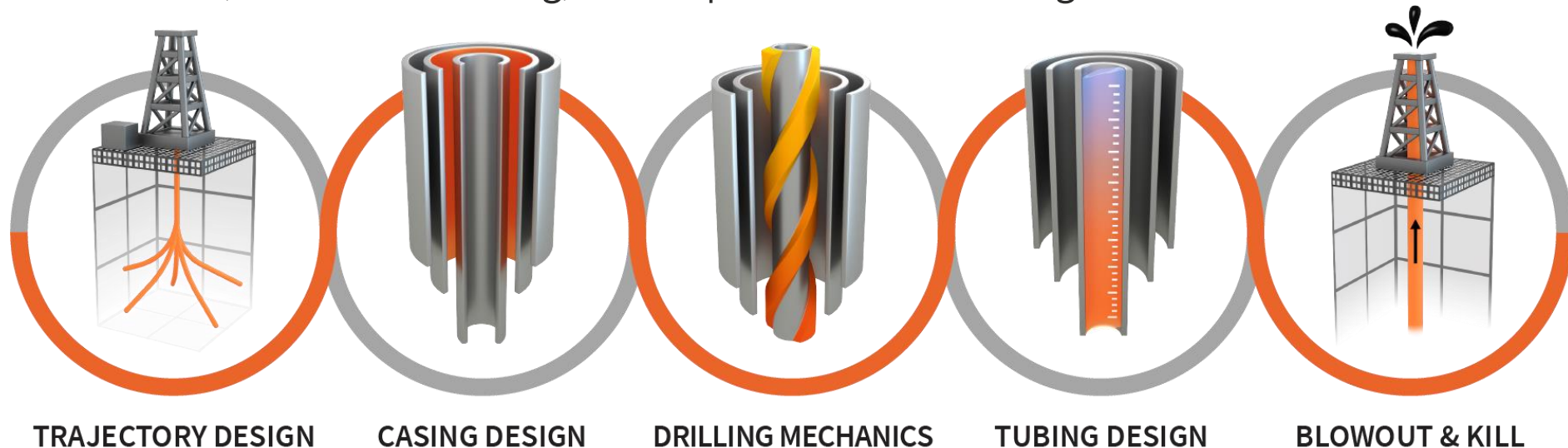
- "Net zero by 2050" trajectory requires approximately 10 Gigatonnes of capture and storage of CO₂ by 2050*
- This translates to ~25000 CO₂ injection wells
- CO₂ injection wells have unique challenges with regards to well control and project cost



*Estimates for required CO2 capture and storage varies from 7.8 gigatonnes (IEA) to 10 gigatonnes (Gates)

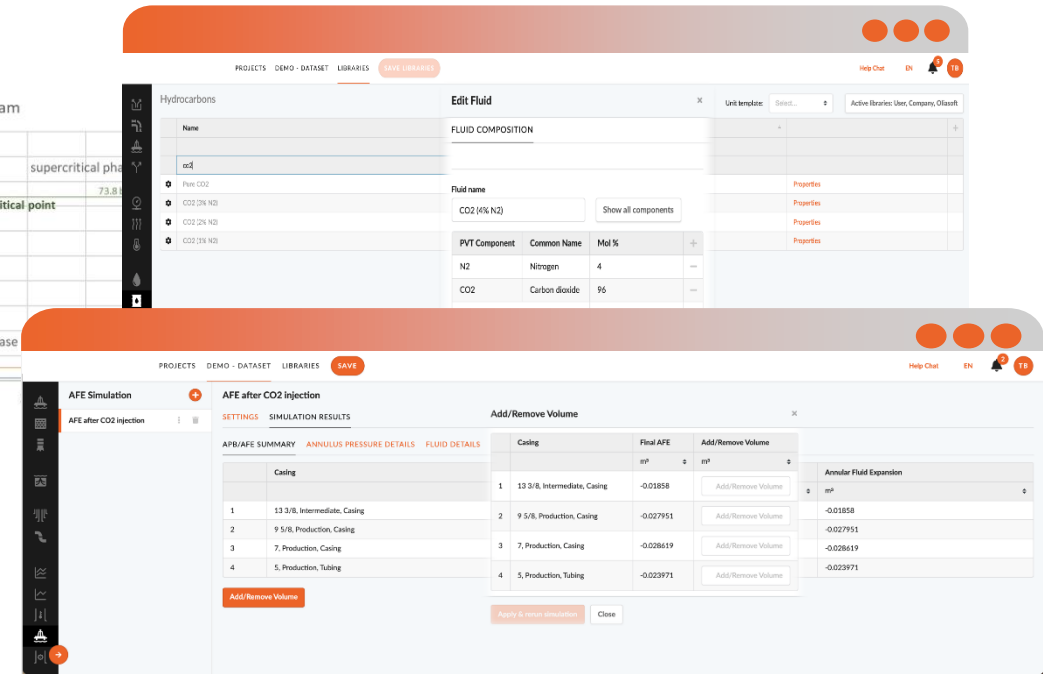
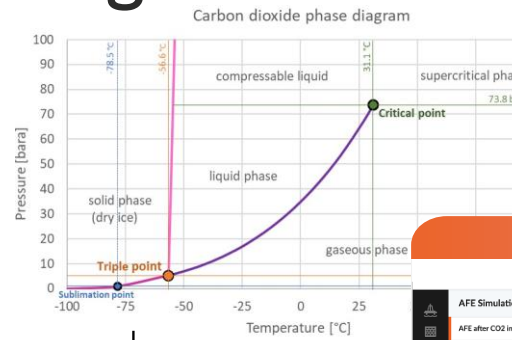
Oliasoft WellDesign® functionality is ready for CO₂-injection wells

