REX-CO_2: RE-USING EXISTING WELLS FOR CO_2 STORAGE OPERATIONS

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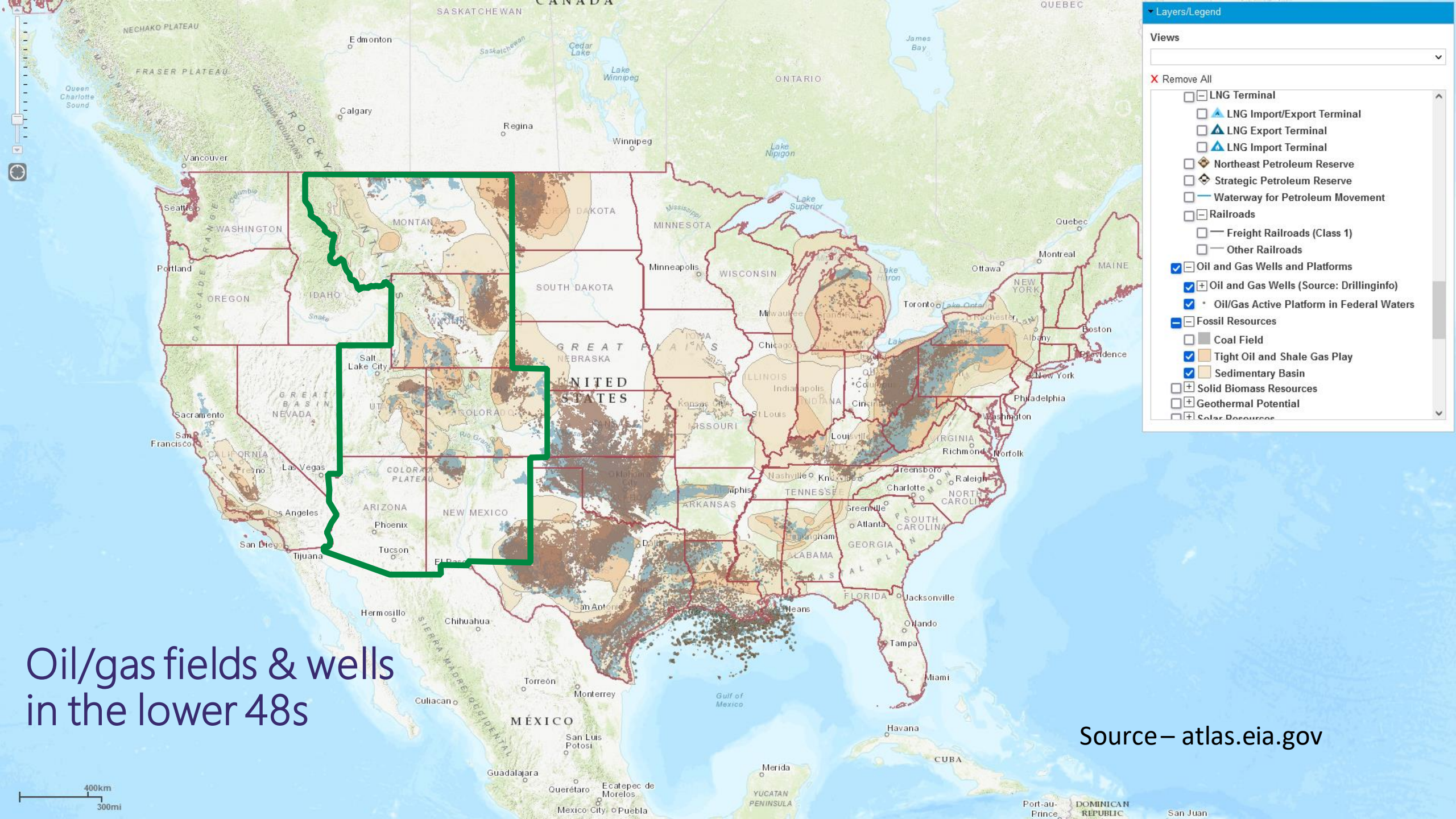
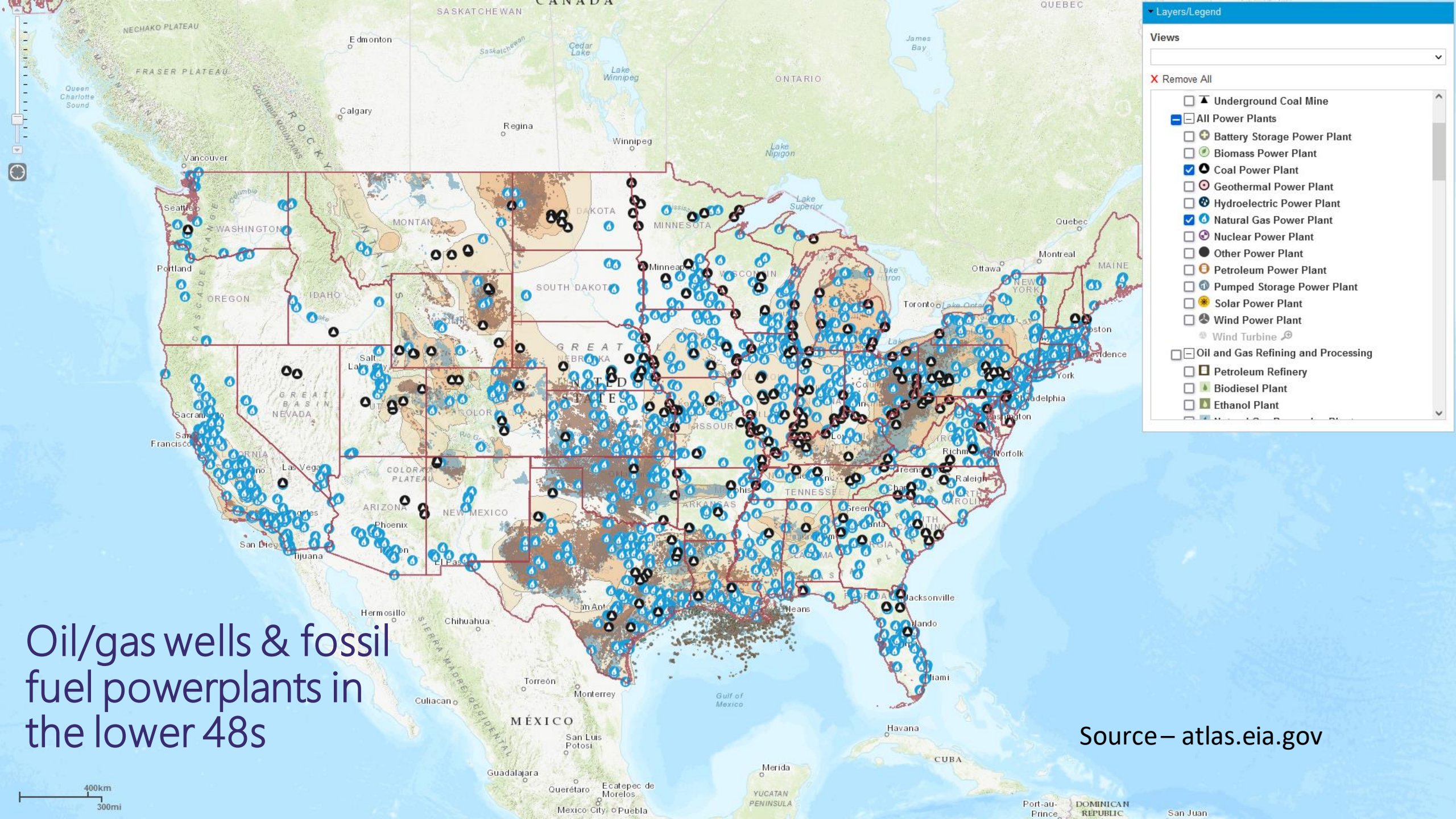


