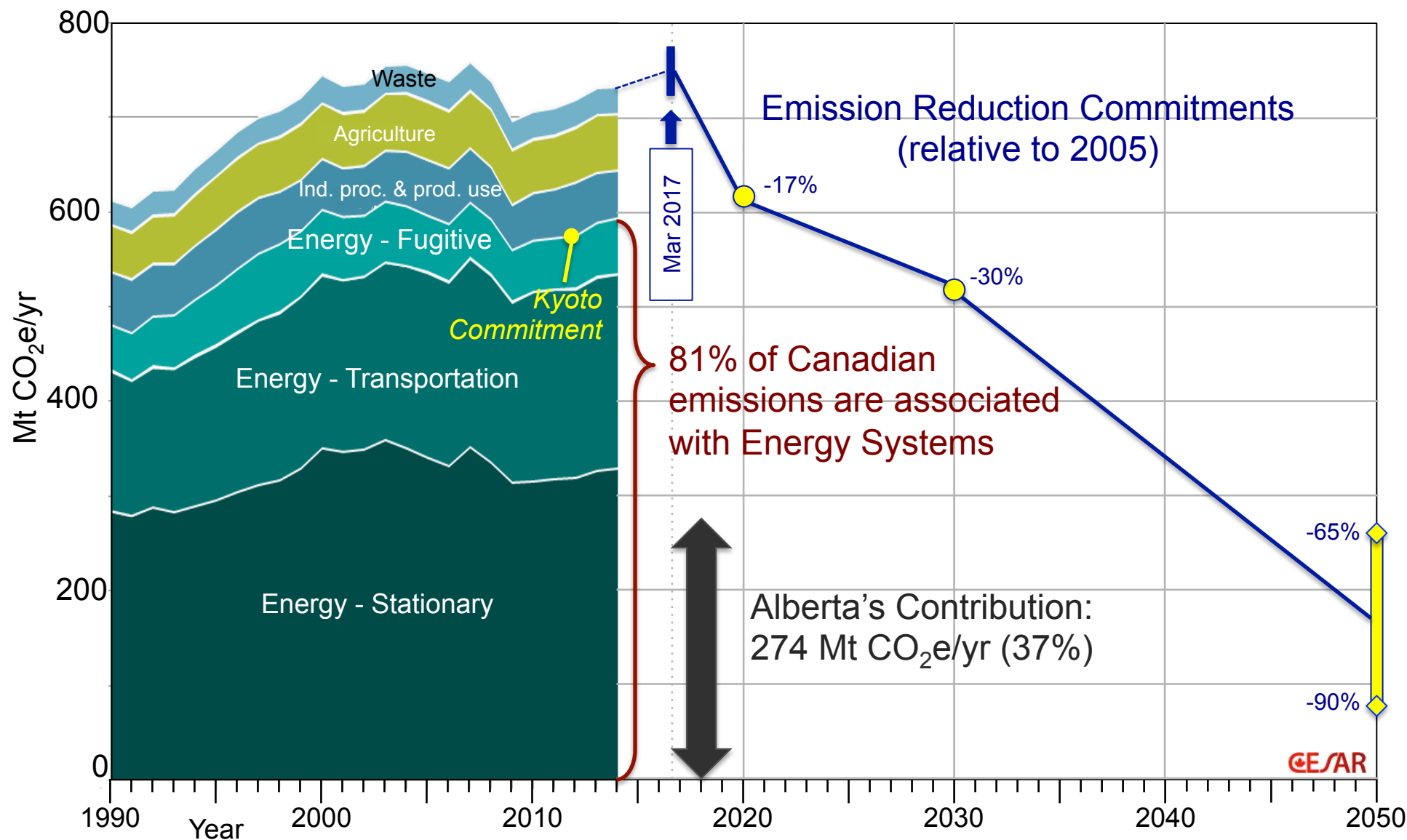


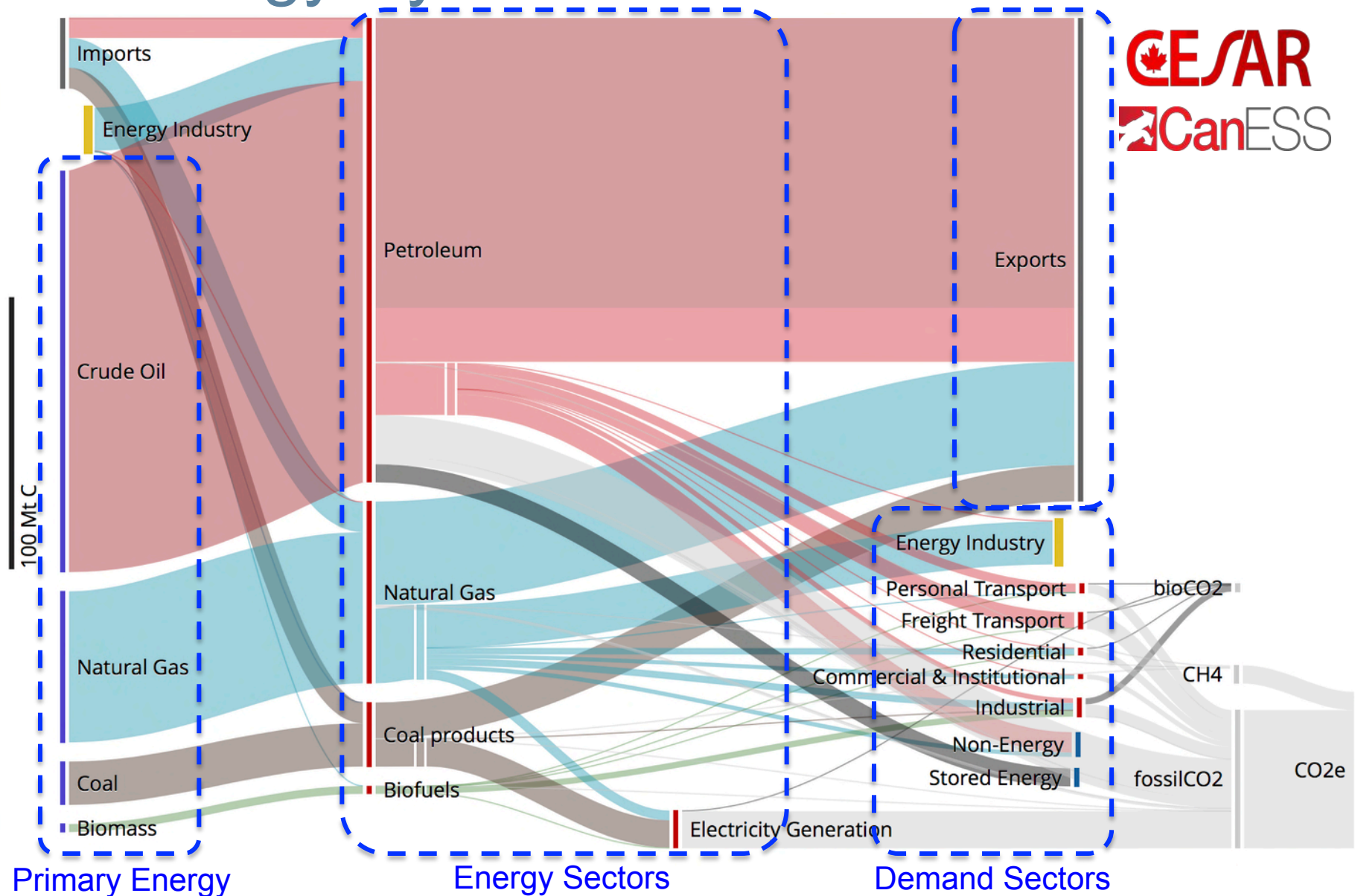
SAGD Cogeneration: Towards Lower Carbon Power & Oil Sands Production

David B. Layzell, PhD, FRSC. Professor and Director,
Canadian Energy Systems Analysis Research (CESAR) Initiative,
Univ. of Calgary. Web: www.cesarnet.ca Email: dlayzell@ucalgary.ca