- Simulating accurate pressures and temperatures in operations related to single phase CO₂
- Mechanical loads on casing and tubing strings. Design/Safety factors on all dimensions
 - Full support for custom loads and import of temperature/pressure profiles
 - import pressure/temperature profiles from external sources (excel, olga, leda etc.) to perform any custom loads simulations
- Advanced pressure build up simulator to simulate contraction and expansion of trapped annular fluids, with full axial effects, such as ballooning, steel expansion and buckling



CO₂ Injection Wells – Design Challenges

- CO₂ phase behavior
 - Varies with impurities
- CO₂ expansion from liquid to vapor generate very low temperature, *Joule-Thompson (J-T) effect*
 - Material selection is challenging
 - Fluid behavior in annuli
 - Unique load cases
- Well operations and lifetime differ from conventional injectors
 - Increasing reservoir pressure over time
 - Inherently corrosive environment
 - Intermittent operations (steady state injection vs transient shut-in and start-ups)



Temperature drop, Joule-Thompson effect



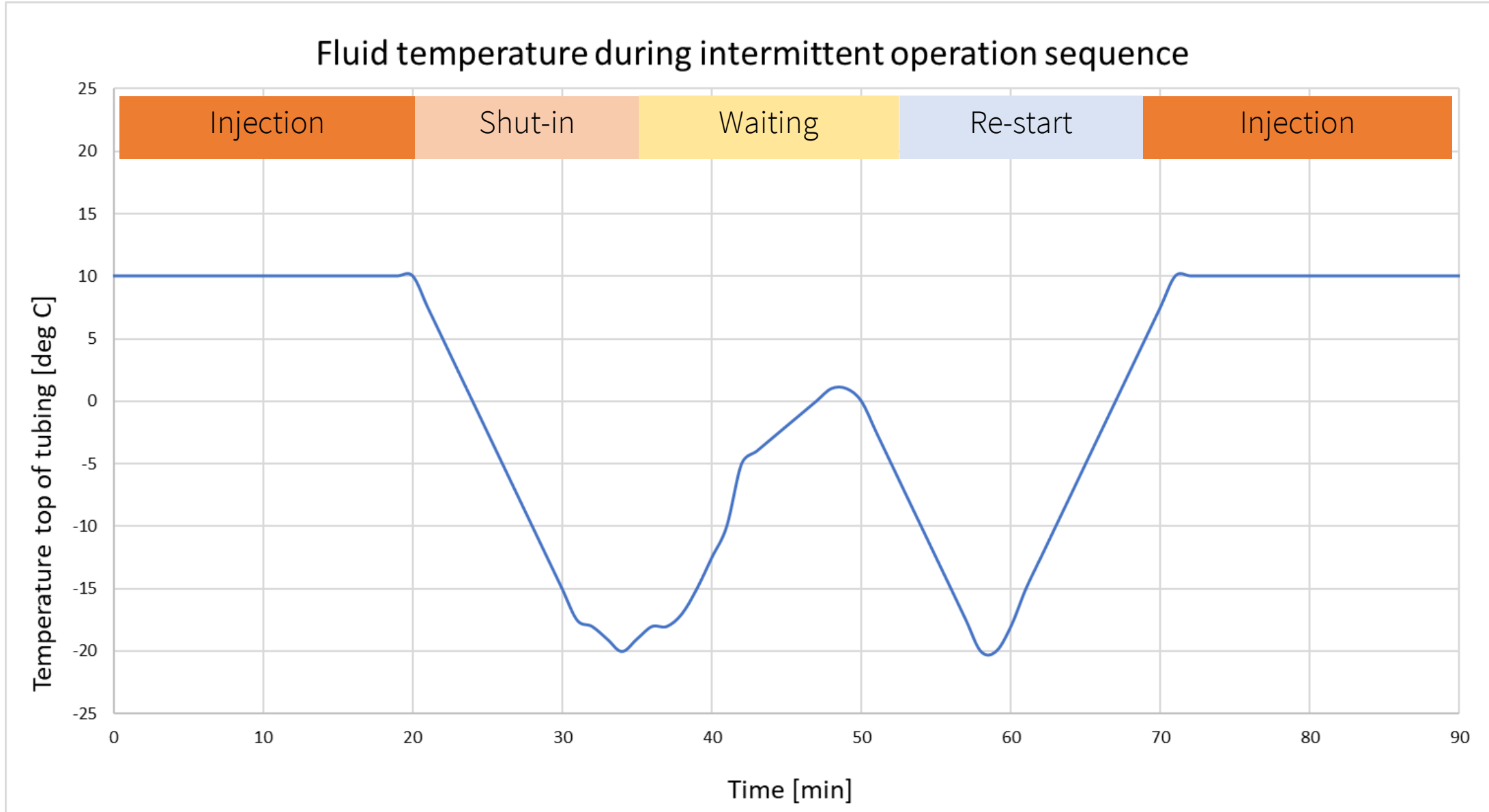
Specimen under testing after Thermal Shock test