Oil/gas fields & wells in the lower 48s

Source – atlas.eia.gov



Oil/gas wells & fossil fuel powerplants in the lower 48s

Source – atlas.eia.gov

CO_2 storage in depleted oil and gas reservoirs

- ~205 billion tons storage capacity
  - Source: Carbon Storage Atlas, 2015
- Potential for cost saving through re-purposing of existing infrastructure – especially, offshore
  - ~900,000 active wells in US (Source: EIA)

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- How do we assess whether oil/gas wells will meet CO_2 storage related requirements?
- Multiple wells will have to be assessed → time consuming and subject to inconsistency/incompleteness
- A structured & independent well screening process is required to help decision-making and stakeholder buy-in

Re-purposing oil and gas infrastructure is one of DOE FECM's strategic priorities to expand reliable CO_2 storage infrastructure

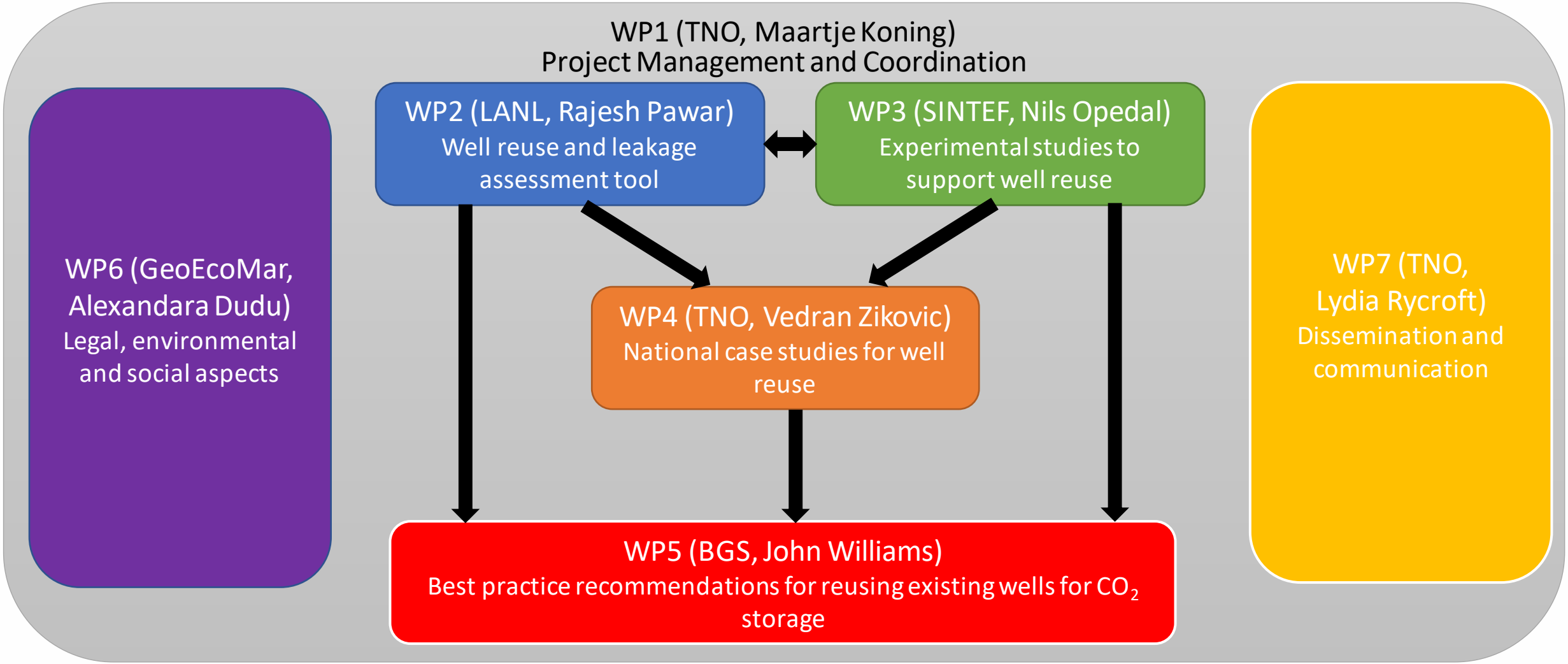
(Source - DOE FECM's Strategic Vision)

