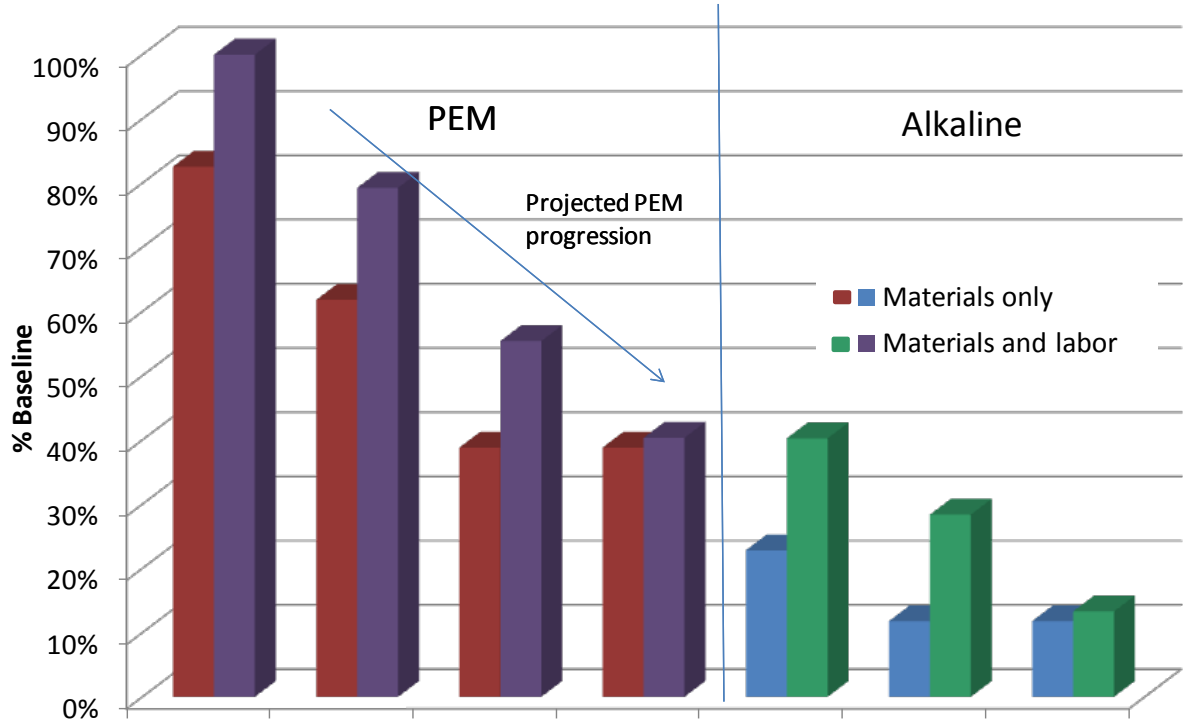
Membrane-Based Electrolysis: Overview

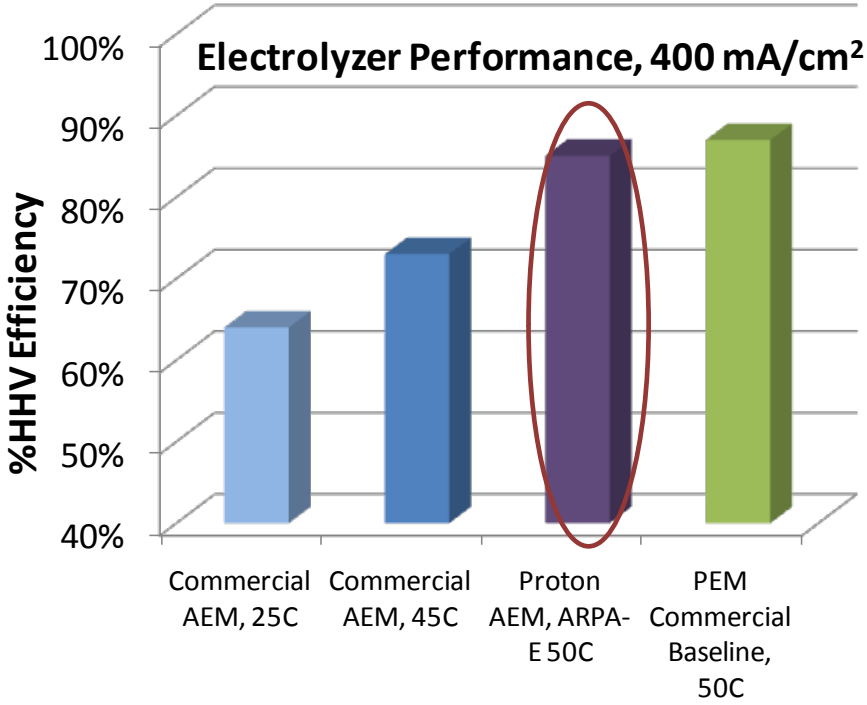
- Many cost and efficiency advancements still feasible for PEM electrolysis
  - >50% reduction in membrane thickness
  - >90% reduction in catalyst loading
  - Improved O_2 evolution activity
  - Part integration and high speed manufacturing
  - Balance of plant improvements: drying, electronics
- AEM electrolysis can enable new cost curve
  - Will need to balance with potential efficiency loss based on OH- conduction
  - Durability still needs significant work