*Joule-Thompson (J-T) may expose tubing connections to a thermal shock with a **drop** of approximately **100°C** in a very short time*

SPE Paper- IPTC-22932-MS- Qualification Tests of OCTG Premium Connection under Cryogenic conditions for CCS projects

*photo from **SPE Paper- IPTC-22932-MS-***

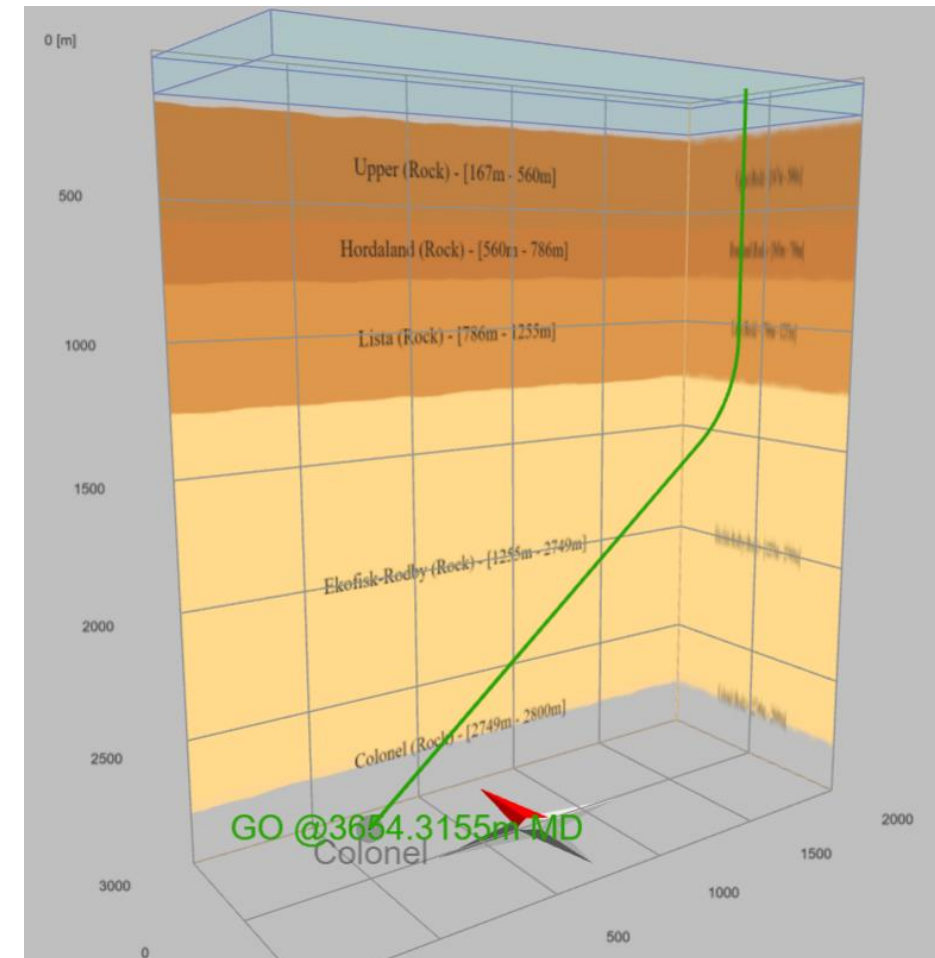
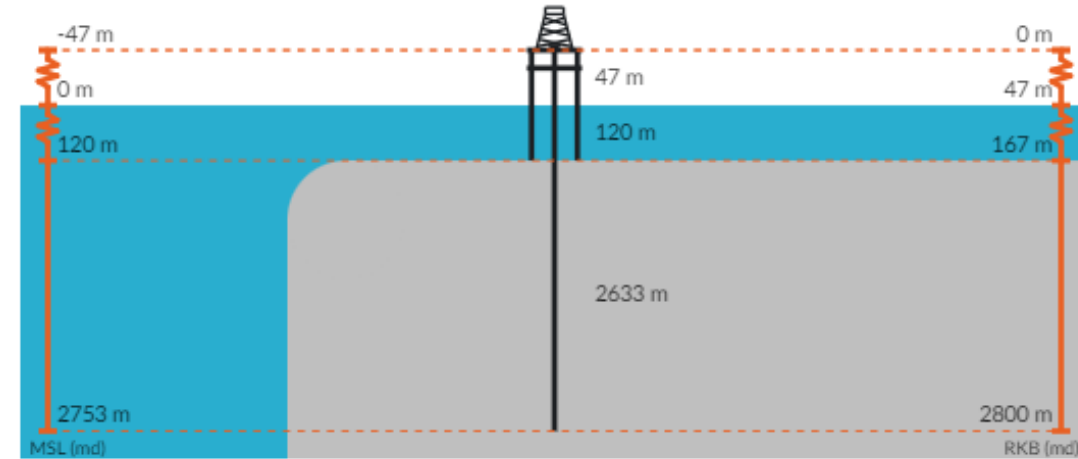
CO2 Intermittent Injection– Typical Well Design sequence plot



