# Solid-state electrolyte technology for low-emission hydrogen/ammonia production

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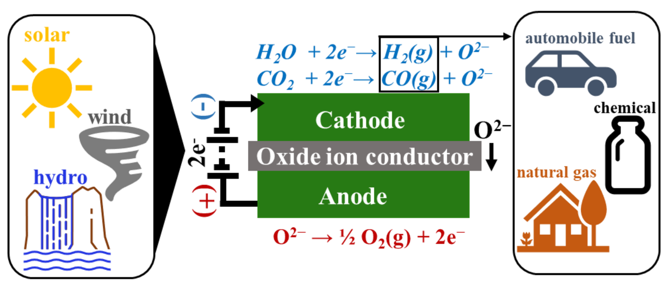
## Introduction

Solid oxide electrolyser (SOE) comprises an oxide ion conducting ceramic electrolyte coated with two porous electrodes

- **Cathode:-** splits steam, $CO_2$ or mixture of both to $H_2$ / syngas
- **Electrolyte:-** transports $O^{2-}$ ions to the anode
- **Anode:-** pure $O_2$ evolves

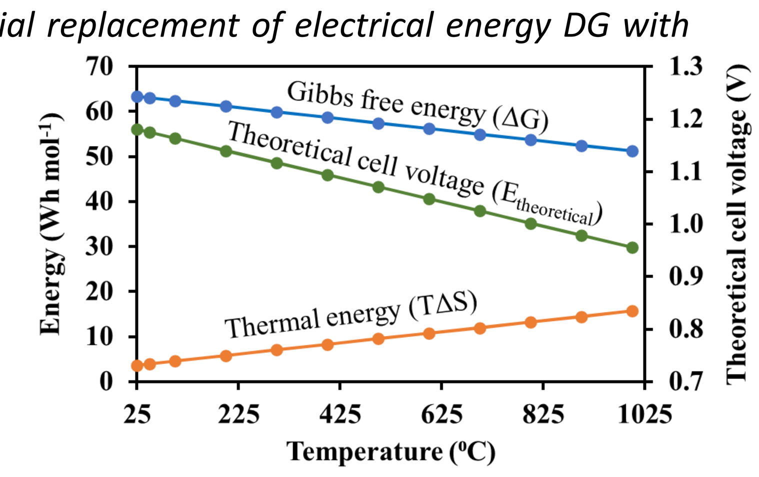



***Advantages include:-***

- High efficiency due to fast kinetics; low cost materials
- Cell thermodynamics lowers operating cost *(partial replacement of electrical energy DG with solar thermal, industrial waste heat TDS)*

