Department of Mineral Fuels
MINISTRY OF ENERGY

Carbon Capture and Storage, CCS, Study in Thailand: Result and Way Forward

Prepared by

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Department of Mineral Fuels
MINISTRY OF ENERGY

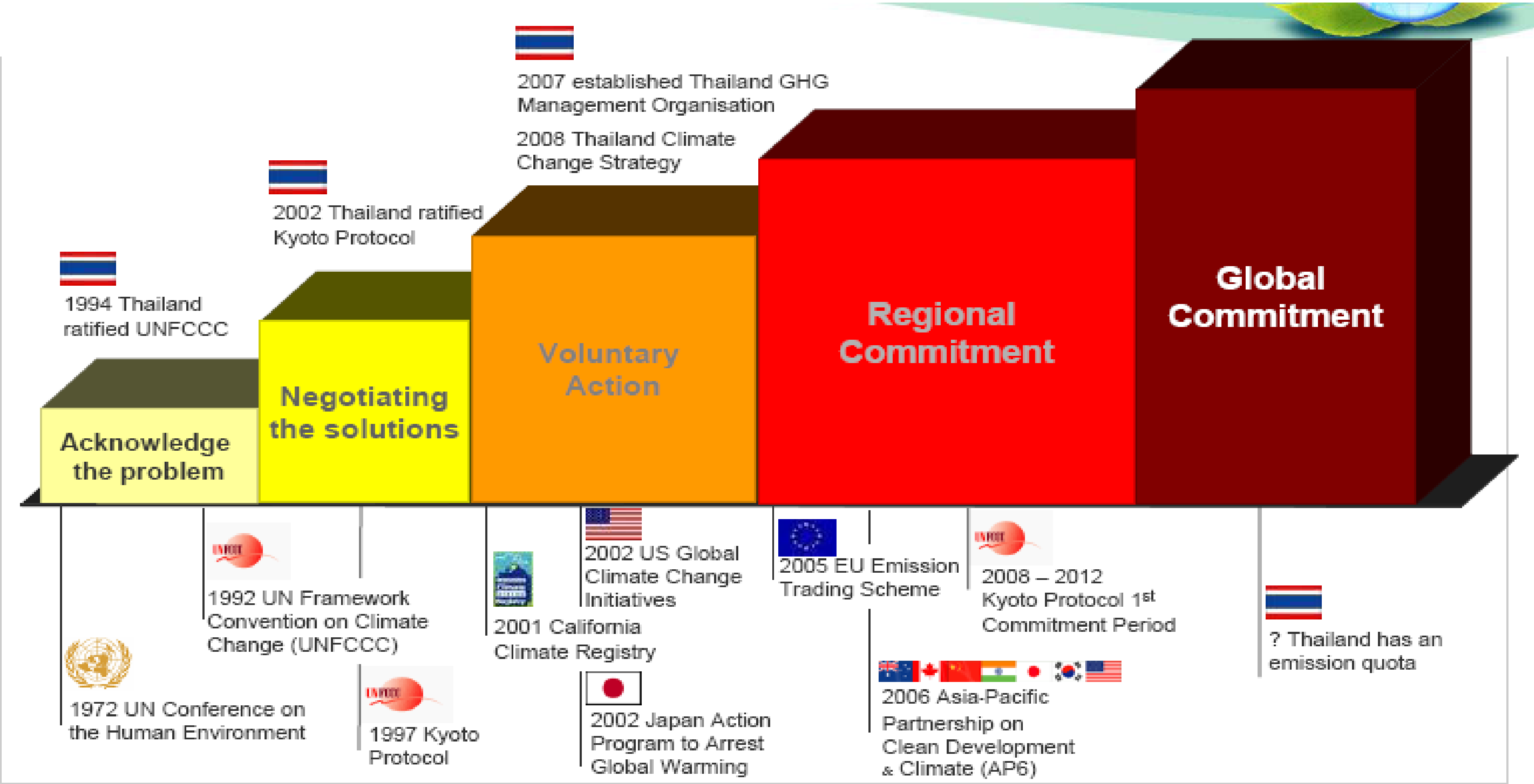
Sep 12, 2012

Outline

1. **Thailand GHG Status**
2. **CCS Study in Thailand**
3. **Conclusion**

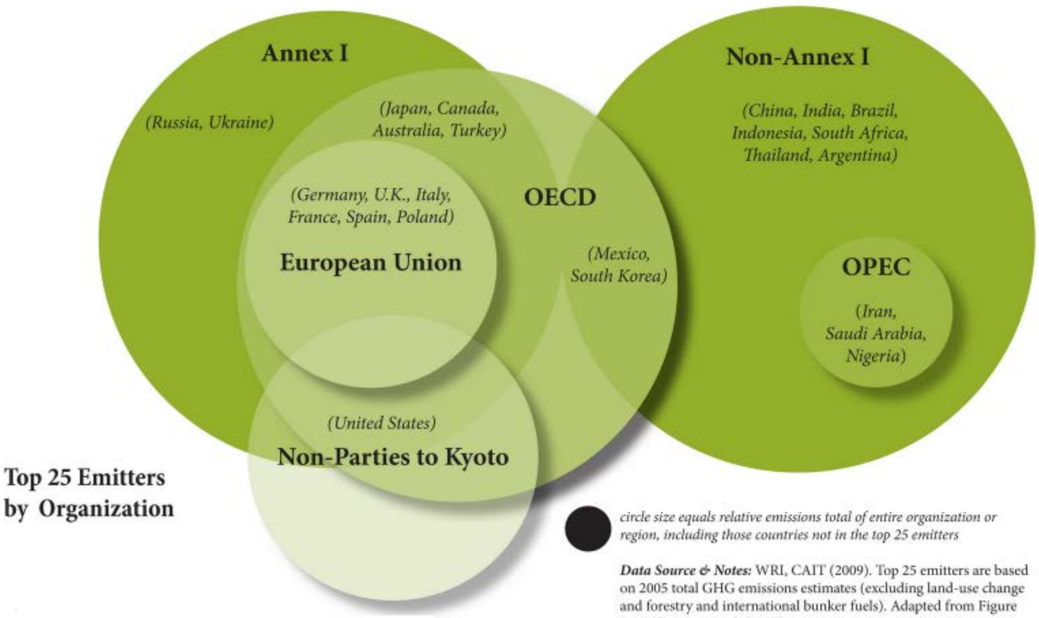
IT IS A "GLOBAL COMMITMENT"

The Kyoto Protocol countries must get involved in emission reduction.