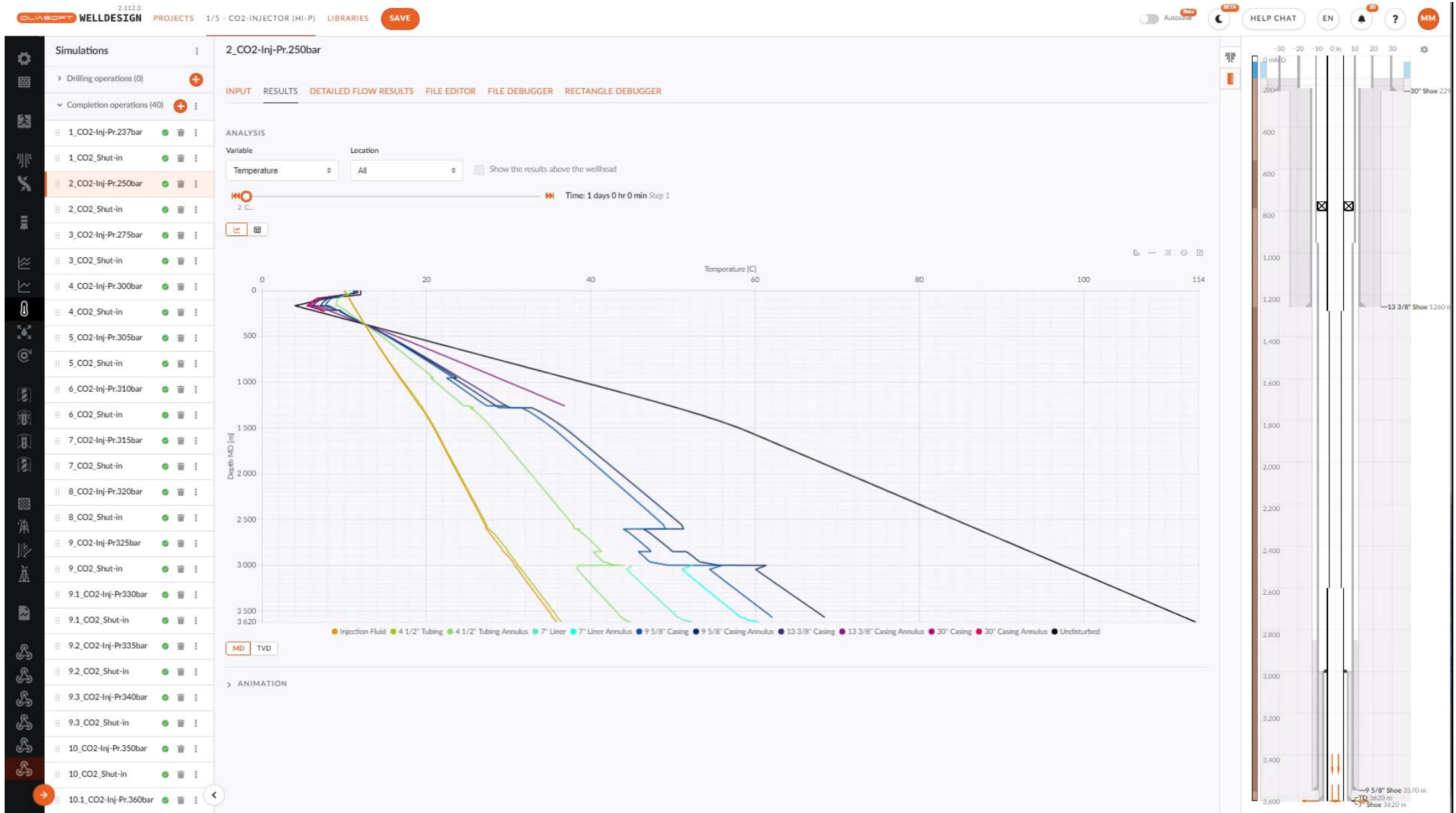
CO₂ injector well design example

Assumptions

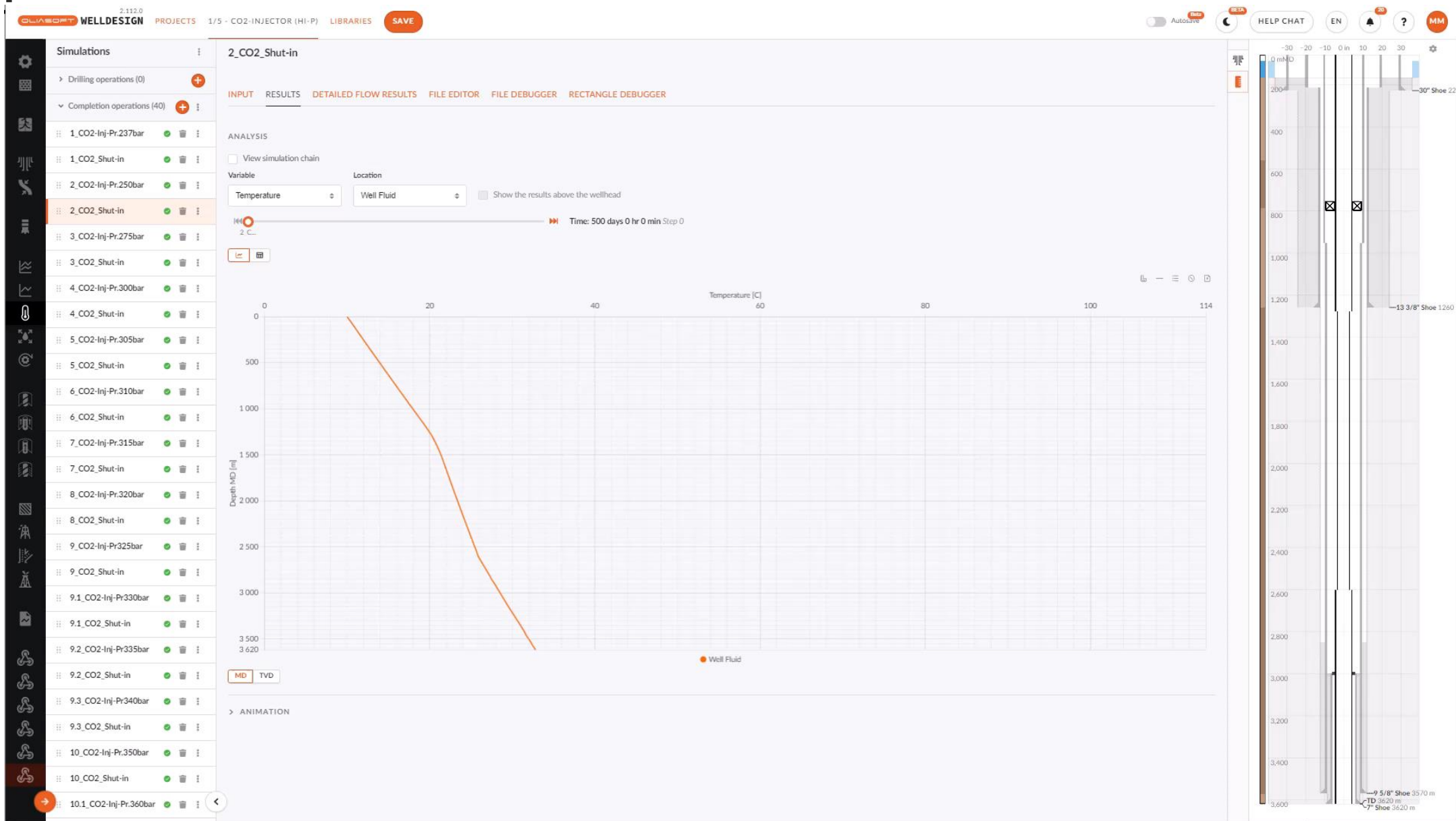
- Formation @ 2860 m TVD / 3650 m MD:
 - Injection reservoir pressure: 250-375 bar
 - Temperature 115° C
- The well need to be re-completed for CO₂ injection
 - Retain well integrity over the injection life
 - Accommodate the phase behavior of CO₂
 - Materials: Chrome and low temperature rated
 - CO₂ storage capacity: 200.000 tonnes/yr
 - Must handle varying injection rates and transient well operations (closing-in, starting-up and SSSV testing)
- CO₂ spec:
 - 99 % Purity (1 % N₂)
 - Arrival temp: 10° C
 - Air temp: 12° C
 - Seabed temp: 4° C



