Canadian Hydrogen Convention

ALBERTA H2

Lowering the Cost of Green Hydrogen

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Who is AlbertaH2?

- Oil and gas engineers
- Extensive Process, Design and Operations experience
- Created H_2 production to leverage:
  - Existing infrastructure
  - Existing disposal practices
  - Oil and gas skillsets
  - A waste product
- Patent pending design is uniquely tailored for WCSB facilities and conditions

AlbertaH2 Features

- Electrolysis H_2 Production
- Configuration presented is for natural brine (i.e. oilfield produced water)
- Designed to be retrofit into existing produced water systems
- Utilizes similar chemical injection to existing produced water system
- Utilizes a small fraction of produced water (110 kg H_2/m^3 of produced water)
- Fluid effluents are made compatible with liquids currently injected (i.e. corrosion inhibition, SRBs)

Common Methods of H2 Production

- Hydrocarbon Source:
  - Steam Reforming
  - Partial Oxidation
  - Autothermal reforming
- Water Feedstock:
  - Electrolysis

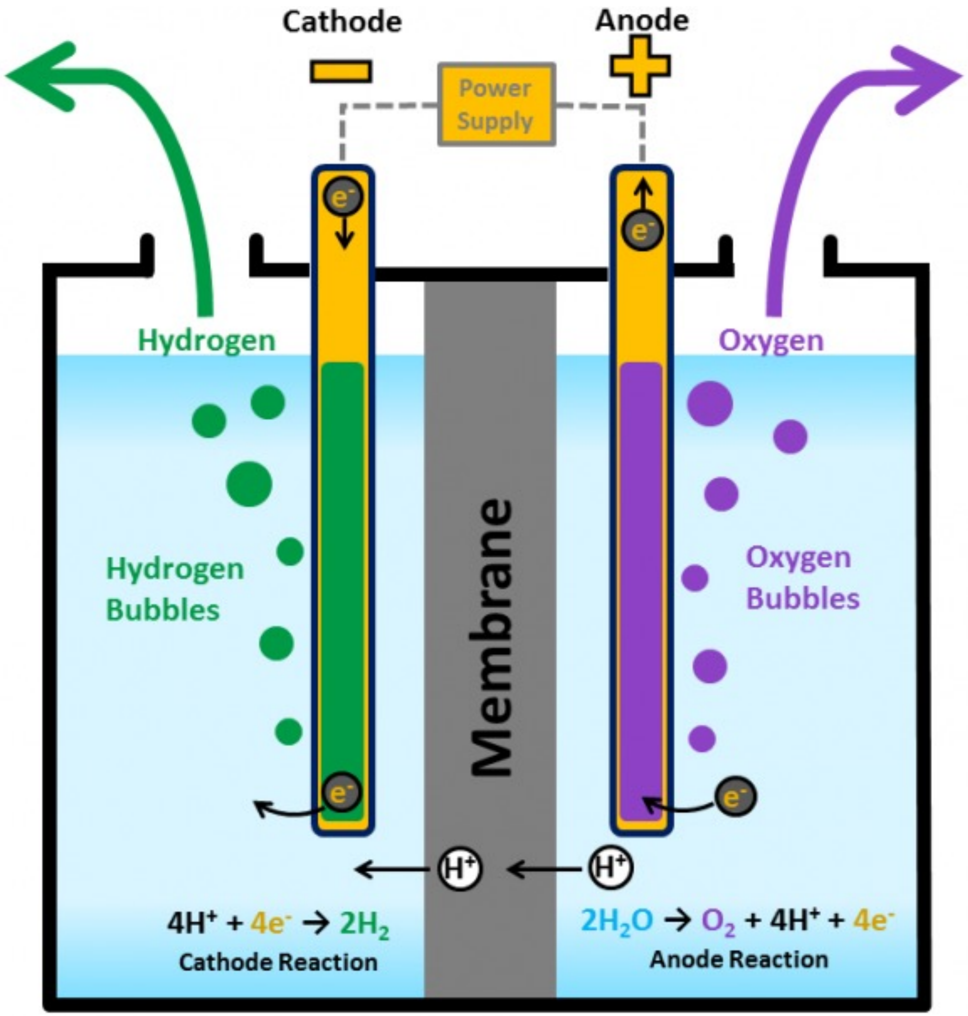
Hydrogen Categorized

Black:	black coal used as feedstock for gasification
Brown:	brown coal used as feedstock for gasification
Pink:	water electrolysis by nuclear energy
Turquoise:	methane pyrolysis forms hydrogen and carbon
White:	naturally occurring hydrogen in reservoir deposits