**Electric input for steam electrolysis:-**

- **AEL/PEM→ 4.2–5.0 kWh/Nm³ $H_2$**
- **SOEC→ 2.5-3.0 kWh/Nm³ $H_2$**



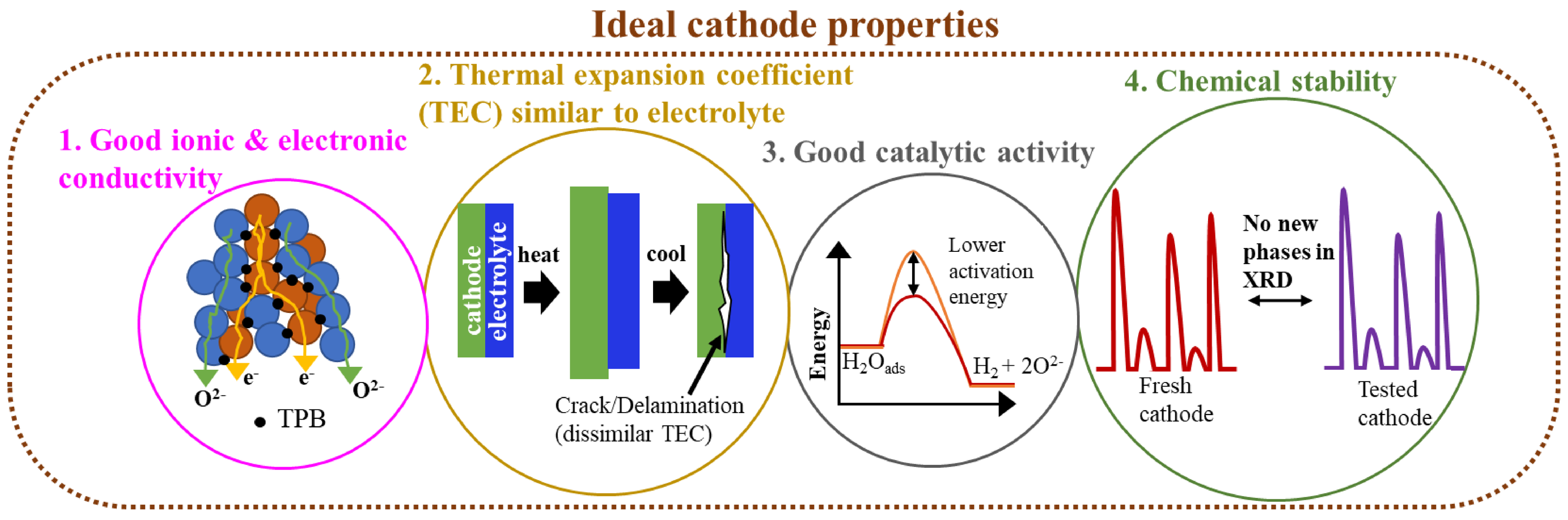

- SOE can be coupled with renewable energy sources like wind and solar PV
- **SOE-generated $H_2$ can be used as a feedstock for ammonia production via Haber Bosch (HB) process**
- **Both processes can be integrated to make it more energy efficient**

## Challenges of SOE technology

***Good cathode material, stability and scalability still a challenge***

- ✓ Lowest degradation so far → 1.7%/kh for 3.6 kh operation* **(DOE target set at 1%/kh tested over 1000 h or more)**
- ✓ Current lifetime < 20 kh **(IRENA target > 80 kh lifetime by 2050)**
- ✓ Capital cost of 1 MW stacks > 2000 USD **(IRENA target < 200 USD by 2050)**