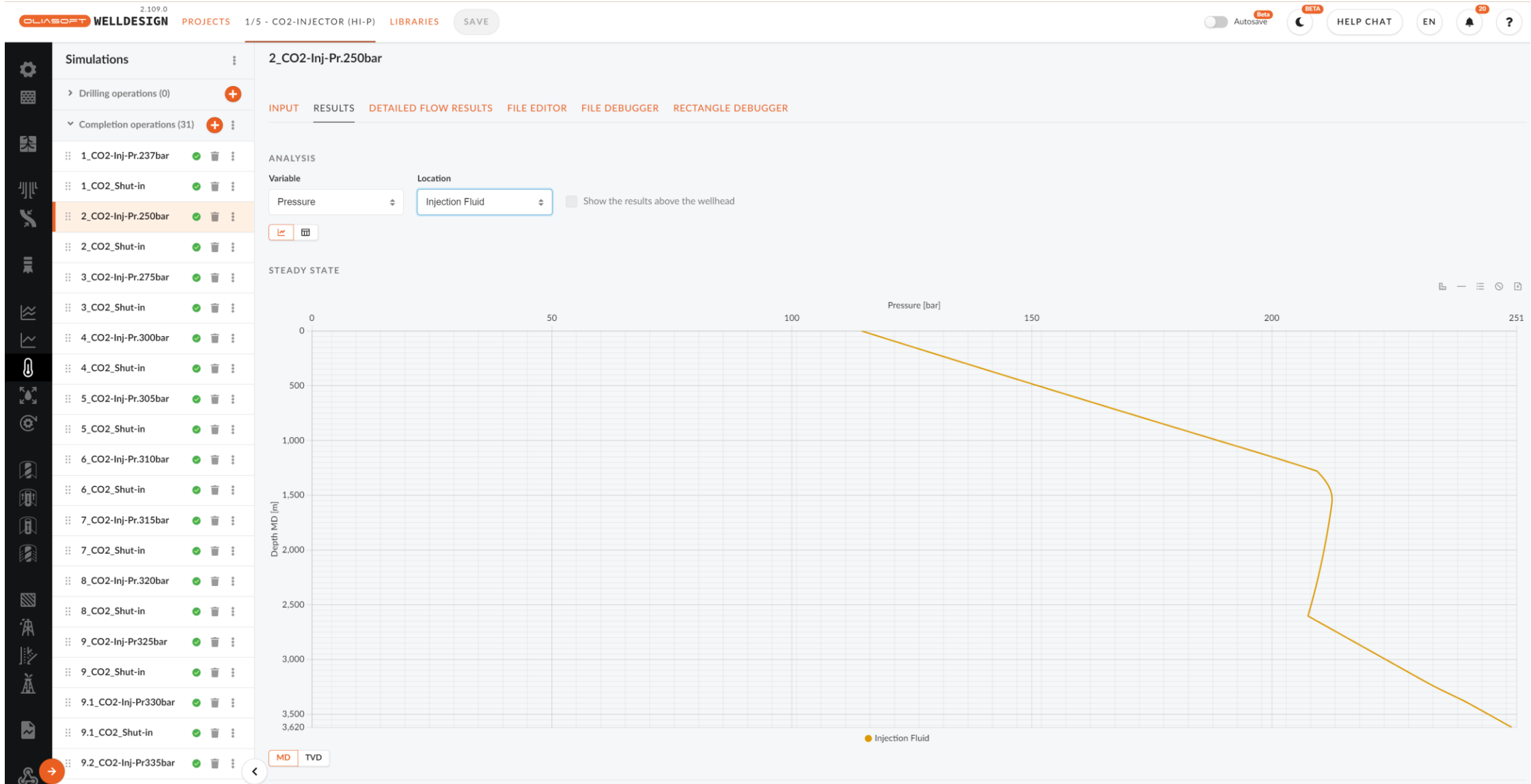
Temperature simulations: Steady state injection (50 mmscf/d) scenario, Pres = 250 bar



Temperature simulations: Transient shut-in following injection scenario, Pres = 250 bar