Hydrogen Categorized

Blue:	natural gas and steam forms hydrogen and CO2 CO2 is captured and stored
Grey:	natural gas and steam forms hydrogen and CO2 CO2 is not captured
Green:	**water electrolysis by surplus renewable energy**
Electrolysis:	PEM (solid plastic electrolyte) AE (alkaline electrolyte, i.e. NaOH) SOE (solid ceramic electrolyte)

Classic Electrolysis



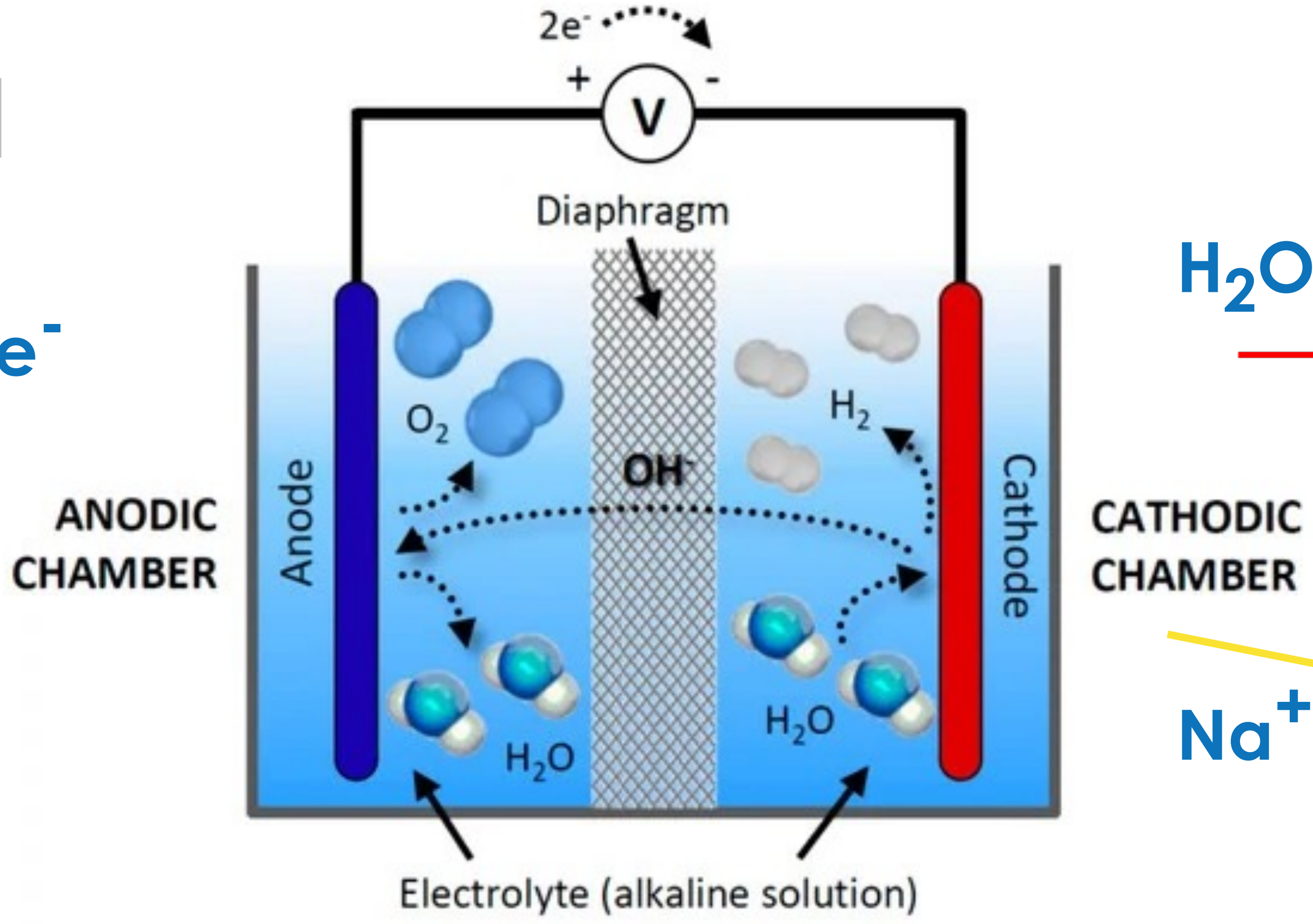
$$4H^{+} + 4e^{-} \longrightarrow 2H_2$$