Canada's GHG Emissions and Future Commitments



The Flow of Carbon Through the Energy Systems of Alberta in 2013

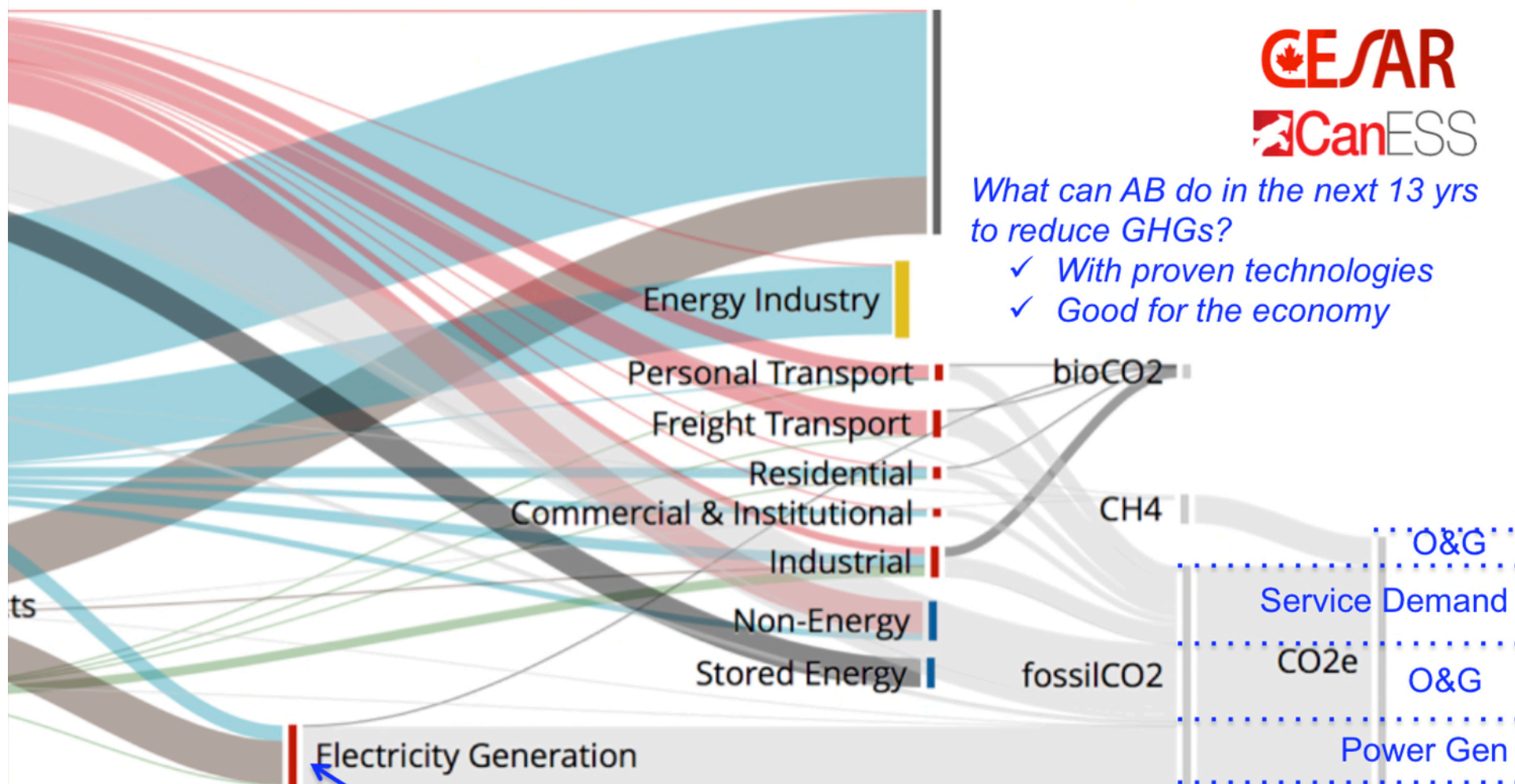


The Flow of Carbon Through the Energy Systems of Alberta in 2013



What can AB do in the next 13 yrs to reduce GHGs?