Pressure profiles: Steady state injection scenario, Pres = 250 bar, Tubing head P = 115 bar



Load cases AFE/APB calculations – CO2 Inj. Well

AFE Simulation + APB

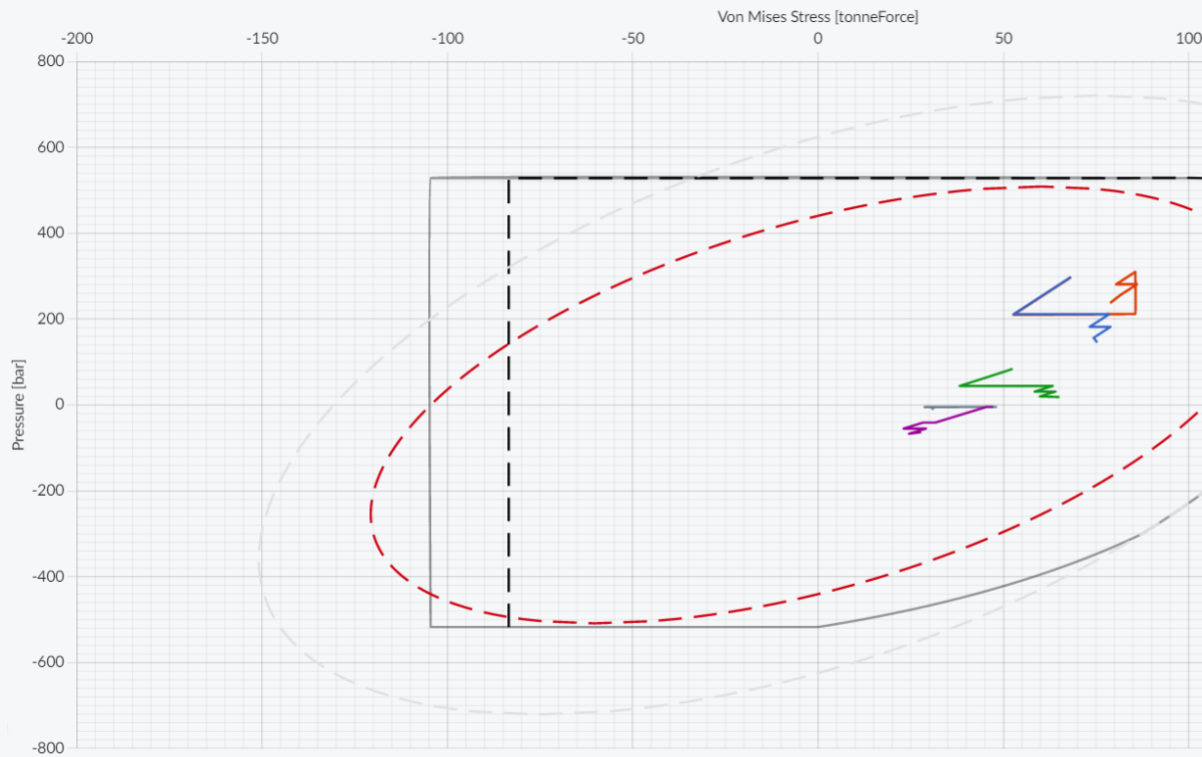
Annular Pressure Build-Up simulator

SUMMARY ANNULUS PRESSURE FLUID

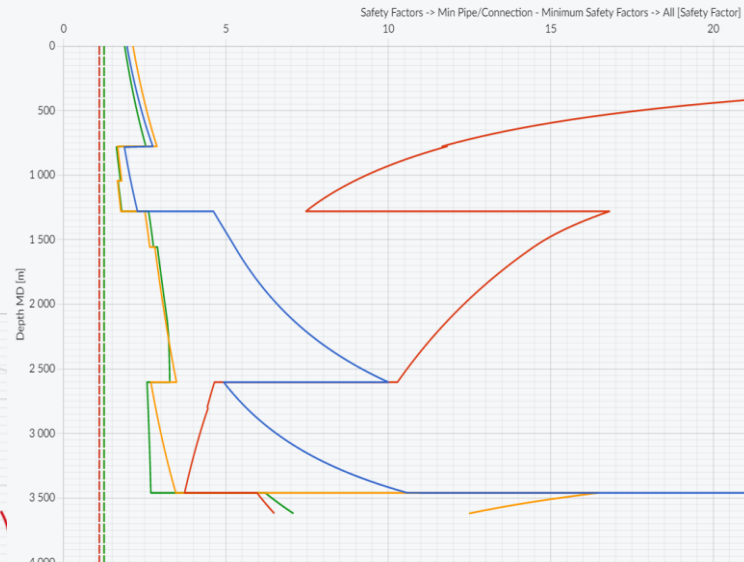
Section	Type	From		To		APB Ⓢ	AFE Ⓢ
		m	⚡	m	⚡		
13 3/8" Casing Annulus	Annulus			167		0.5	0
9 5/8" Casing Annulus	Annulus			2850		4	0.01
4 1/2" Tubing Annulus	Annulus			777		0	0
	Annulus		777	3000		17.3	0.06