$$2H_20 \longrightarrow O_2 + 4H^{+} + 4e^{-}$$

Alkaline Electrolysis

Oxidation

$2OH^- \rightarrow H_20 + O_2 + 2e^-$



Reduction

$H_2O + 2e^- \rightarrow H_2 + 2OH^-$

$Na^+ + e^- \rightarrow Na$

Reaction Controls

- Cell potential of Na^+ reduction is - 2.71 V
- Cell potential of H_2O reduction is - 0.83 V
- Even if ***some*** Sodium is reduced:

$$2Na + 2H_2O \longrightarrow 2NaOH + 2H_2$$

- **Cell potential** drives the outcome

AlbertaH2 Process

- ❑ Electrolyte is a minimally treated produced water
- ❑ Separates H_2 and O_2 production
- ❑ No membrane between electrodes
- ❑ Eliminates limiting anode O_2 reaction
- ❑ Increased H_2 production efficiency
- ❑ Utilizes existing oil and gas infrastructure
- ❑ Simple equipment and operation
- ❑ Minimal gas cleaning
- ❑ Patent pending

AlbertaH2 Conditions

- Produced Water Electrolyte
  - H_2O, $NaCl$, Ca^{2+}, CO_3^{2-}, SO_4^{2-}…
- NaCl: 3,000 – 30,000 ppm
- Voltage (1<DC<6 volts) applied is controlled
- Unpartitioned electrolytic cell
  - Includes driving electrodes and one or more pairs of bi-polar electrodes
- Hydrogen production achieved in a "two-step" process
- Catalyst bed used to reduce OCl^- to enable normal disposal well injection

Chemistry

$2H_2O_{(aq)} + 2e^- \rightarrow H_{2(g)} + 2OH^-_{(aq)}$ (-1.0 V) ✓

$Na^+_{(aq)} + e^- \rightarrow Na_{(aq)}$ (-2.71V)

$2H_2O_{(aq)} \rightarrow O_{2(aq)} + 4H^+ + 4e^-$ (-1.42 V)

$2Cl^-_{(aq)} \rightarrow Cl_{2(aq)} + 2e^-$ (- 1.36V) ✓

$2OH^-_{(aq)} + Cl_{2(aq)} \rightarrow 2OCl^-_{(aq)} + H_{2(g)}$

At pH>7, favoured due to high OH^- ions

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Key Reactions

$$OCl^-_{(aq)} + H_2O_{(l)} + 2e^- \rightarrow Cl^-_{(aq)} + 2OH^-_{(aq)}$$

- Hypochlorite ions migrate from anode to cathode
- Allowed to occur because there is no membrane
- This also increases the concentration of OH^- at anode, and
- Promotes the following reaction:

$$2OH^-_{(aq)} + Cl_{2(aq)} \rightarrow 2OCl^-_{(aq)} + H_{2(g)}$$

✓ The OCl^- ion production reduces O_2 production at the anode

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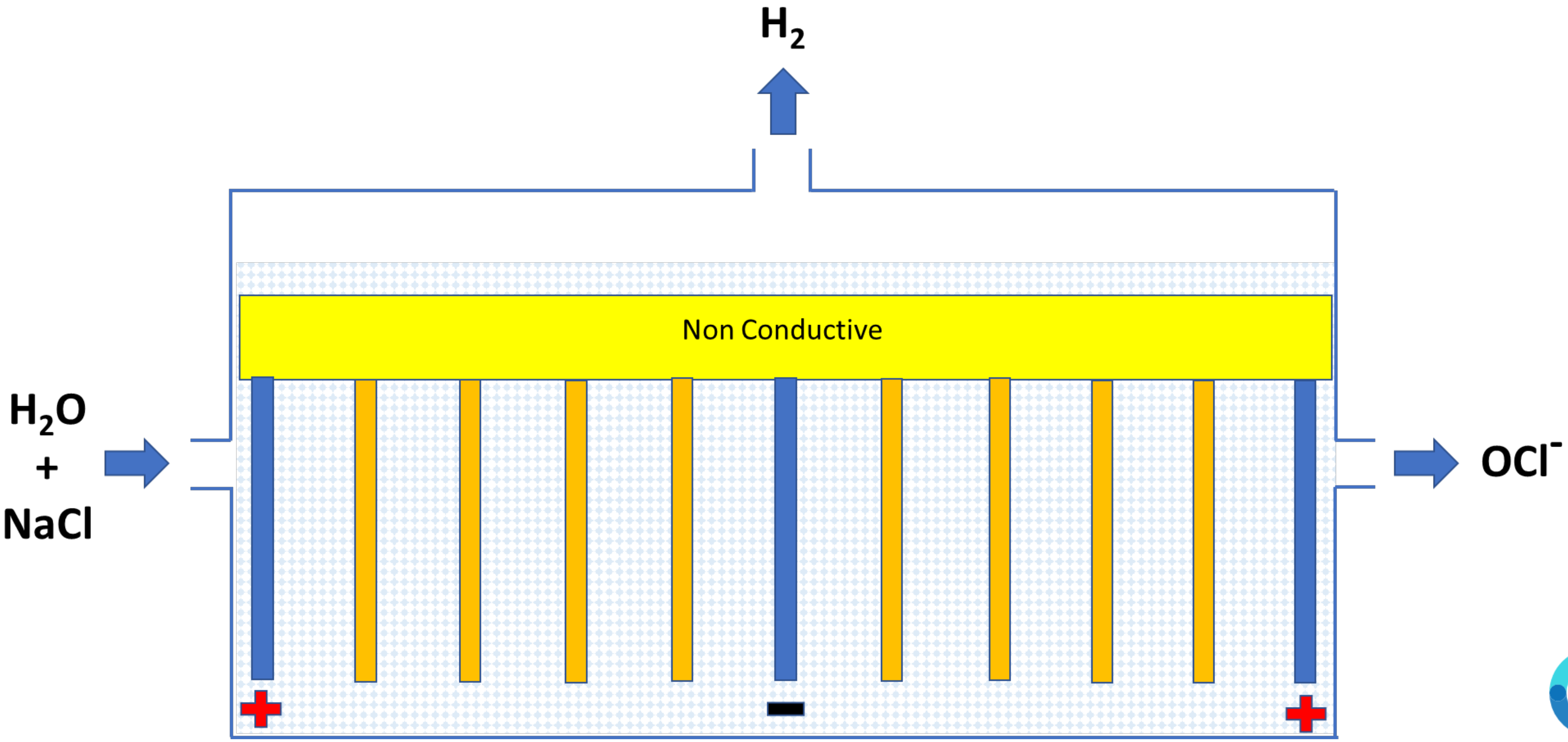
AlbertaH2 – Electrolytic Cell



Electrolyte Self-Conditioning

The following is favoured at higher pH due to more OH^- ions:

$$2OH^-_{(aq)} + Cl_{2(aq)} \rightarrow 2OCl^-_{(aq)} + H_{2(g)}$$

HCL formation through Hypochlorous Acid:

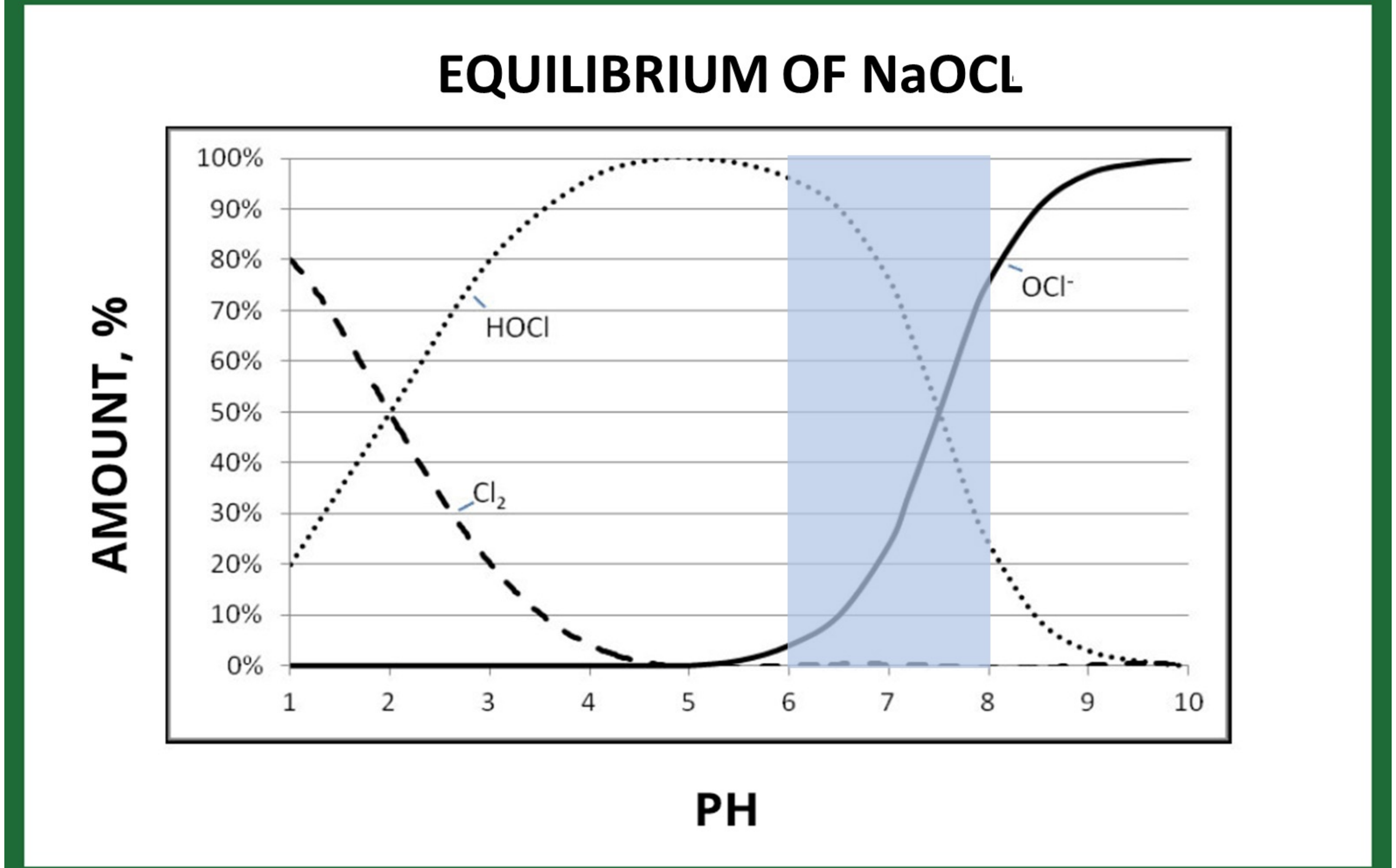
$$2H_2O_{(l)} + 2OCl^- \ aq) \rightarrow 2HOCl_{(aq)} + 2H^+_{(aq)}$$