REX-CO_2

Re-using Existing wells for CO2 storage operations (https://rex-co2.eu/)

- International research project, funded through the ACT (Accelerating CCS Technologies) programme (http://www.act-ccs.eu/)
- Objective: Provide decision makers with mechanisms and information to evaluate re-use potential of existing oil and gas well infrastructure
- Six Countries: Netherlands, USA, France, UK, Norway, Romania
- 13 research partners; 4 stakeholders; 6 R&D organizations
- Duration: September 2019 – August 2022

REX-CO_2 Project Organization



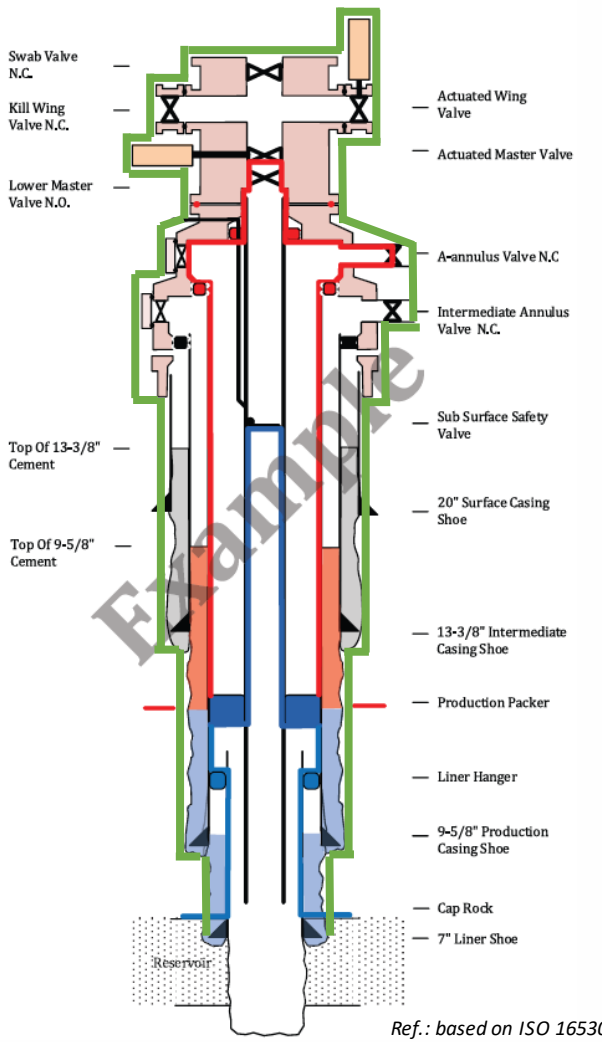
Well screening tool & workflow

Objectives:

- Develop a workflow for assessment of re-use potential of existing oil and gas wells
  - Very limited information in the public domain
- Create a publicly available tool to enable assessment:
  - Useful for a wider set of stakeholders including oil/gas industry & CCS regulators

Minimum functional requirements for tool

1. Screening wells with currently available data
2. Universal and intuitive
3. Swift and consistent screening of portfolios of wells
4. Stand-alone, offline tool
5. Focus on well integrity during CO_2 injection and storage