Add/Remove Volume

Triaxial - Von Mises Stress Axes String 1. od: 4 1/2 weight: 12.6 grade: 13 Cr-80



Safety Factors - Min Pipe/Connection - Minimum Safety Factors




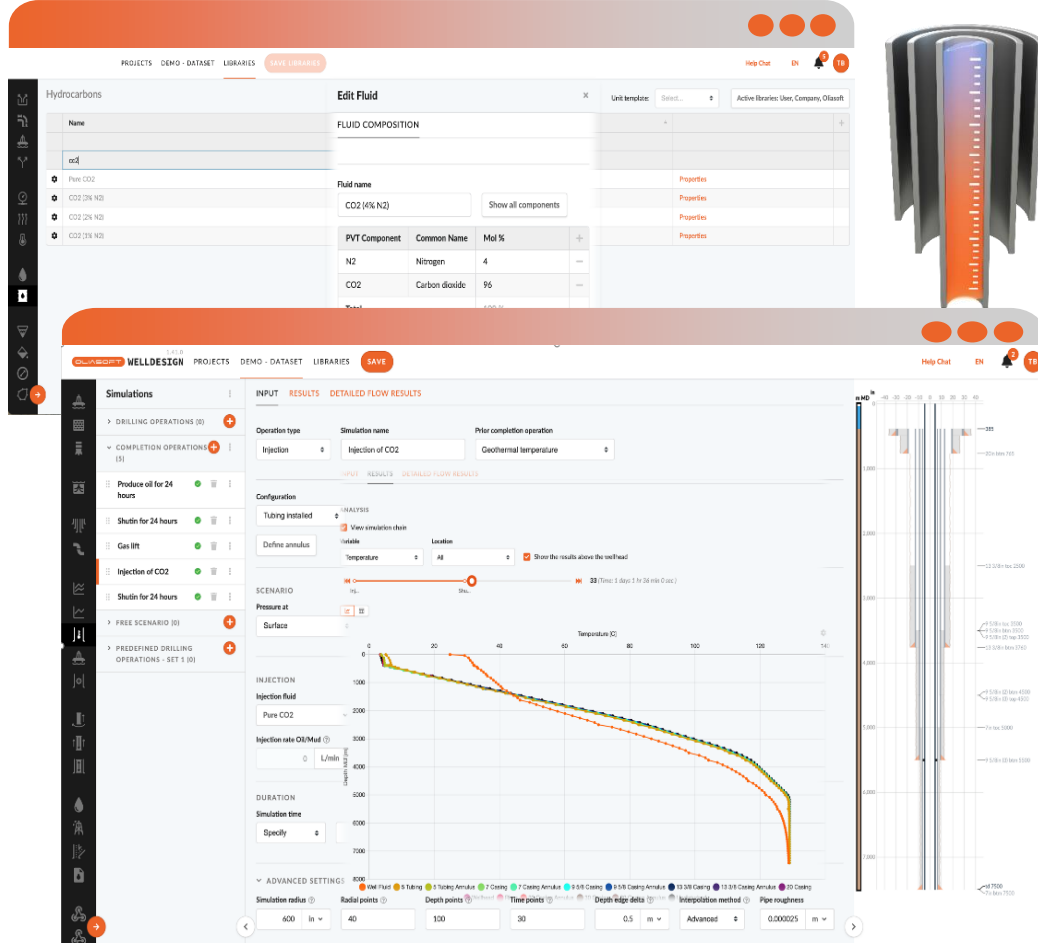
JIP – Accurate CCS Well Design Models

- Oliasoft WellDesign will develop CCS capabilities for well design and planning together with Institute for Energy Technology (IFE)
- We invite companies to participate in a joint industry project (JIP)

PVT = Develop and implement **Equation of State (EoS)** to produce fluid properties based on CO₂ stream composition

 Develop and implement more accurate functionality for **multi-phase flow** for simulating CO₂ well operations

 Develop and implement pre-defined operations relevant for CO₂ wells (injection, shut-in, early/late life, load cases)



- The JIP partners will have access to previous CO₂ flow test results and have access to the Falcon Flow loop at IFE

FALCON – IFE's Flow Assurance Loop for CO2



FALCON CO2 flow loop with an inclined test section. The inclination angle can be changed from full horizontal to full vertical



FALCON CO2 flow loop with the test section in vertical position.



THANK YOU!

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