Cost and Efficiency Comparison

- Advanced PEM can reach projected AEM introduction on cost
- AEM approaches current PEM efficiency at low current density but PEM has potential for additional improvement
- Need to balance technology with application (OpEx vs. CapEx)



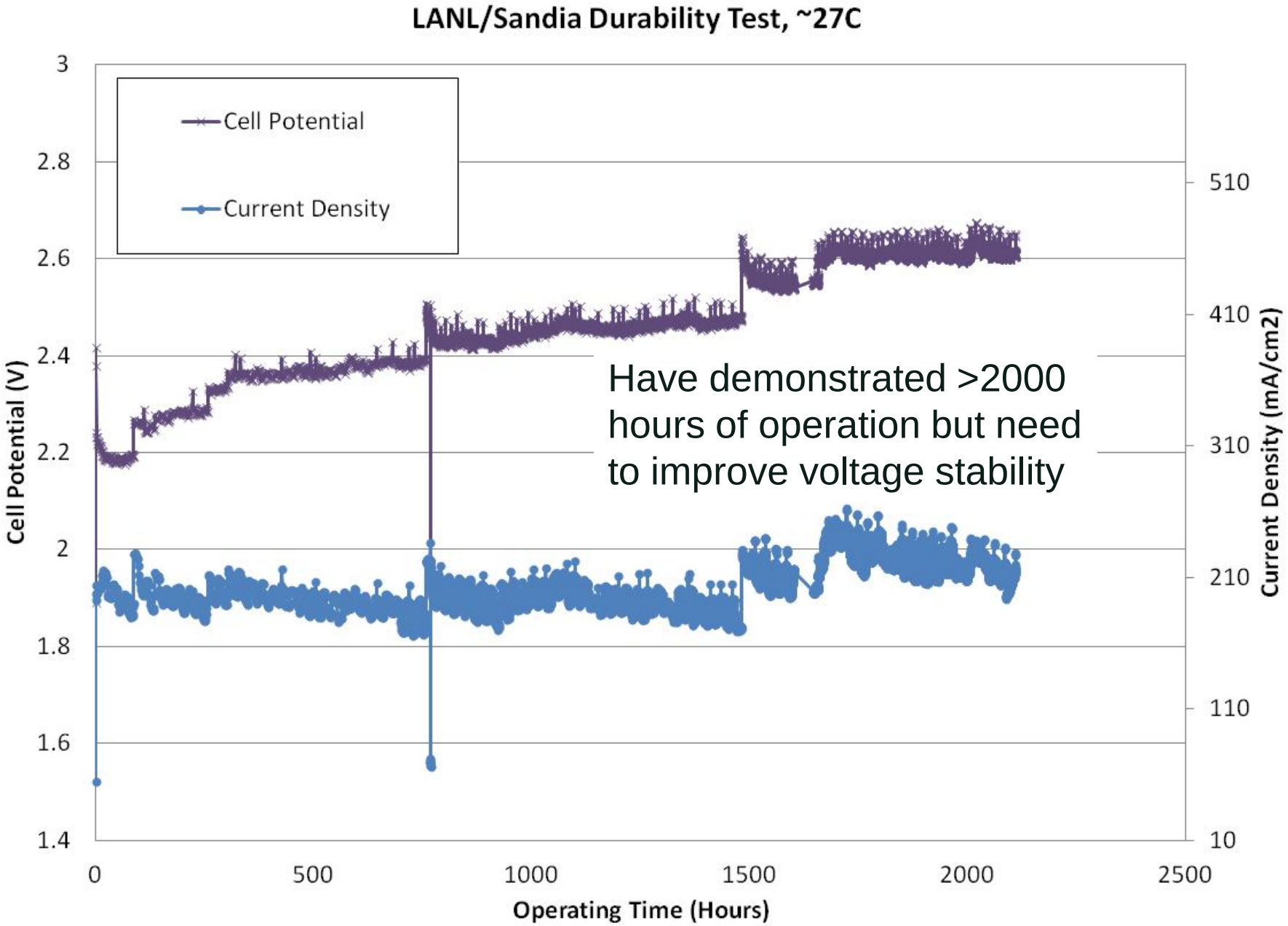
Design changes with demonstrated feasibility in PEM system and as applied to AEM