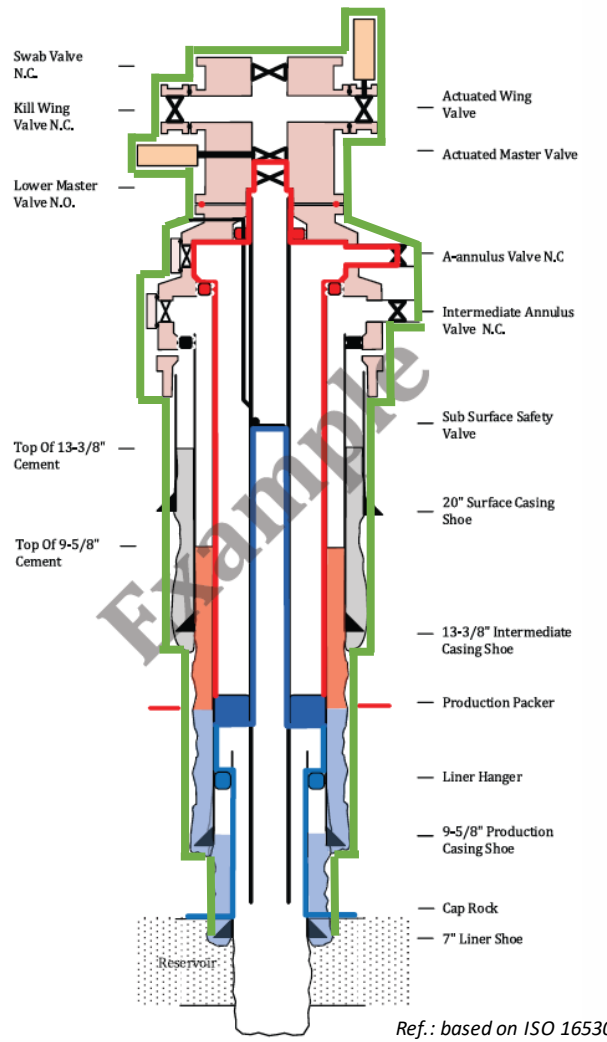


Ref.: based on ISO 16530-1, fig. F.1

Tool development – Workflow for well screening

- Workflow based on SoA practices, well design/well integrity standards & guidelines (including CCS wells):
  - ISO Standard 27914 (CCS-specific)
  - ISO Standard 16530 & NORSOK D010 (Oil & Gas – Specific)
  - Regulatory requirements on CCS wells
  - Reference projects - Peterhead/Goldeneye, Porthos P-18

- Assessment focused on five pillars:
  - Out of zone injection risk
  - Integrity of primary well barrier
  - Integrity of secondary well barrier
  - Structural integrity
  - Material compatibility