- ✓ *With proven technologies*
- ✓ *Good for the economy*

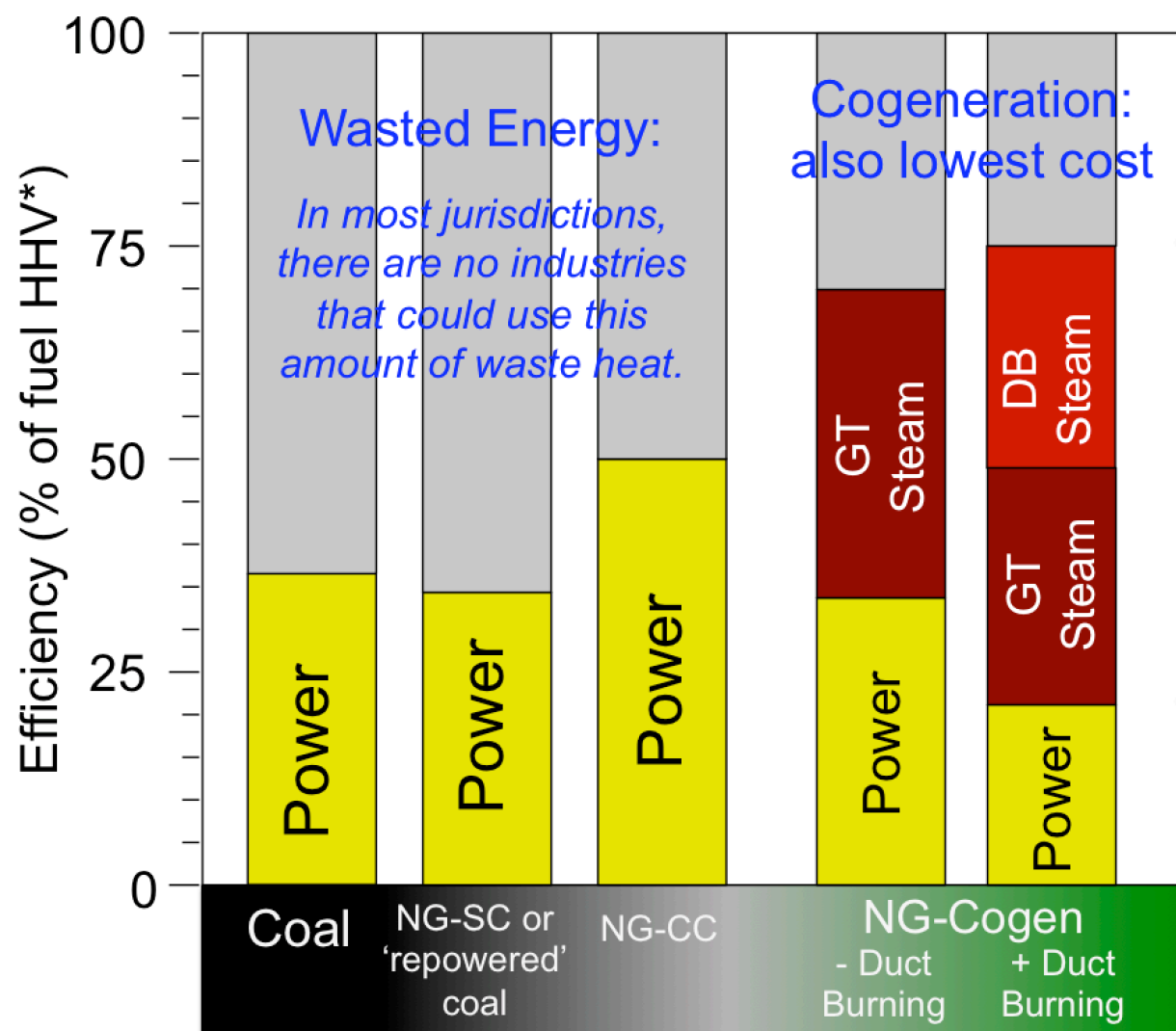


Inefficient!

(50% to 65% of fuel energy lost as heat)

By integrating Power Gen'n into O&G, can AB improve efficiency & reduce GHGs?