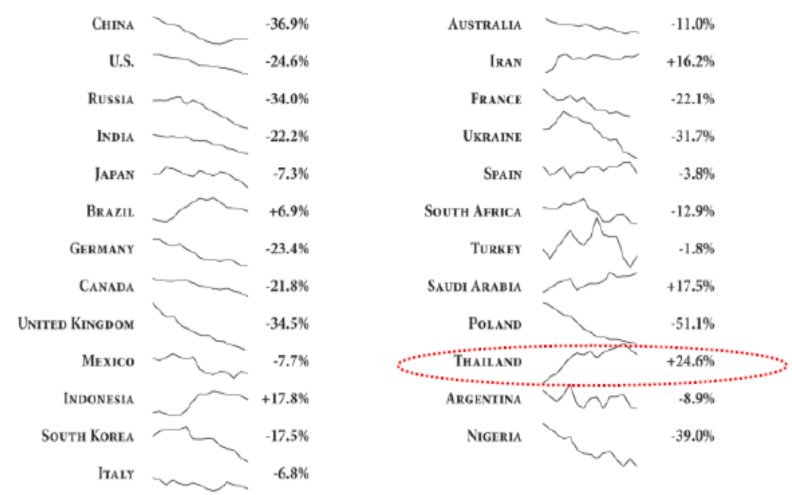


Thailand GHG Status

Even though Thailand is non-annex 1 party, Thailand is in the top 25 emitters, but only ranked 71st based on CO2 emission per capita (3.3 Tons per capita).



Data Source & Notes: WRI, CAIT (2009). Top 25 emitters are based on 2005 total GHG emissions estimates (excluding land-use change and forestry and international bunker fuels). Adapted from Figure 2.4 in Baumert et al. (2005).



Data Source & Notes: WRI, CAIT (2009) using GDP data from World Bank (2009). Top 25 emitters based on 2005 total GHG emissions estimates (excluding land-use change and forestry and international bunker fuels).

Emission intensity during 1996-2006 increased approximately 25%

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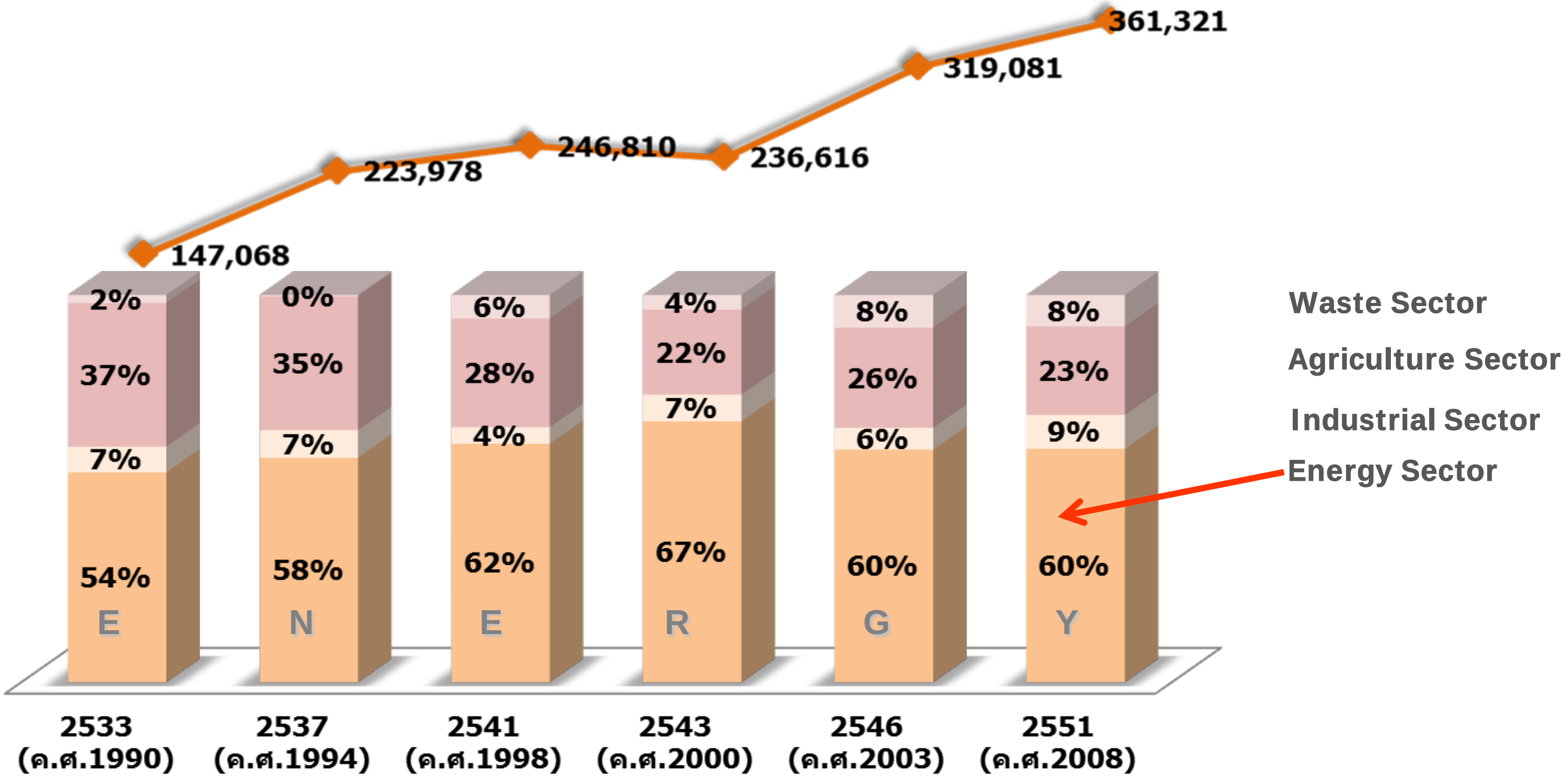
Thailand GHG Status