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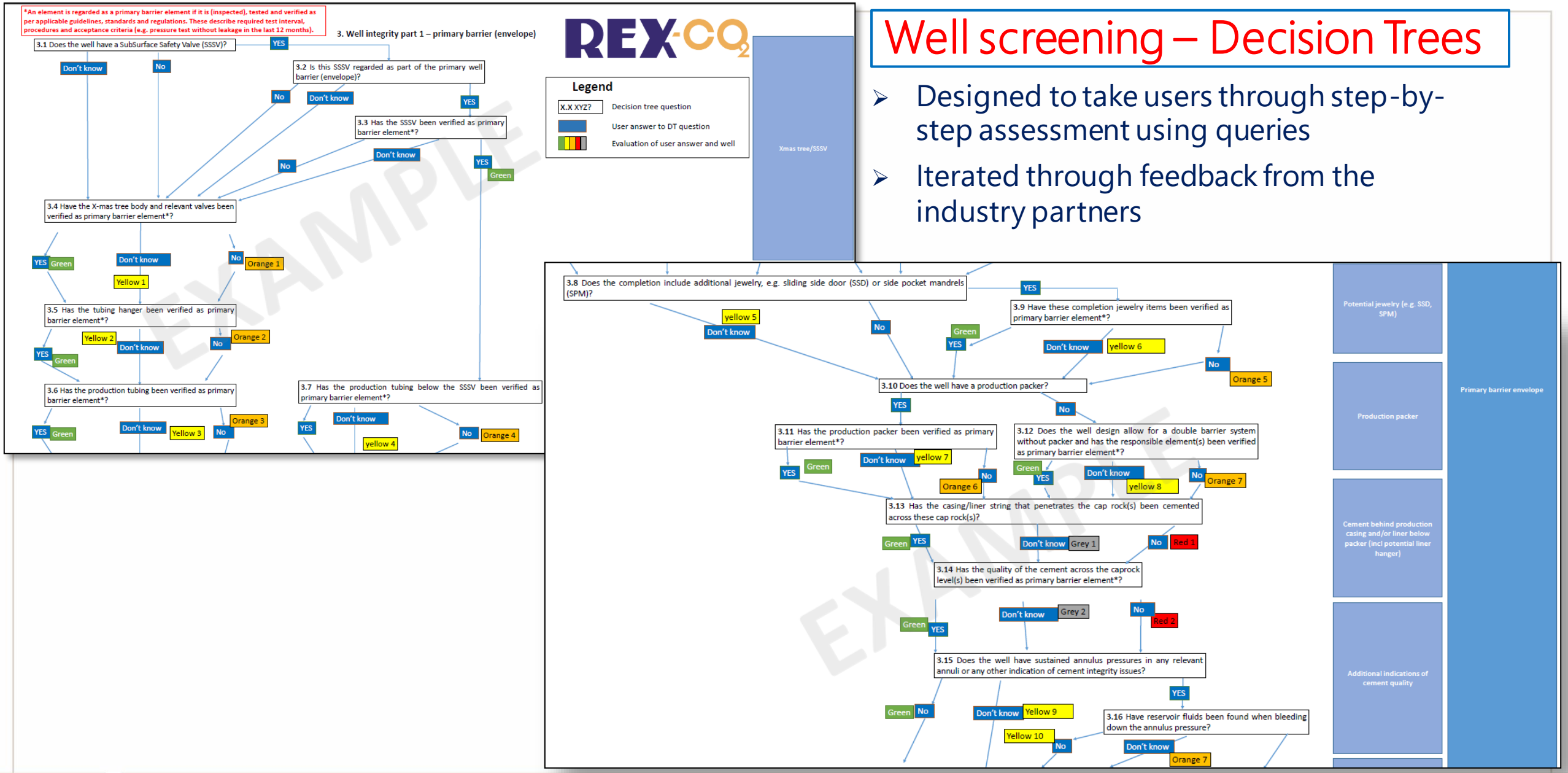
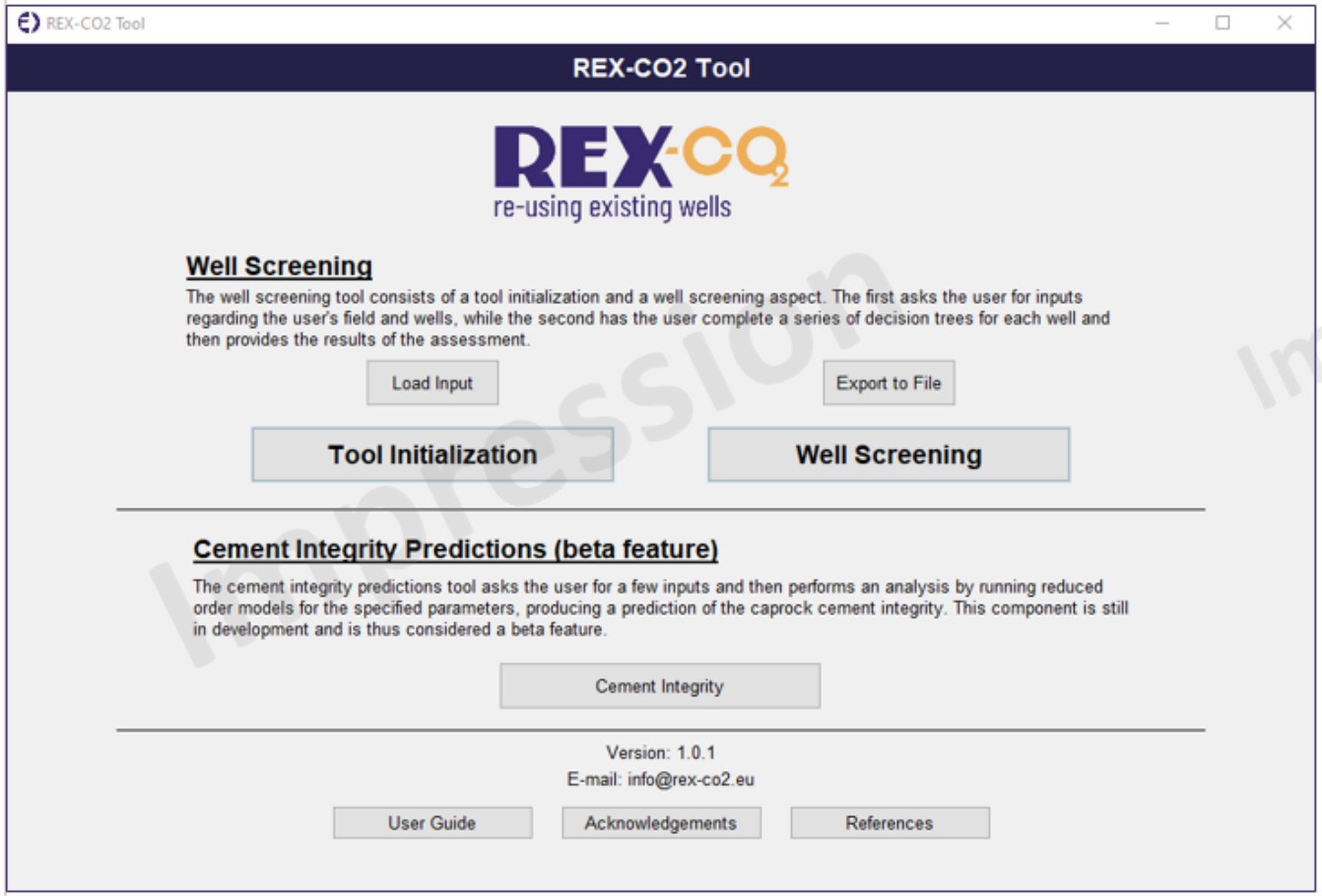
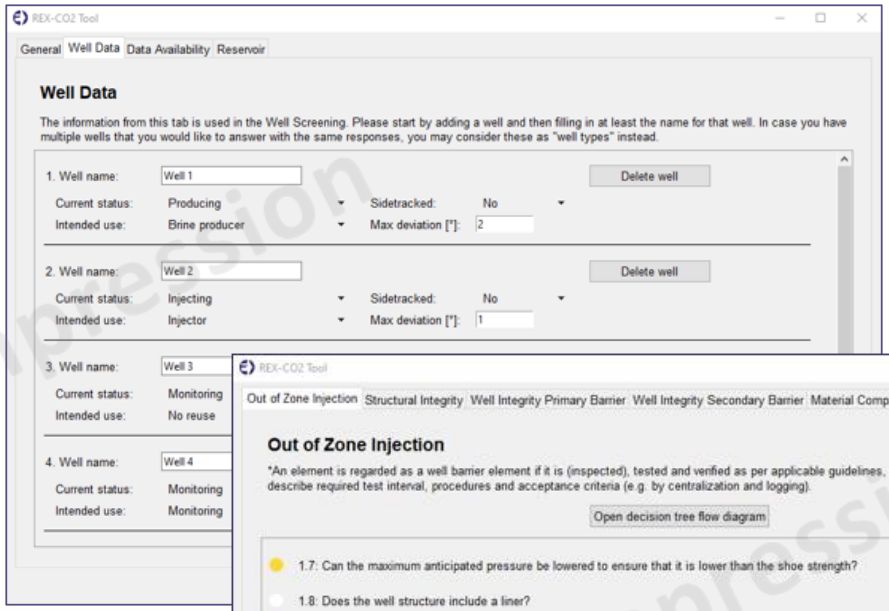
Well screening – Decision Trees