AEM Challenges

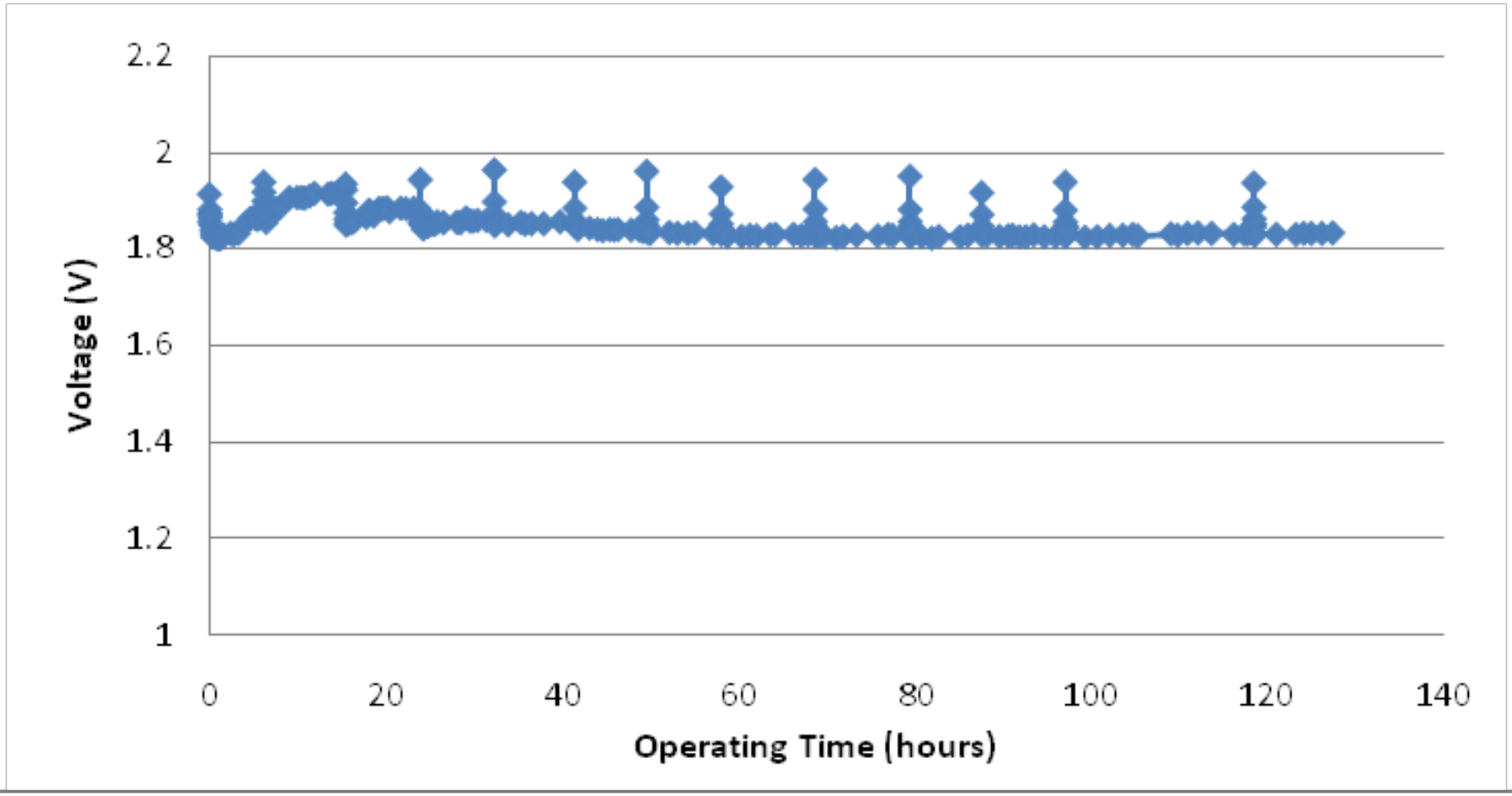
- Materials are not at same scale or maturity yet
- Membrane and ionomer are far less stable than PEM especially to temperature
  - Need alternate electrode manufacturing methods
  - Air sensitivity requires special electrode conditioning
  - Proton OnSite has become standard test bed
- Non-PGM catalysts have had complications translating from liquid systems
  - Need optimization of 3-phase boundary layer at GDL
- Water management is more difficult
  - Combined with lower OH- conductivity likely limits operating current range