REFERENCES:

1. 1990 Ministry of Science and Technology, by TEI
2. 1994 Ministry of Science and Technology, by KU (First National Communication)
3. 1998 Ministry of Science and Technology, by ERM Siam
4. 2000 Ministry of Science and Technology, by JGSEE (รายงานแห่งชาติฉบับที่ 2)
5. 2003 Department of Alternative Energy Development and Efficiency, by ERM Siam
6. 2008 Thailand GHG Management Organization (Public Organization) , by ERM Siam

Source : *EPPO*

Thailand's Climate Change Master Plan

Greenhouse Gas Mitigation Plans

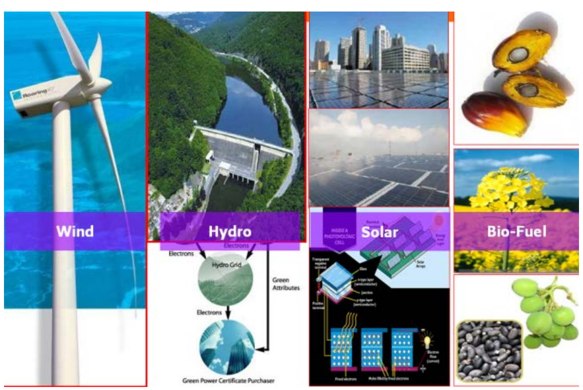
Energy Efficiency

Forestation

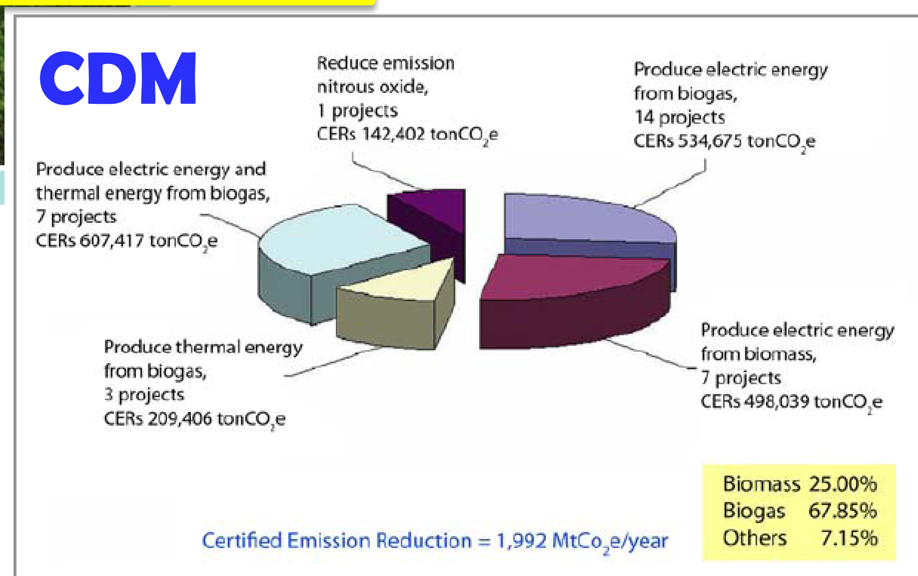
Reduce Agricultural Burn

DO WE NEED CCS ?

Alternative Energy



CDM



The Second National Communication under UNFCCC (2000)

CCS Study in Thailand

CCS Study In Thailand

Ministry of Energy CCS Task Force

DMF

1.Geological Storage Potential Study
(Cooperation with Tetra Tech)

2. Potential for CCS in Southeast Asia, Thailand
(Cooperation with ADB)

3. Carbon Capture and Storage for Upstream Petroleum Business in Thailand: Governmental Roles and Regulatory Framework
(Cooperation with PTIT)

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TETRA TECH

ADB

1. Storage Potential Study

Thailand CCS Site Selection: Screening Processes

Initial

- ✓Depth ≥ 1000 m
- ✓CO_2 Capacity of ≥ 2 Million Ton (EUR 20 Bcf or 2 MMbbl)
- ✓Reservoir thickness ≥ 10 m

Secondary

5 Onshore Areas
20 Offshore Areas

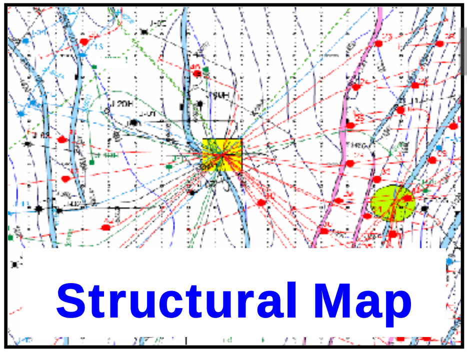
- ✓Super-Critical Phase
- ✓Primary seal
- ✓Secondary Seal

Ranking

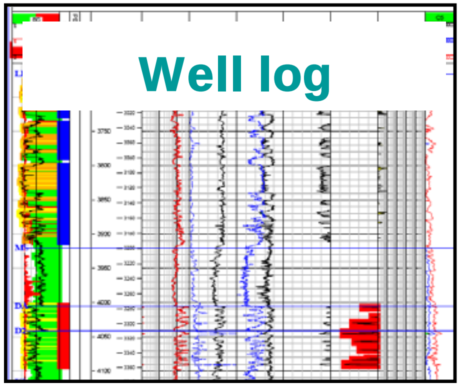
- ✓Oldenburg (2005) Screening and Ranking Framework or SRF

Scope of this project is limited to petroleum producing fields.