**Ideal cathode properties**




## CSIRO facilities

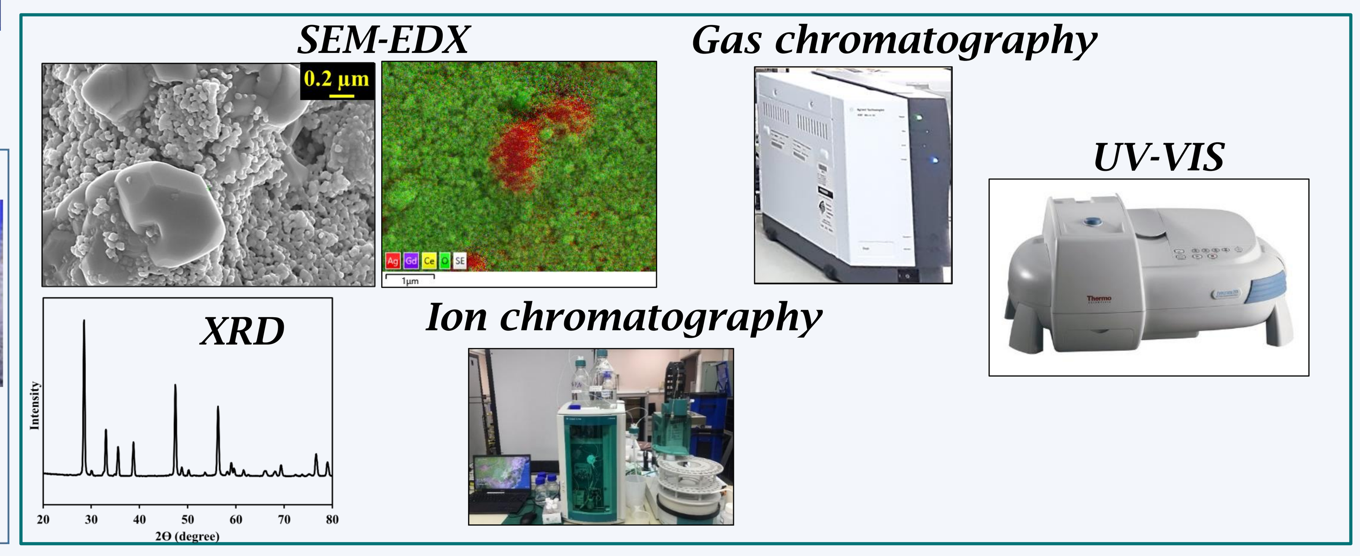
### Electrode synthesis


### Cell testing

*Test station for evaluating single cells to multiple cells/stacks*

### Electrolyte pressing


### Characterisation




## FINAL TARGET

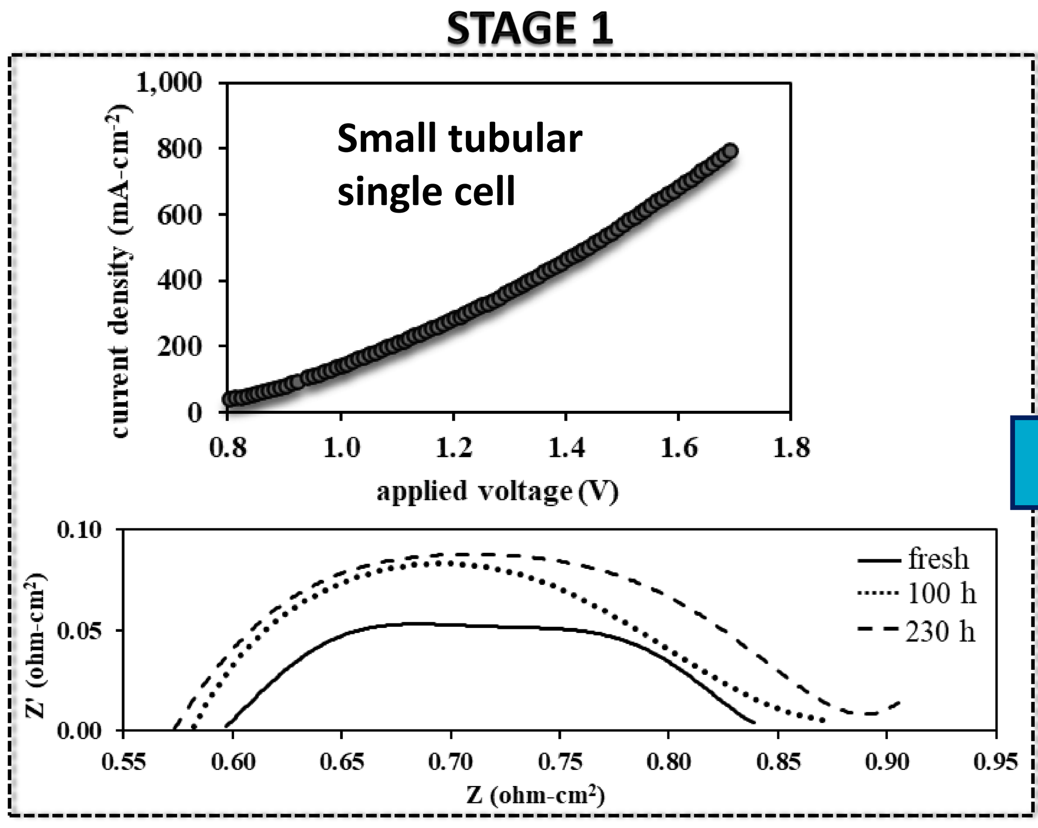
- ✓ Further work in progress to achieve ***95% stability over 1000 hours of continuous operation for large-area tubular cells/ stacks***
- ✓ Multiple tubular cells can be assembled as per $H_2$ requirement on the downstream side or the processes for which this $H_2$ will be utilised, for example Haber Bosch process

