

The Three Sisters: CCS, AGI, and CO₂ EOR

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The Three Sisters



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AGI

1. Sweetening
2. Compression
3. Pipeline
4. Injection

CCS

1. Capture
2. Compression
3. Pipeline
4. Injection

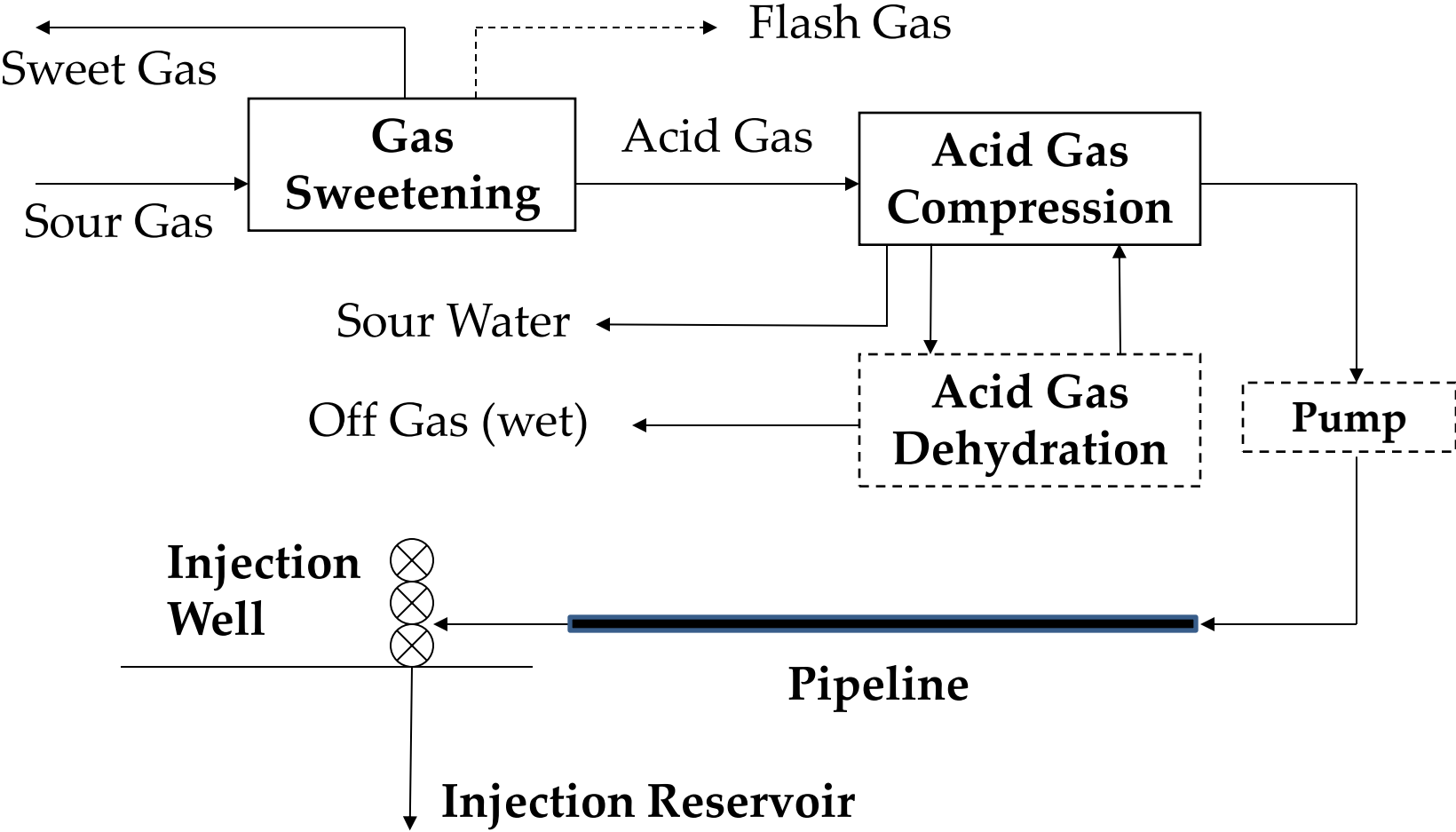
EOR

1. CO₂ Source
 - a) Virgin
 - b) Recovered
2. Compression