Data for Primary and Secondary Screen



Geological Structure
Facility Location



Rock Type
Reservoir Thickness
Seal Thickness
Pressure / Temp

Production
Reservoir Parameters
Fluid Properties

Reserves Reports

Thailand Petroleum Reserves as of December 2008

Cumulative Production			Proved			Probable		
Separator [4] Gas (Bcf)	Condensate (MMbbl)	Oil (MMbbl)	Separator [4] Gas (Bcf)	Condensate (MMbbl)	Oil (MMbbl)	Separator Gas (Bcf)	Condensate (MMbbl)	Oil (MMbbl)
12,007.25	380.75	264.02	11,435.80	268.94	128.04	12,345.02	336.87	398.56
8,113.76	297.79	73.09	5,192.27	174.36	47.10	7,166.91	238.47	95.21
-	-	18.69	-	-	0.66	-	-	8.84
-	-	1.14	-	-	15.54	-	-	26.84
-	-	1.14	-	-	15.54	-	-	26.84
-	-	0.19	-	-	8.00	-	-	115.05
-	-	0.19	-	-	8.00	-	-	50.00
-	-	-	-	-	-	-	-	65.05
297.14	3.90	-	3,193.78	32.90	6.35	2,225.16	25.25	4.95
297.14	3.90	-	2,171.43	20.05	2.00	1,479.87	15.30	2.60
-	-	-	1,022.35	12.85	4.35	745.29	9.95	2.35
882.33	0.34	198.97	566.75	1.91	54.87	137.84	0.52	39.47
434.68	0.34	-	434.57	1.91	-	121.00	0.52	-
367.59	0.00	0.00	49.57	-	-	16.00	-	-
367.59	-	-	49.57	-	-	16.00	-	-
67.09	0.34	0.00	385.00	1.91	-	105.00	0.52	-
67.09	0.34	-	385.00	1.91	-	105.00	0.52	-
447.65	-	198.97	132.18	-	54.87	16.84	-	39.47
-	-	4.48	-	-	9.31	-	-	30.71

Ranking

Screening and Ranking Framework, SRF (Oldenburg 2005)