Membrane/Ionomer Durability Status

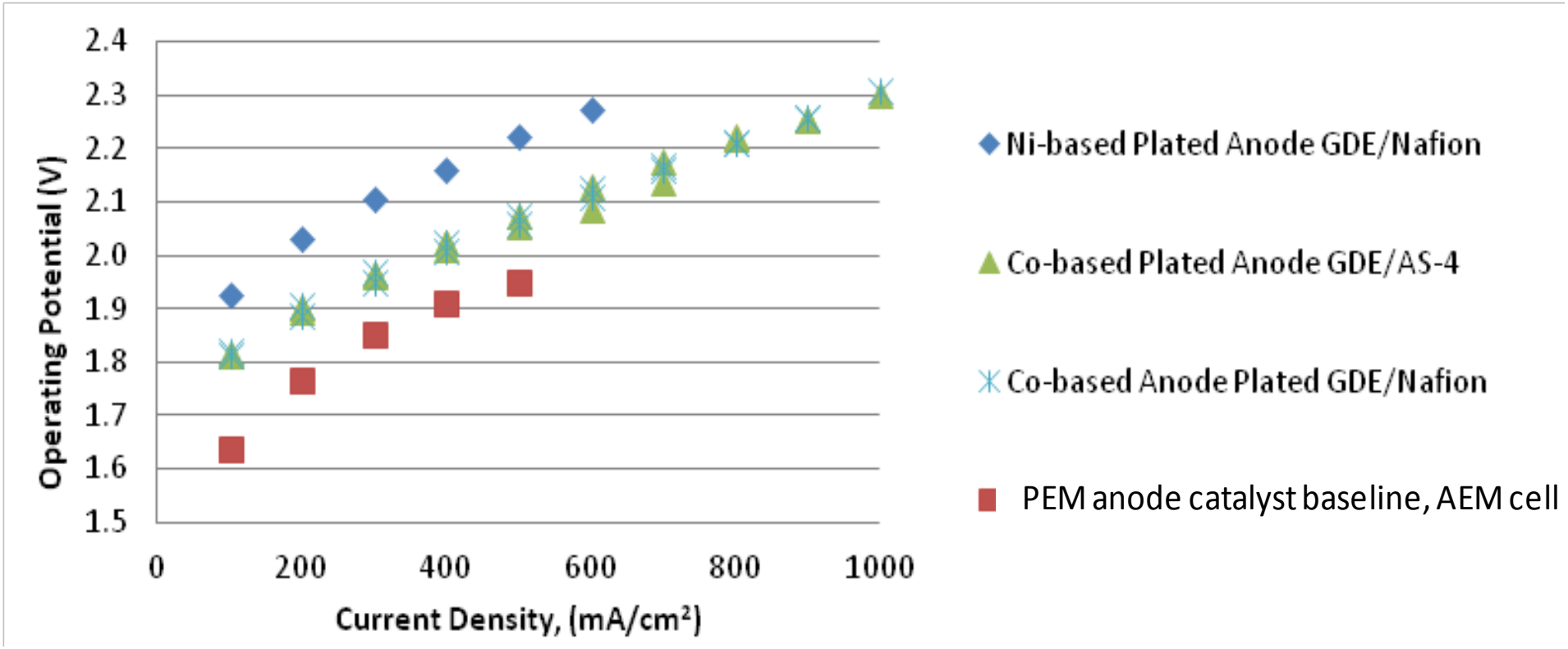


Alternate Approach to Stability

- Carbonate electrolyte can stabilize ionomer but need to balance with balance of plant complexity



Non-PGM Catalyst and Cost Validation



	PEM baseline	Alkaline equivalent	Alkaline + improvements	% Original component
O_2 flowfield	100%	20%	13%	13%
H_2 flowfield	54%	24%	8%	15%
MEA	30%	5%	2.4%	8%

Cost estimates and validation

Needed Activities and DOE Assistance

- Need cohesive team efforts to make progress
  - Material interactions need to be understood
  - Multi-phase boundaries require strong analytical tools
- Use of consistent device testing under practical conditions for valid comparisons
- Integrators have the knowledge of the pieces and need to drive the effort
- Many parallels with the status of PEM electrolysis and integration of advanced materials