## CSIRO targets/achievements

***CSIRO's objective is to address the issues related to state-of-the-art SOE technology and our work encompasses:-***

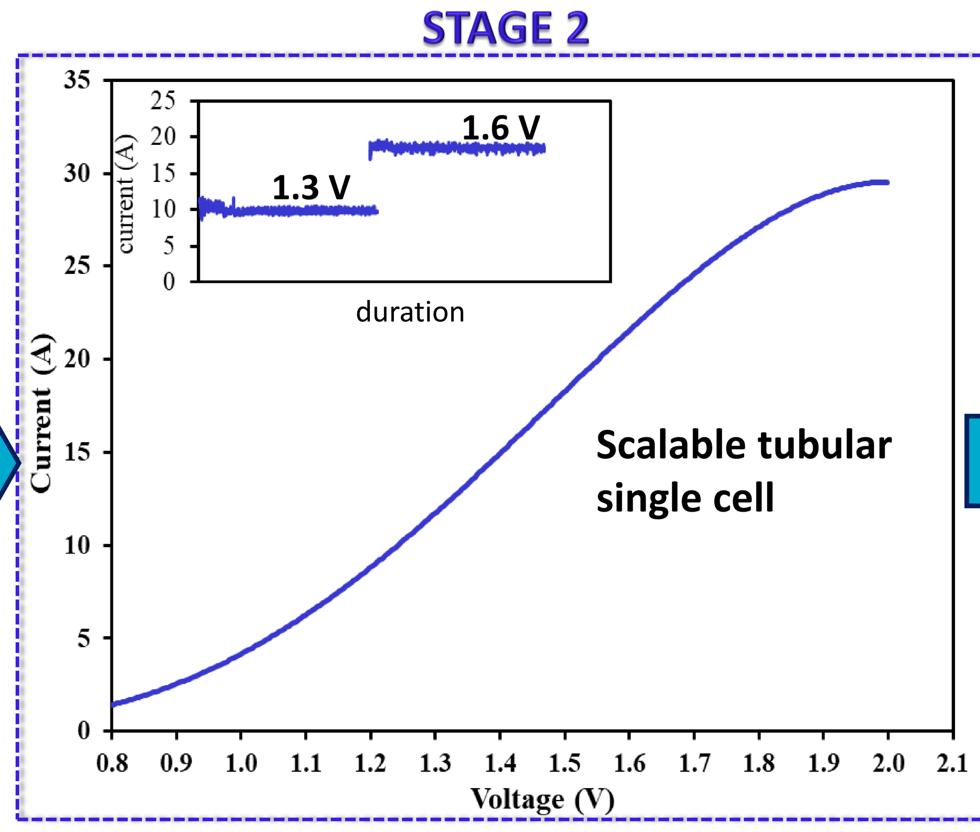
- ✓ Design and development of stable electrode materials for $H_2$ production in solid oxide cells with energy input ***<40 kWh/kg $H_2$***
- ✓ State-of-the-art Ni-YSZ based solid oxide electrolytic cells need $H_2$ recycling (up to 20%) to maintain Ni in metallic state; CSIRO targets ***symmetrical configuration robust cells scalable to multi-kW systems with simple fabrication, reduced capex, no $H_2$ recycling***