$$Cl_{2(aq)} + H_2O_{(l)} \rightarrow HOCl_{(aq)} + 2H^+_{(aq)} + Cl^-_{(aq)}$$

$$2HOCl_{(aq)} \rightarrow HCl_{(aq)} + O_{2(aq)}$$

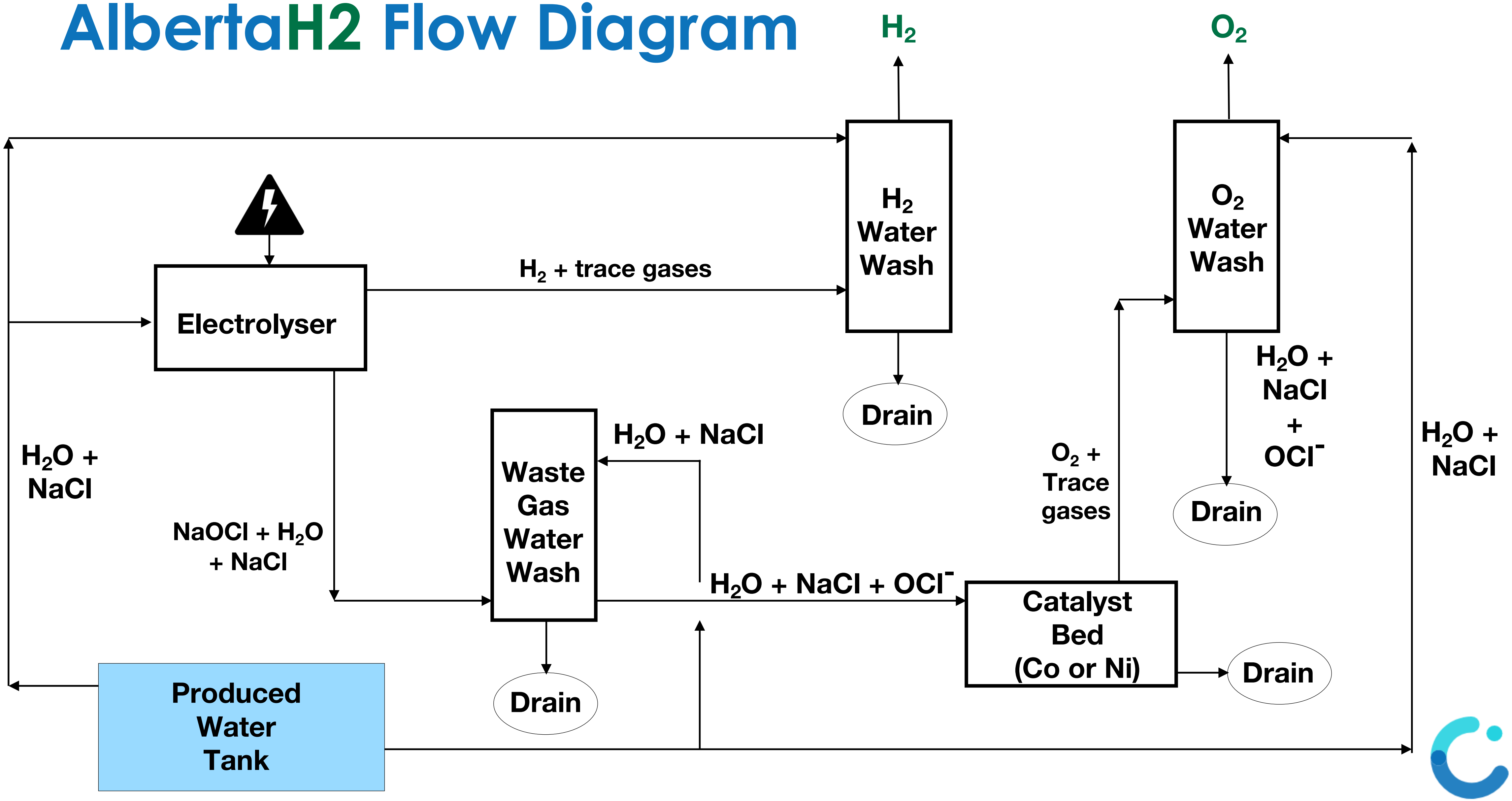
HCl helps minimize deposits

AlbertaH2 – Operating Range



AlbertaH2 operating range

AlbertaH2 Flow Diagram



Summary

- Electrolytic cell construction is simplified, reducing fabrication cost
- pH controlled Hypochlorite (OCl^-) generation over O_2:
  - decreases resistance in the electrolytic cell and improves H_2 formation
- Electrode depolarization, improving electrical performance
- Utilizes conductive polymer electrodes – lowers cost vs Ti
- Minimal water treatment – self cleaning (HCl)
- Water washes removes Chlorine gas from H_2 and O_2
- Utilize existing infrastructure (i.e. decommissioned leases)
- H_2 produced locally for use at site and/or slipstream into natural gas pipeline
- Reduces emissions where natural gas used as fuel

Thank you!

Questions?