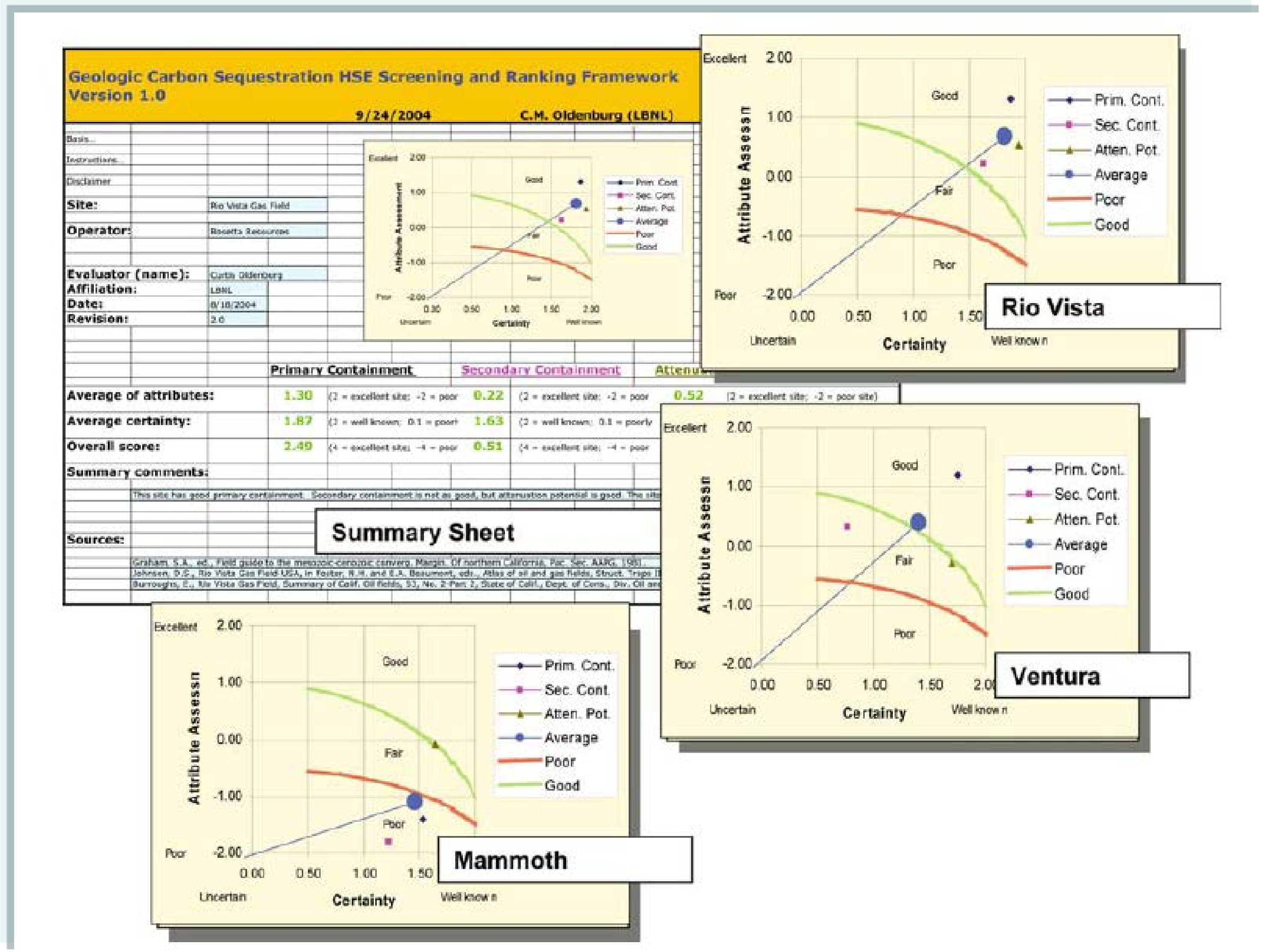
Primary Containment

Primary Seal	Normalized Weighting	Score Definition	Basis for Score	Parameter Weighting
Thickness, ft	0.48	2 >500m, 1 >200m, 0 100m, -1 <100m, -2 <10m	Prevent leakage	10
Lithology	0.24	2 shale, 1 clayey-siltstone, 0 mudstone, -1 siltstone, -2 sandy-sil	Low permeability to reduce migration	5
Demonstrated sealing	0.24	2 "good" seal,1 gas production from multiple horizons, -2 "weak	Evidence of seal or trap	5
Lateral continuity	0.05	2 regional seal, -2 local seal	Laterally extensive seal reduces potential for leakage	1
	1.00			21
Depth				
Distance below ground, ft	1	2 >1000m, 1 <1000m, ~0 800m, -2 <500m	Depth preferred so that CO_2 is supercritical	10
	1			10
Reservoir				
Lithology	0.07	2 unconsolidated sandstone, 1 sandstone, 0 carbonate, -1 silty-sandstone, -2 siltstone	Permeable, porous formation necessary	1
Perm., poros., K in mD	0.13	2 >500 mD,1 >200 mD, 0 100 mD, 1 <50mD, -2 <10 mD	Higher permeability increases injectivity	2
Thickness, m	0.07	2 >100m,1 >50m, 0 20m, -1 <10m, -2 <5m	Greater thickness increases storage capacity	1
Fracture or primary poros.	0.07	2 primary, 1 fracture	Primary porosity stores CO_2, fractures might increase migration	1
Pores filled with...	0.07	2 natural gas, 1 low TDS water, 0 brine, -1 hypersaline brine, -2 unrecoverable oil	Gas means more pore volume available for storage, higher injectivity	1
Pressure, psia	0.07	2 underpressured, 0 hydrostatic, -2 overpressured	Overpressured reservoirs could lead to fracture of seal	1
Tectonics	0.13	2 not active, 0 neither inactive or very active, -2 very active	2 not active (even if growth faults present,0 inactive or little activity, -2 very active tectonics	2
Hydrology	0.13	2 stagnant, 0 water drive but very slow flow, -2 flowing	Groundwater moving may transport CO_2	2
Deep wells	0.13	2 no known deep wells, 1 one known deep well, 0 two deep wells, -1 >5 deep wells, -2 many deep wells	More wells could provide more pathways for potential leakage of CO_2 upward toward surface	2
Fault permeability	0.13	2 numerous fault traps, 1 fault traps present, 0 no fault traps-but low K, -2 numerous leaking faults	Potential for trap along fault or leakage across fault	2
	1.00			15

Oldenburg, C.M., 2005. Health, Safety, and Environmental Screening and Ranking Framework for Geologic Co2 Storage Site Selection. Lawrence Berkeley National Laboratory LBNL Report No. LBNL-58873. Rev. 1.0.

Ranking

Screening and Ranking Framework, SRF (Oldenburg 2005)



Preliminary Result

Geological Storage Potential

- **Depleted oil and gas reservoir 70 Million Ton**
- **Saline Aquifer 7 Million Ton**

Ranking

1. Sirikit (E, K)	in Pitsanulok Basin
4. Namphong	in Khorat Basin
4. Uthong	in SuphanBuri Basin

1. Erawan - H	in Pattani Basin
2. Benchamas	in Pattani Basin
2. Bualaung	in Western Basin
2. Bongkot (3, 6, 9)	in North Malay Basin

2. Potential for CCS in Southeast Asia

Storage : Screening Guideline

- ✓Capacity ≥ 10 Million Ton at field level
- ✓Injection rate ≥ 100 Ton/day/well
- ✓Reservoir thickness ≥ 3 m
- ✓Seal thickness ≥ 10 m
- ✓Depth ≥ 1,000 m

Storage : Ranking

- ✓Capacity
- ✓Injectivity
- ✓#existing wells, # abandoned wells
- ✓Seal thickness
- ✓Contamination of other resources
- ✓Economics; EOR or other $$ offset, infrastructure, availability
- ✓Willing operator

Preliminary Result

Geological Storage Potential

- Depleted oil and gas reservoir 1,935 MMT
- Saline Aquifer 9,000 MMT

Ranking

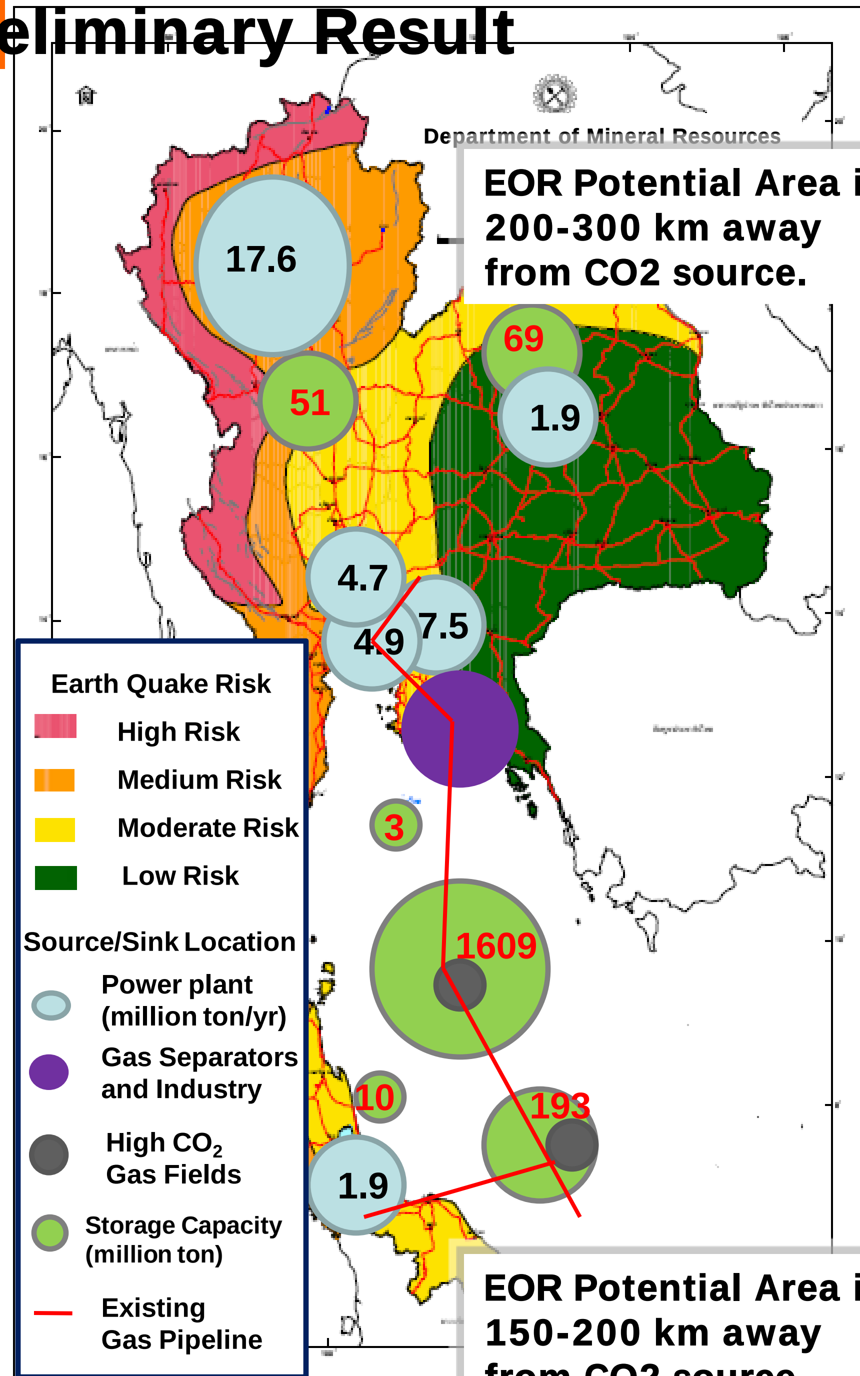
3. Sirikit in Pitsanulok Basin
5. SinPhuHorm in Khorat Basin