3. Distribution
4. Injection

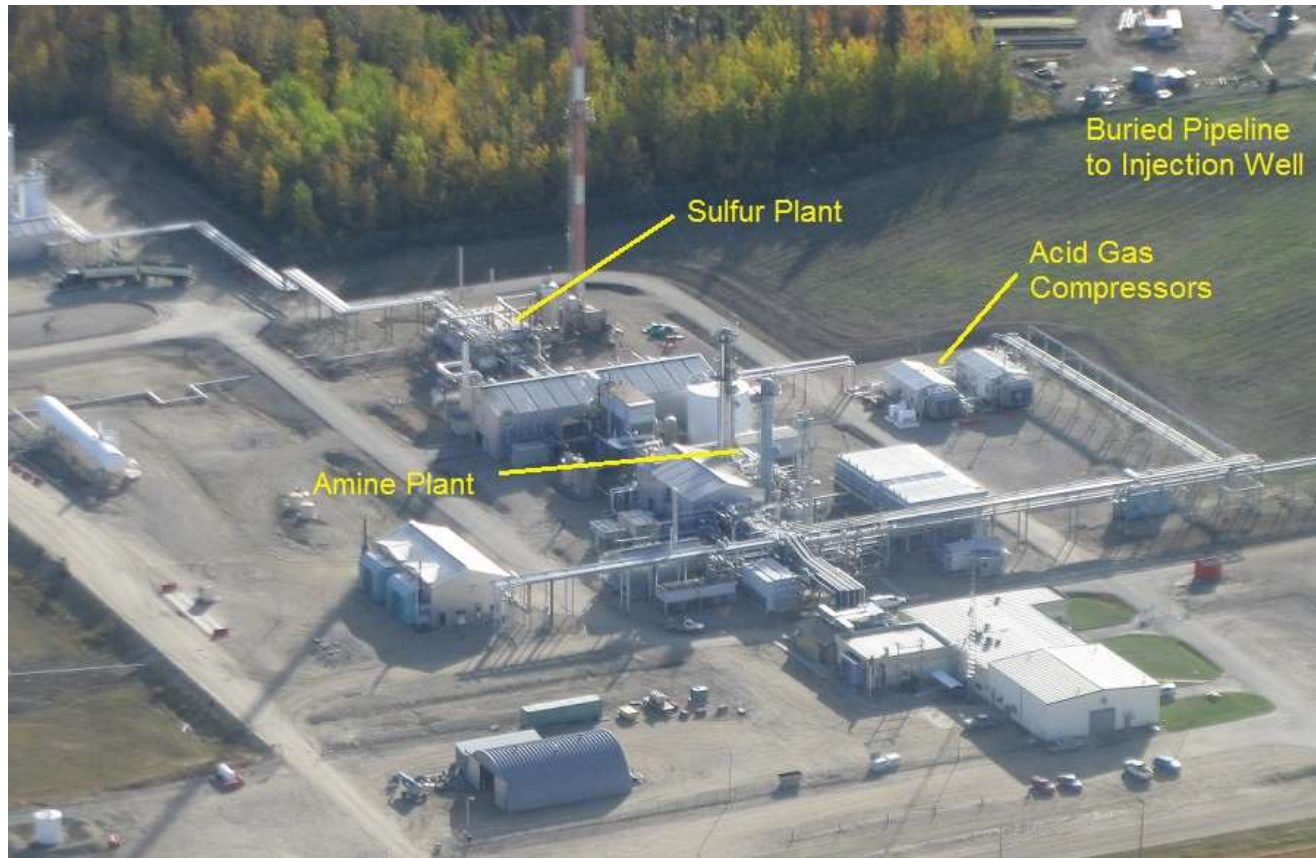
Comparing Technologies

	AGI	CCS	CO₂ EOR
First Project	1989	2016	1972
where:	Acheson, AB	Boundary Dam, SK	West Texas, USA
Number	~50 Canada	~5	~5 Canada
	~25 USA	Shell Quest, AB	~125 USA
	~5 others	NRG Energy, TX	
Largest Size	85 MMSCFD	1.3 Mt/a	220 MMSCFD
	Qatar	(~65 MMSCFD)	SACROC
	66 MMSCFD		90 MMSCFD
	Wyoming		Weyburn, SK