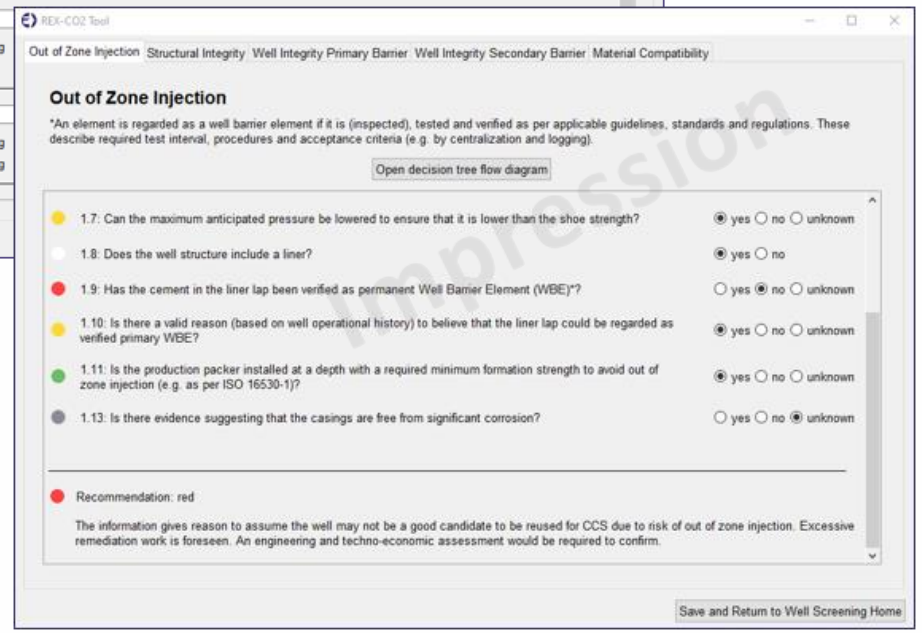
- Designed to take users through step-by-step assessment using queries
- Iterated through feedback from the industry partners



REX-CO_2 tool - designed to be interactive







REX-CO_2 tool will be publicly available – for info email to info@rex-co2.eu

Well screening results

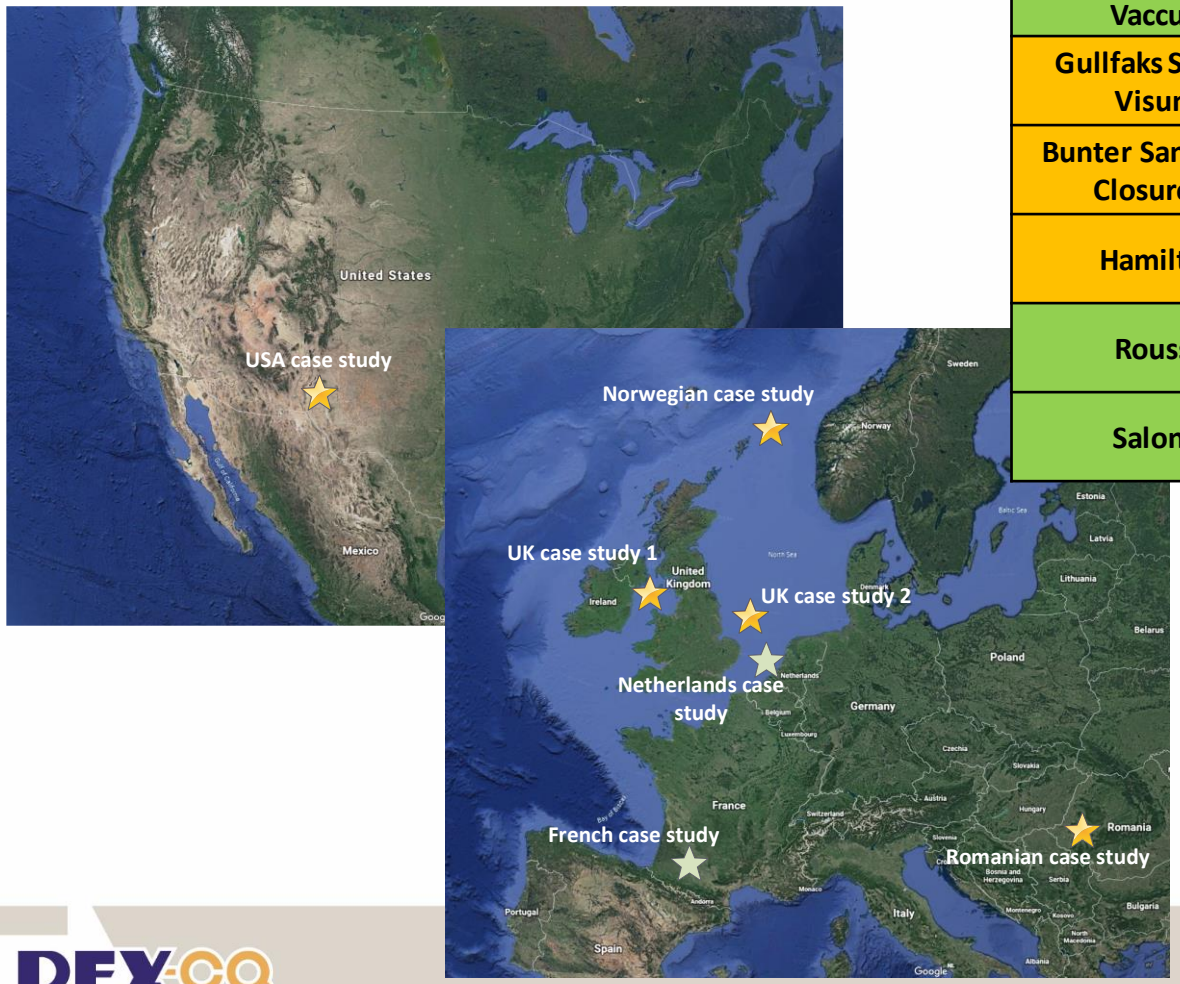
Results of well screening are qualitative and are provided in the form of traffic light recommendations