1. Erawan in Pattani Basin
2. Benchamas in Pattani Basin
4. Bongkot in North Malay Basin

Sink

CO2 EOR + Industry Uses, and Storage

Source



EOR Potential Area is 200-300 km away from CO2 source.

EOR Potential Area is 150-200 km away from CO2 source.

3. Case Study

Objective

– to carry out a high level technical-financial assessment of two potential CCS projects in Thailand

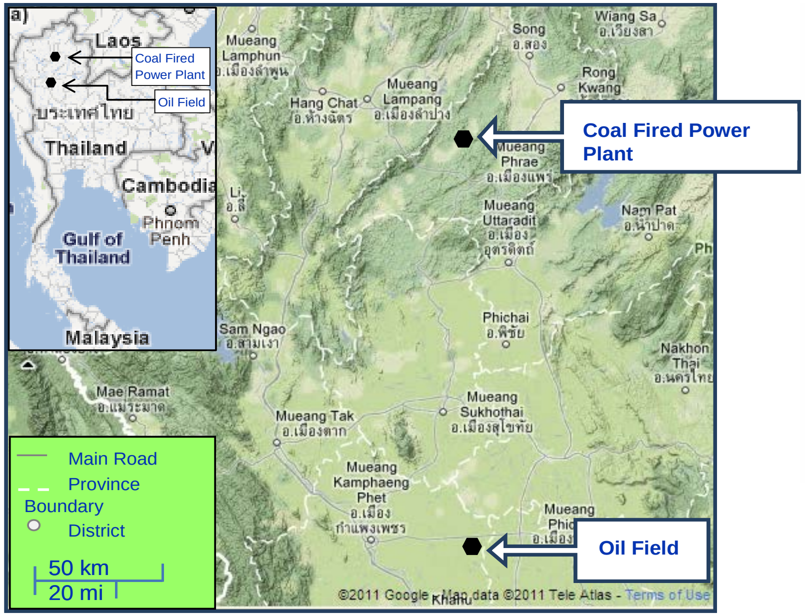
– to inform policy makers, regulatory agencies and other key stakeholders of the potential, obstacles and key success factors for implementing CCS in Thailand

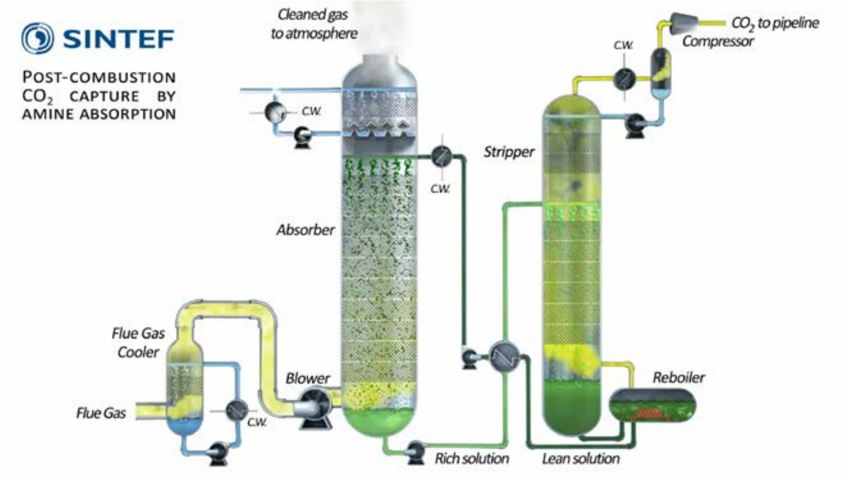
Assumptions and limitations

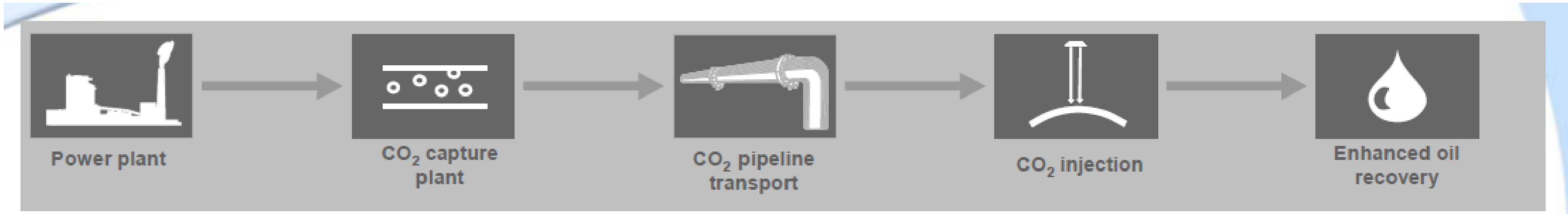
- Due to early nature of the study it is based on limited information and data
- No engineering activities have been carried out
- The total cost of the capture unit and pipeline has been estimated based on a generic capture plant and pipeline
- The cost of key elements for the storage site was included in the cost estimates
- The schedule of the projects has not been part of the assessment
- The cost data from public international sources include significant amount of uncertainties and are very site specific and differ from country to country
- With uncertainty factor of +/- 40%, the cost was calculated as high and low values
- More detailed and extensive feasibility and concept studies have to be carried out to get more site specific cost estimates

Onshore Case study

Onshore Case : Capture of 1 mill tones of CO2 per year from a coal fired power plant and transport the CO2 to an onshore oil field for use in Enhanced Oil Recovery (EOR).