### STAGE 1



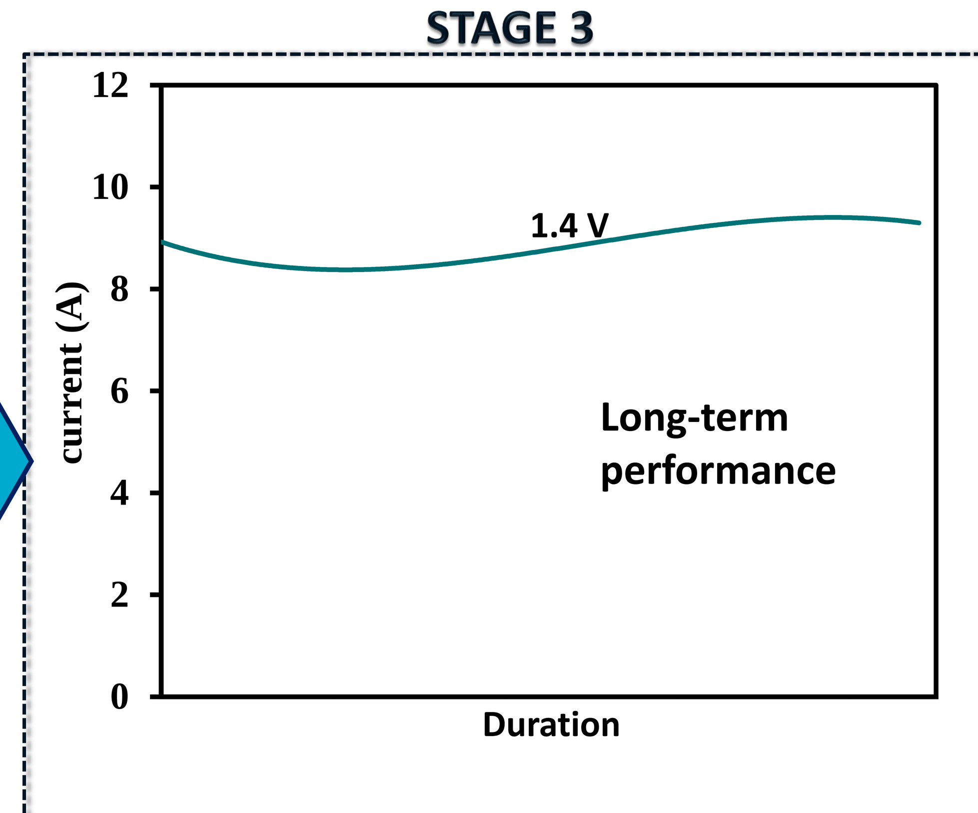

✓ Developed electrodes with $R_{pol}$ *<0.3 ohm-cm², with the lowest being 0.18 ohm-cm²*

### STAGE 2

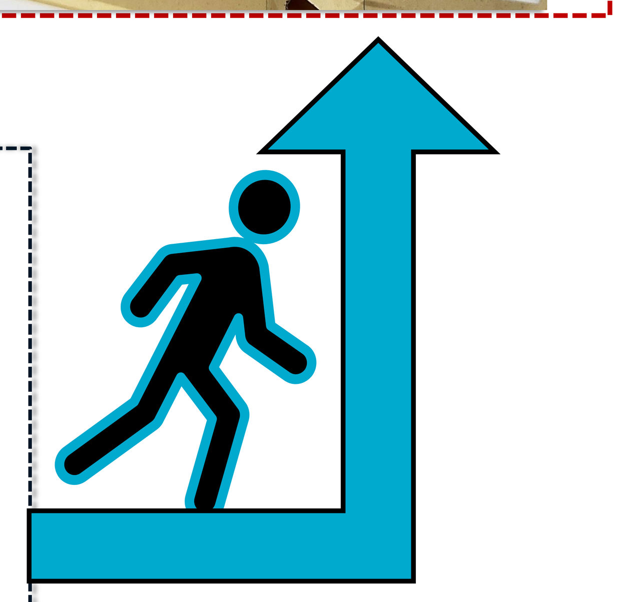



✓ Stable cell performance generating ***27.5 L/h $H_2$ from single cell*** at 100% electrical energy to $H_2$ production efficiency

### STAGE 3




✓ Excellent long-term stability with ***312 L/day $H_2$ production from a single cell*** with 100% electrical energy to $H_2$ production efficiency



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**FOR FURTHER INFORMATION**

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*Our team*

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