Recommendation	Explanation
	Only minor or no remediation could be expected
	Moderate remediation or additional verification efforts could be expected
	Severe remediation or a **comprehensive risk management strategy** on retrievable/replaceable items could be expected.
	Severe remediation or a **comprehensive risk management strategy** on non retrievable/replaceable items could be expected.
	Critical information is missing for the tool.

REX-CO_2 screening results are meant to inform the first steps in the decision-making process which will subsequently involve detailed techno-economic assessment

Tool application: International case studies

Tool validated using previous assessments for P18-2 and Rousse



Case study name	Country	Onshore/offshore	Type	Reference
P18-2 (Porthos)	Netherlands	Offshore	Depleted gas field	Zikovic and van der Valk (2021)
Vaccum	USA	Onshore	CO_2-EOR field	Chen (2021)
Gullfaks Sør and Visund	Norway	Offshore	Oil fields	Grimstad et al., (2022)
Bunter Sandstone Closure 36	UK	Offshore	Saline aquifer	Williams and Hoskin (2021)
Hamilton	UK	Offshore	Depleted gas field	Williams and Hoskin (2022)
Rousse	France	Onshore	Depleted gas field and pilot CO_2 storage site	Guy and Cangemi (2022)
Salonta	Romania	Onshore	Depleted gas field (abandoned)	Dudu et al., (2022)

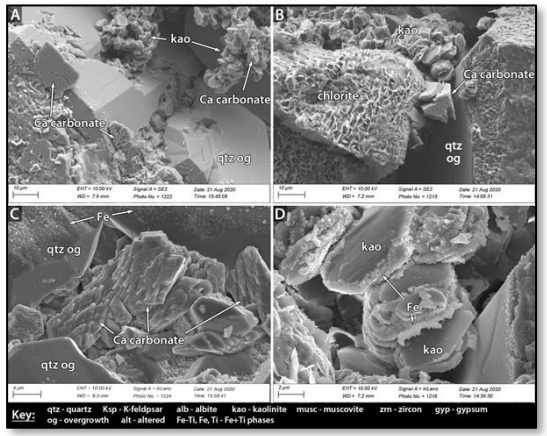
- Location: on-shore and off-shore
- Applications: Saline, depleted gas and CO_2-EOR
- Depths: 1400-5000 m
- Reservoir rock: sandstone and carbonate
- Reservoir type: gas field, oil field, saline aquifer
- Reservoir capacity: 37 – 280 Mt CO_2
- Number of available wells >100

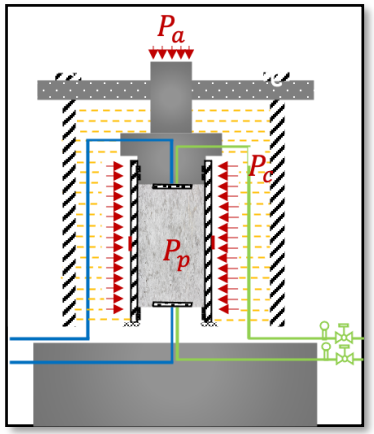
Key findings from case studies

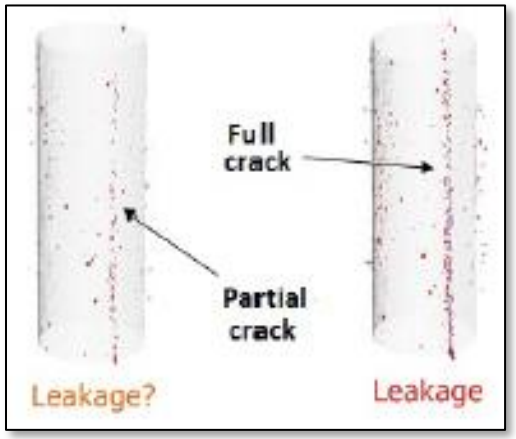
- Data/information needed for assessment can be limited
- Intervention required to re-purpose all wells
  - A rig or workover is usually required to repurpose wells
  - Remediation can be achieved via coiled tubing interventions
- Primary barrier components and completions may be subject to cooling and may not be fit for re-use
- Structural integrity may be costly and technologically challenging to assess
- Quality of cement sheath and casing corrosion uncertainty
  - New logs may be necessary
  - Dual-cased sections may be difficult due to logging challenges