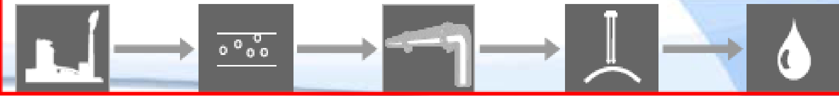






Base case concept

Coal fired power plant with 13 operating units ranging from 75-300 MW capacity	Post combustion CO_2 capture: Chemical absorption (amine)	CO_2 is transported via 270 km pipeline	CO_2 is injected in the onshore oil field in the Northern part of Thailand	EOR using 100 existing injection wells, CO_2 is not recycled

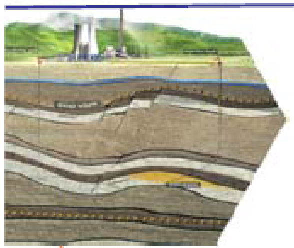


Onshore case study – Main observations and conclusions

Main conclusions

Post-combustion capture technology is recommended due to its level of maturity compared to the existing alternative (oxy-fuel technology).

Pipeline solution is recommended due to unfeasibility of transporting large quantities of CO_2 with road tankers

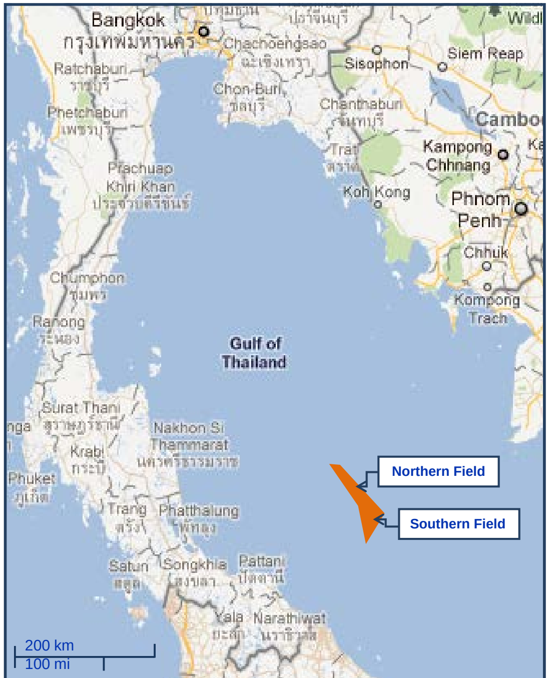


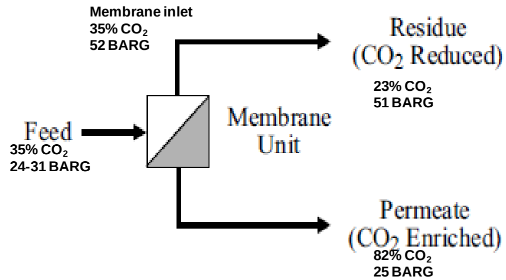
EOR concept (WAG, recycling of CO_2) has to be detailed through further studies

Main observations

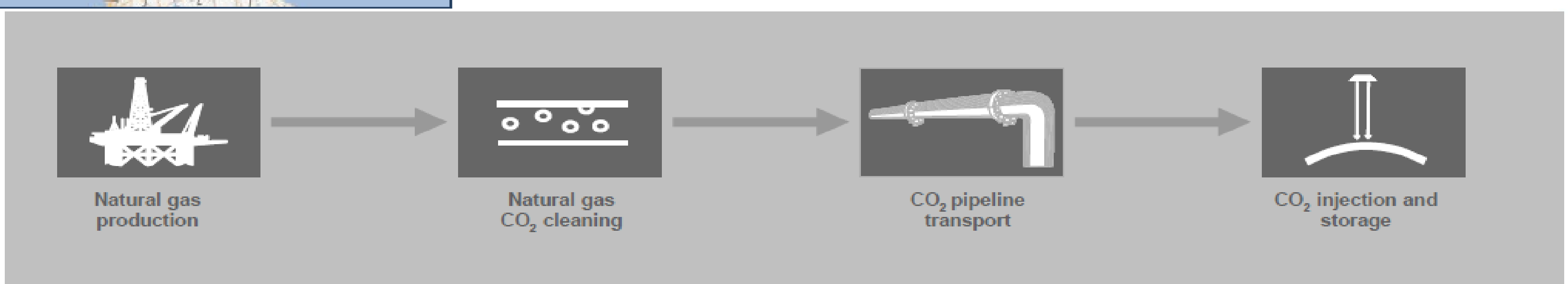
- Due to early nature of the case study it is currently too early to conclude on the financial feasibility of the onshore case
- There is need for further studies particularly related to storage part of the project
- Project schedule should be taken into account in further studies
- CCS projects developed in the near future will be exposed to higher uncertainties and risk than the following projects

Offshore Case study



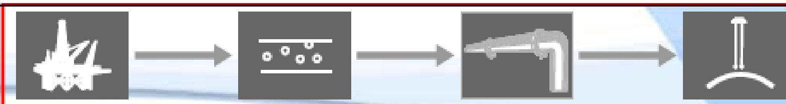


Offshore Case : Natural gas cleaning operation offshore at the Southern gas field with geological storage of the captured CO2 in a depleted gas reservoir in the Northern field



Base case concept

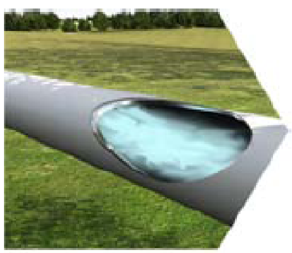
Natural gas is produced at the southern offshore field with CO_2 content around 35%	CO_2 content in natural gas is reduced to 23% using membrane technology	CO_2 is transported via 40 km pipeline	CO_2 is stored in depleted gas reservoir in the northern offshore field



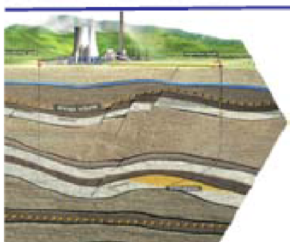
Offshore case study – Main observations and conclusions

Main conclusions

Alternative concept is not feasible
Base case concept with one stage membrane is recommended



Pipeline solution is recommended



Injection and operation strategy has to be detailed through further studies

Main observations

- It is recommended to study potential geological storage site in more detail with the aim of establishing the capacity and injectivity.
- The more detailed study of the storage site will form the basis for determining the strategy for injection wells and potential need for an additional platform at the storage site.