AGI - Block Diagram



South Rosevear Gas Plant



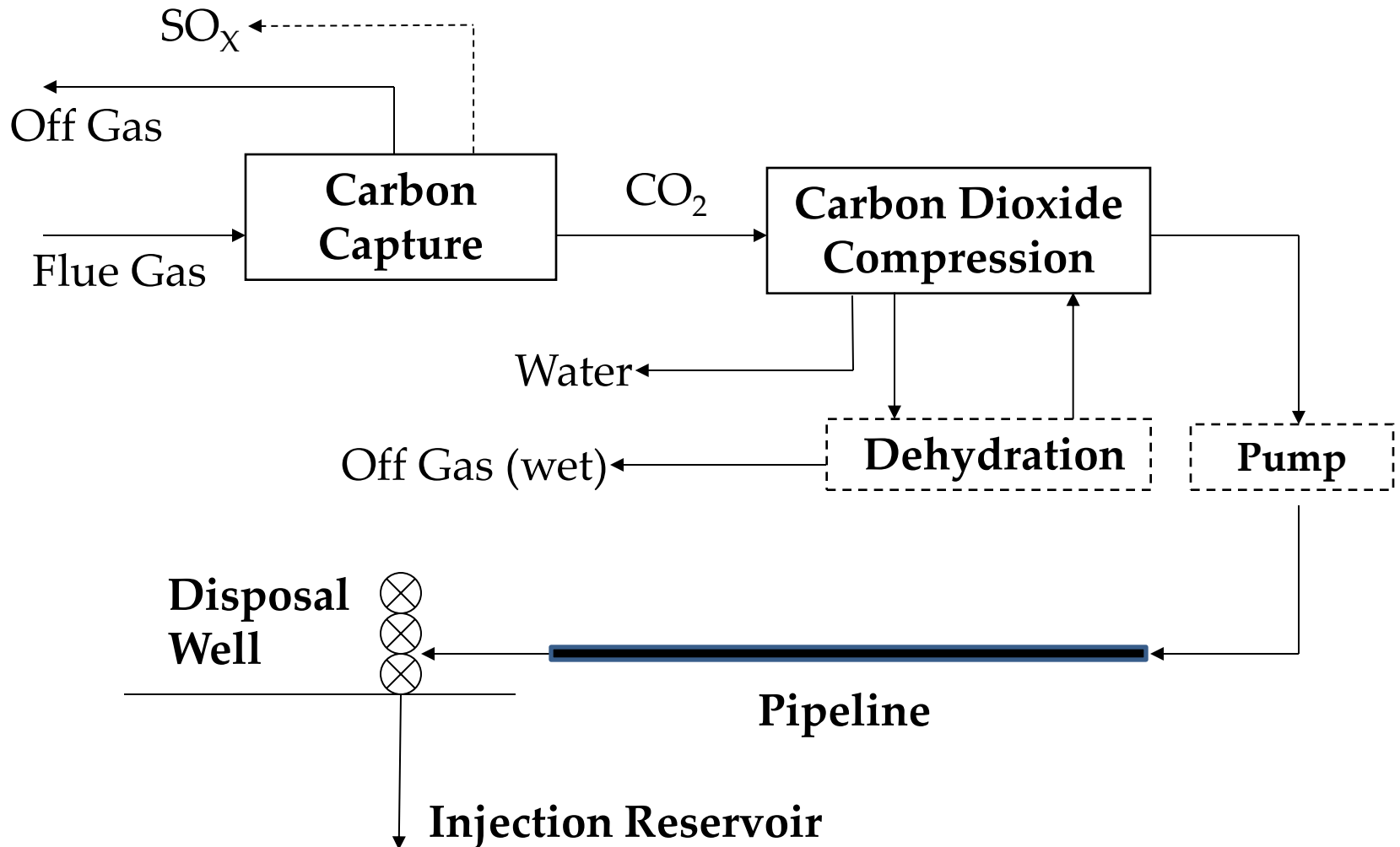
Acid Gas Compressor (Puskwaskau)



Injection Well (Puskwaskau)



CCS - Block Diagram



Boundary Dam



Sweetening vs. Capture

Gas Sweetening	Carbon Capture
<u>Source</u> : Raw Natural Gas	<u>Source</u> : Industrial Waste Gas
<ul style="list-style-type: none">● raw gas contains H₂S and/or CO₂	<ul style="list-style-type: none">● commonly flue gas from burning fossil fuels
<ul style="list-style-type: none">● may contain mercaptans and other sulfur compounds	<ul style="list-style-type: none">● may contain SO_x and O₂ (excess air) which are “poisons” to amine solvents