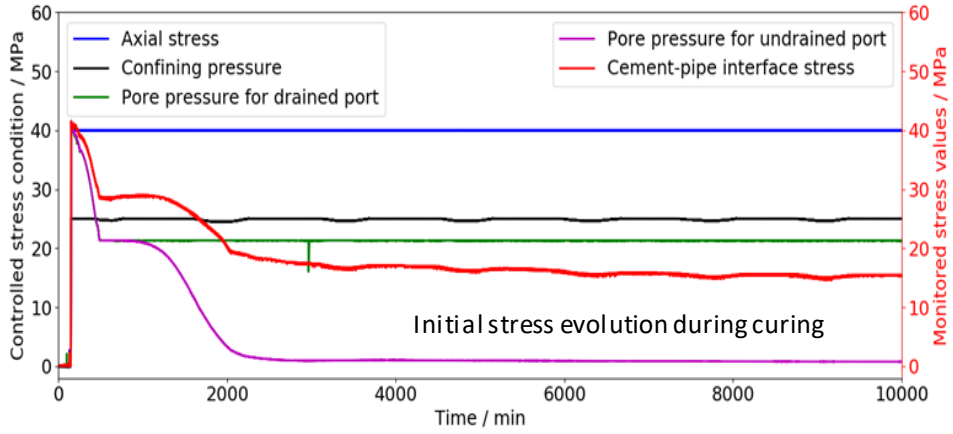
Experimental investigations for re-using wells for CO_2 storage

- Provide experimental data that describe how well degradation and well design influence potential re-use as CO_2 injectors
  - Bond strength between cement & steel
  - Mechanical behaviour & integrity of cement-rock systems & interfaces
  - Downhole cement state of stress
  - Self-healing of leakage pathways
  - Microbial remediation
- To define boundary conditions at which well integrity could fail and/or be remediated









Highlights of experimental investigations

- State-of-stress experiments and simulation studies indicate that well integrity is more robust to thermal and mechanical stresses than previously understood (Agofack *et al*., 2021; Meng *et al*., 2021).
- Cycling tests on downscaled wellbore samples illustrate that the ratio between the stiffness of cement and of rock formations is important.
- Higher pressure conditions during cement curing increases the mechanical strength of cemented interfaces (Rossillon *et al*., 2022).
- Determining leakage rates that account for the stresses and mechanical behaviour of cement in well systems should be prioritised.
- Down hole microbial-induced carbonate precipitation (MICP) technologies have potential applications in geotechnical engineering including the remediation of oil and gas wells for CO_2 storage.

Regulatory and social aspects

Objective:

- Assess non-technical aspects that influence the implementation of well re-use application, from regulatory (legal) aspects to public acceptance
  - Assessment of national legal frameworks
  - Workshops with regulators and other stakeholders
  - Guidelines for permitting process
  - Public perception and acceptance of well re-use for CCS

Possible gaps identified in national legal frameworks

LIFETIME STAGE/ MILESTONE/POLICY	POSSIBLE REGULATORY/POLICY GAP	FR	NL	NO	RO	UK	US
TRANSITION FROM PRODUCTION TO STORAGE	Procedure for postponing decommissioning of wells	o	(+)	o	o	o	+
	Simultaneous HC production and CO_2 storage	o	+	+	o	o	+
	Arrangements during mothballing/hibernation	o	o	o	o	o	+
HIBERNATION (TEMPORARY ABANDONMENT)	Rules for mothballing and hibernation of wells	+	o	+	+	+	+
	Ownership of wells and costs	o	o	o	o	o	+
PERMITTING WELL RE-USE	Rules for permitting, monitoring and testing	o	o	o	o	o	+
POLICY FOR WELL RE-USE	Promoting re-use	o	(+)	o	o	+	o
	Incentivisation	o	o	o	o	(+)	o

+ = none, (+) = proposal/in consideration, o = possible gap

Summary & take-away points

Value of REX-CO_2:

- Fast turn-around time & systematic approach to assess large number of wells – publicly available well screening tool
- Improved decision making, optimised capacity planning & cost savings when maturing CCUS opportunity
- Facilitate safe well re-use & CCS uptake – project deliverables, results and recommendations on project public site
- **Case studies:**
  - Well Screening tool results in line with Engineering Assessments
  - Well intervention always required to re-purpose for CO_2 injection
- **Experimental:**
  - Provides insights in fundamental well integrity processes
  - A (larger) data-base with actual and historic downhole data for different well conditions is needed
- **Permitting:**
  - Major differences in permitting & lack of specific legislation for well re-use
  - Regulatory barriers expected (not in US)
  - Data sharing & early discussion between operators, regulators and future CO_2 storage operators should be encouraged
- **Recommendations for re-using existing wells – Report D5.1 (available on project web site)**

REX-CO2
re-using existing wells

Thank you for your attention

https://www.rex-co2.eu

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