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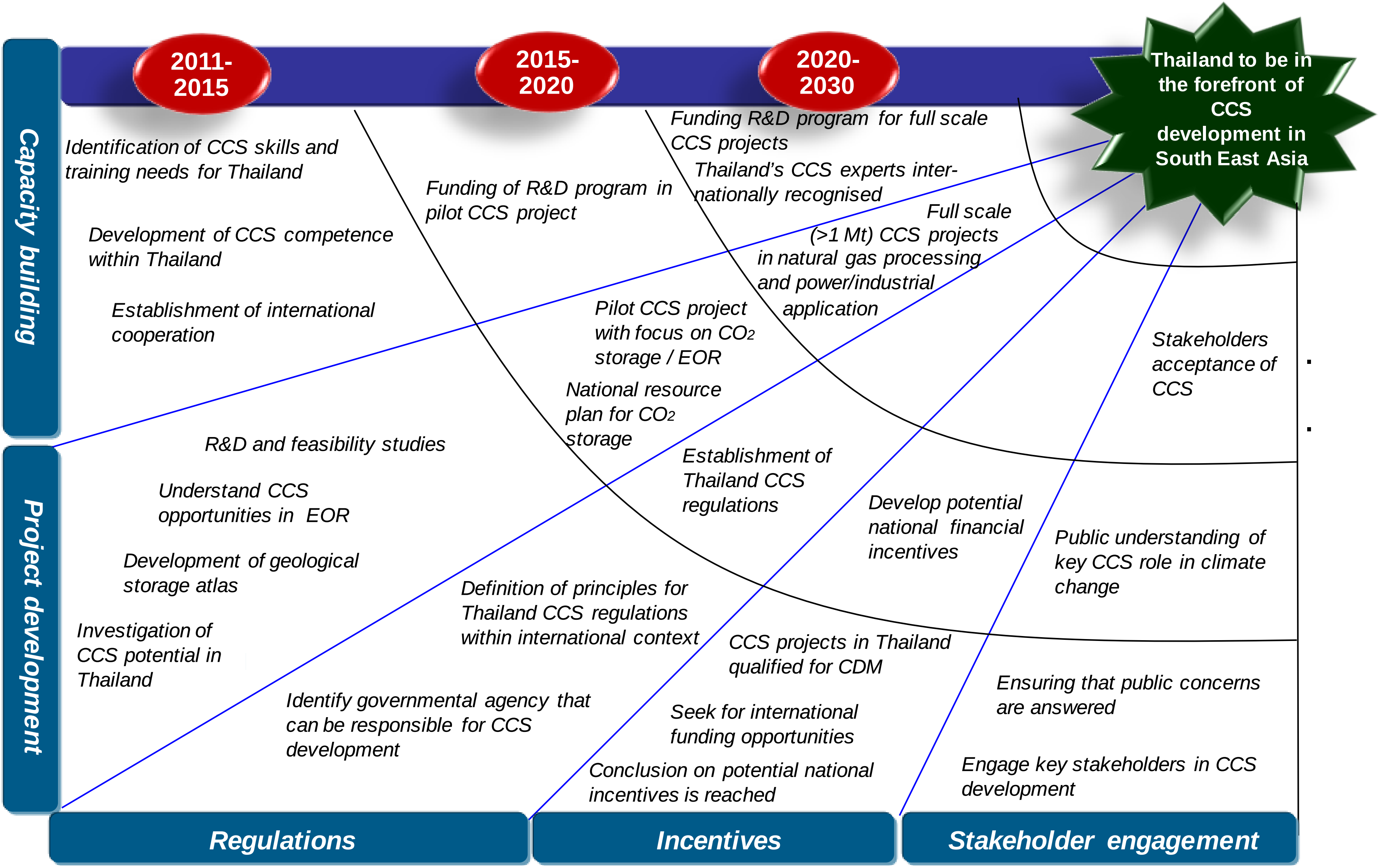
CCS Roadmap


2011-2015
2015-2020
2020-2030
Thailand to be in the forefront of CCS development in South East Asia
Capacity building
Project development
Regulations
Incentives
Stakeholder engagement
Identification of CCS skills and training needs for Thailand
Development of CCS competence within Thailand
Establishment of international cooperation
Funding of R&D program in pilot CCS project
Funding R&D program for full scale CCS projects
Thailand's CCS experts inter-nationally recognised
Full scale (>1 Mt) CCS projects in natural gas processing and power/industrial application
Pilot CCS project with focus on CO_2 storage / EOR
National resource plan for CO_2 storage
R&D and feasibility studies
Understand CCS opportunities in EOR
Development of geological storage atlas
Investigation of CCS potential in Thailand
Establishment of Thailand CCS regulations
Definition of principles for Thailand CCS regulations within international context
Identify governmental agency that can be responsible for CCS development
Develop potential national financial incentives
CCS projects in Thailand qualified for CDM
Seek for international funding opportunities
Conclusion on potential national incentives is reached
Stakeholders acceptance of CCS
Public understanding of key CCS role in climate change
Ensuring that public concerns are answered
Engage key stakeholders in CCS development

Way Forward of CCS In Thailand

Future of CCS in Thailand?

- **CCS is not primary energy & environment policies for GHG mitigation (RE, EE, Forestation are still cheaper and easier options)**
- **No main government or public organization responsible for the whole CCS value chain**

(Which department will be in charge of CCS in Thailand?)

More studies are required.

- **Site characterization and injectivity**
- **Can existing facilities be utilized?**
- **Will CO_2 leak along faults or existing well paths?**
- **Monitoring Program**
- **Environmental impact?**
- **New law or modify existing laws?**
- **Which existing law to be modified?**

THANK YOU

(QUESTIONS)

“Climate change is such a huge issue that it requires strong, concerted, consistent and enduring action by governments”