Sweetening vs. Capture

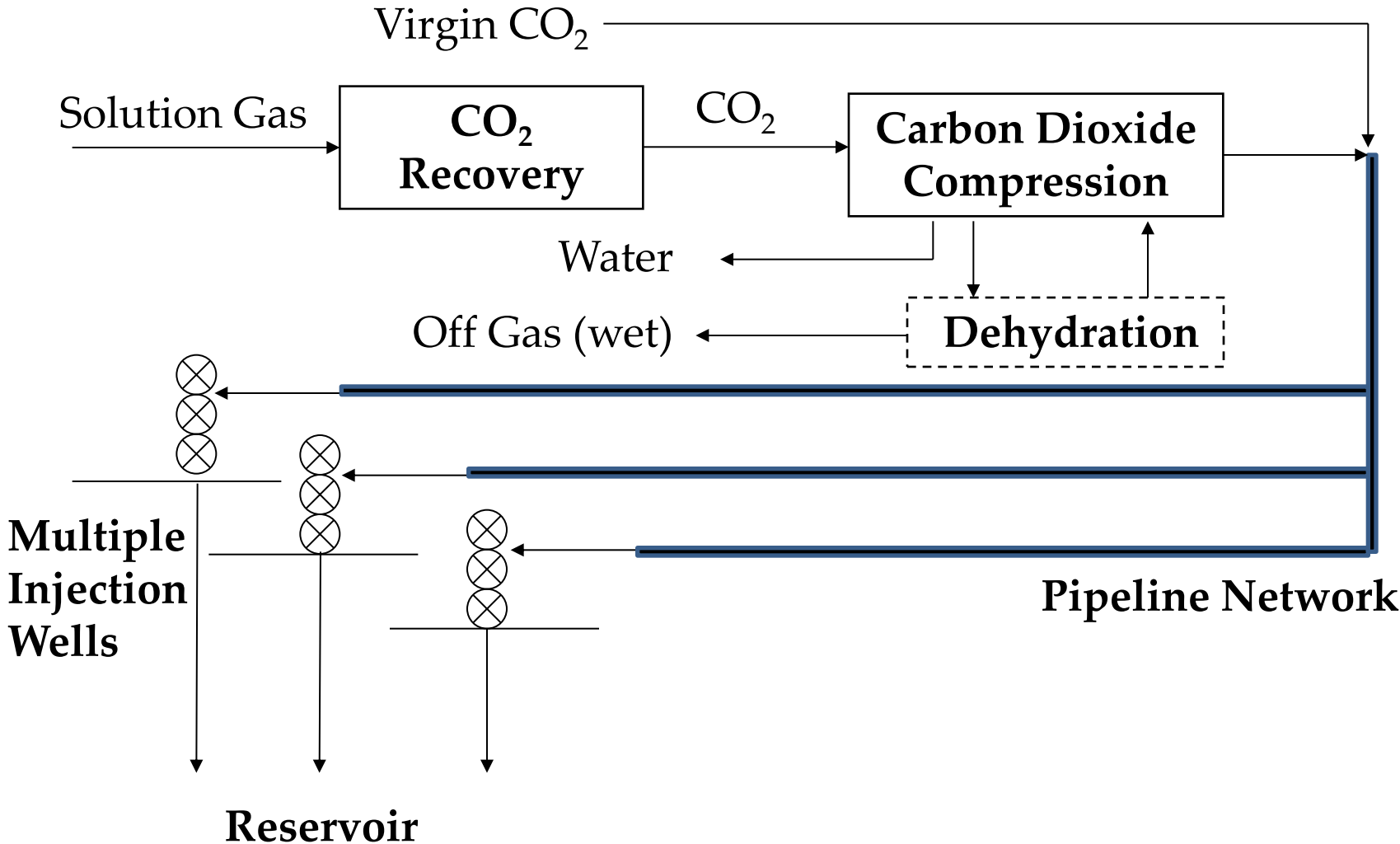
Gas Sweetening	Carbon Capture
<u>Solvent:</u> Amine and/or Physical	<u>Solvent:</u> Amine
<ul style="list-style-type: none">● a wide range of alkanolamines are used	<ul style="list-style-type: none">● MEA seems to be the most common
<ul style="list-style-type: none">● MDEA is now very common – CO₂ slip	<ul style="list-style-type: none">● what about MDEA?
	<ul style="list-style-type: none">● because of CO₂ and the “impurities” a reclaimer may be necessary

Sweetening vs. Capture

Gas Sweetening	Carbon Capture
High Pressure (20 to 70 bar)	Low Pressure (less than 2 bar)
Low Temperature (~50°C)	High Temperature (greater than 100°C)

High pressure and low temperature favor absorption

CO₂ EOR - Block Diagram



Incentives

AGI	CCS	CO ₂ EOR
Monetize small sour gas plays	“Save the Environment”	Produce more oil, increase profits
Formerly flared acid gas	CO ₂ implicated climate change	Extend the life of older fields
Acid gas H ₂ S lean	Avoid <i>Carbon Tax</i>	Sequester some CO ₂
Avoid sulfur stockpiling	Public image	

It's Just Semantics

- Is Cenovus' Weyburn really a CCS project?
 - Weyburn is an EOR project where CO₂ is injected in order to increase oil production
 - Of the 90 MMSCFD injected about 40 MMSCFD are recycled, however CO₂ is “permanently” sequestered
- Is Statoil's West Sleipner really a CCS project?
 - Sleipner is an AGI project, natural gas is produced, the CO₂ is removed in an amine plant, and is injected into a subsurface reservoir

It's Just Semantics

- Both acid gas injection and CO₂ enhanced oil recovery sequester CO₂ and thus are technically CCS projects

In Summary

- The Three Sisters: AGI, CCS, and CO₂ EOR share many common elements:
 - Compression, water handling, pipeline, reservoir flow, material selection and corrosion considerations, and others
- Lessons learned from the older sisters (the more mature technologies: AGI and CO₂ EOR) can be transferred to the youngest sister (CCS)

謝謝

Thank you!