The Inefficiency of Thermal Power Generation

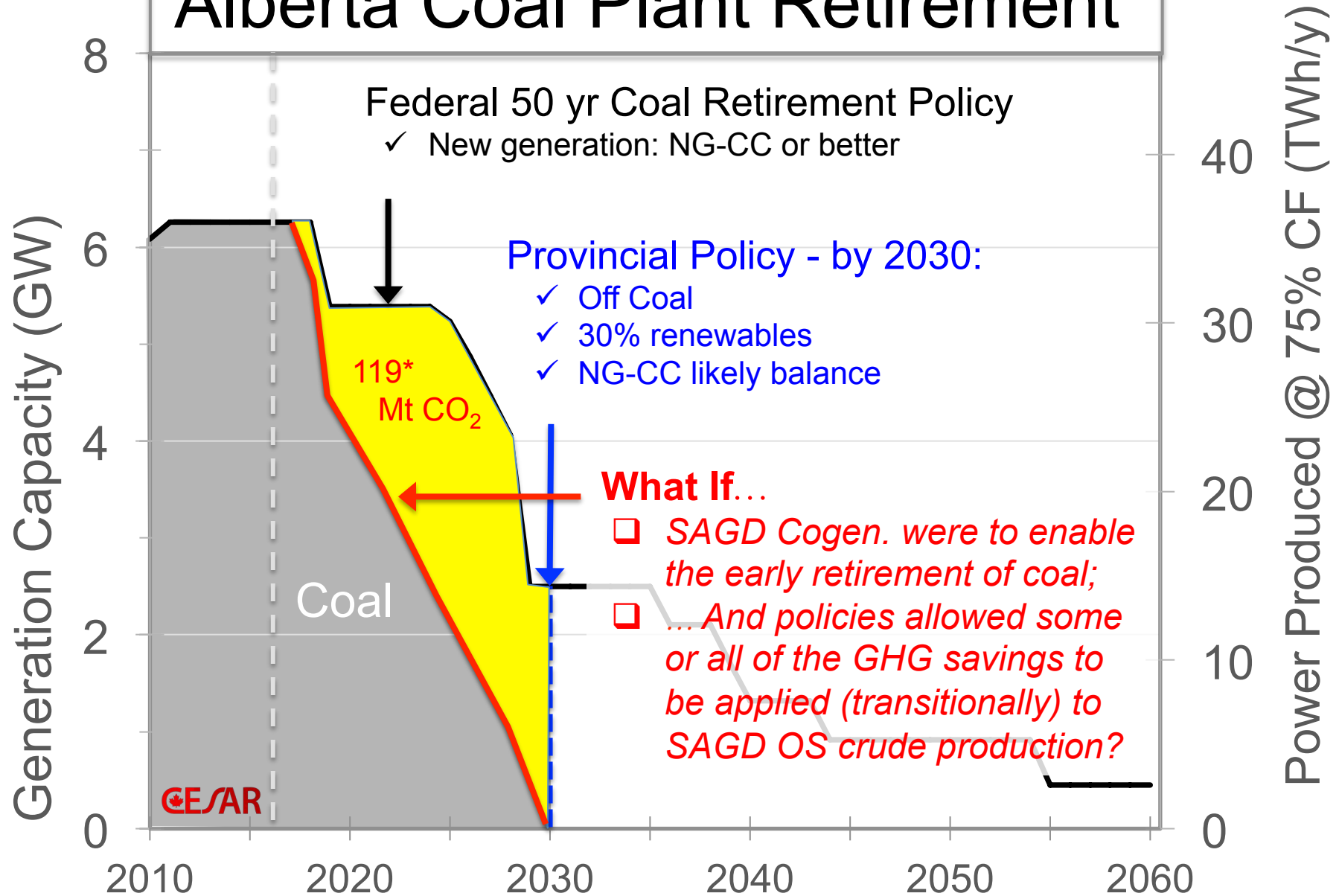


Cogeneration of heat & power can increase fuel use efficiency to 75% or more if one has an appropriate heat demand.

With Steam Assisted Gravity Drainage (SAGD), AB has the heat demand

DB, duct burning; GT, gas turbine; HHV, higher heat value; NG, Natural gas; SC, single cycle; CC, Combined cycle

Alberta Coal Plant Retirement



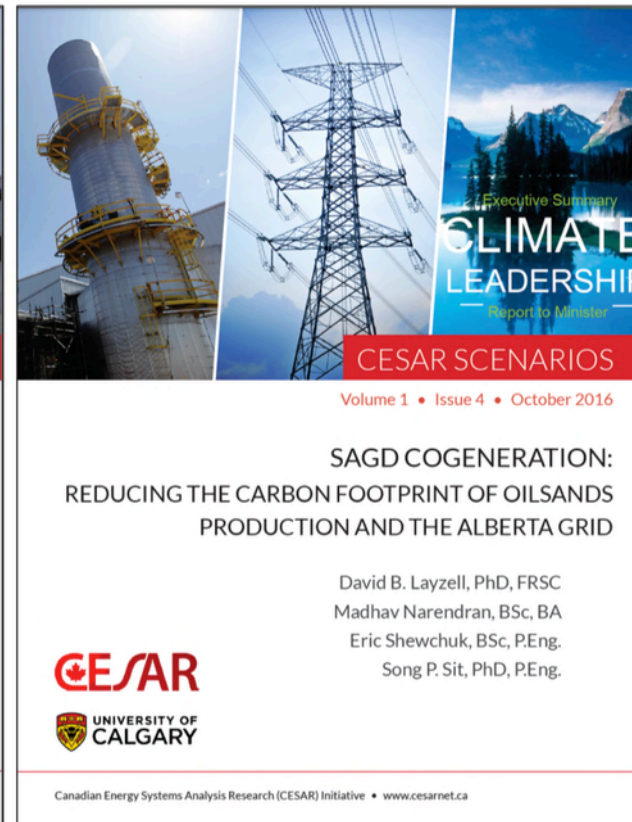
**Assumes: Coal generation (@ 1008 kg CO₂/MWh) replaced with NG-Cogen or NG-CC (@ 390 kg CO₂/MWh)*

Two Reports:



*Facility
Perspective*

- ❑ Target Audience: SAGD Operators
- ❑ Techno/economic/environmental analysis showing that a 'standard' 33,000 bpd SAGD facility could efficiently use all the heat from two 85 MW gas turbines and put over ~150 MW on the grid



*Provincial
Perspective*

- ❑ Modelled Five Energy Scenarios to 2030 for all SAGD + all Electrical Grid in Alberta
- S1: 2014 Policy
 - S2: Current Policy (~30% renewables, coal retire @2030)

}

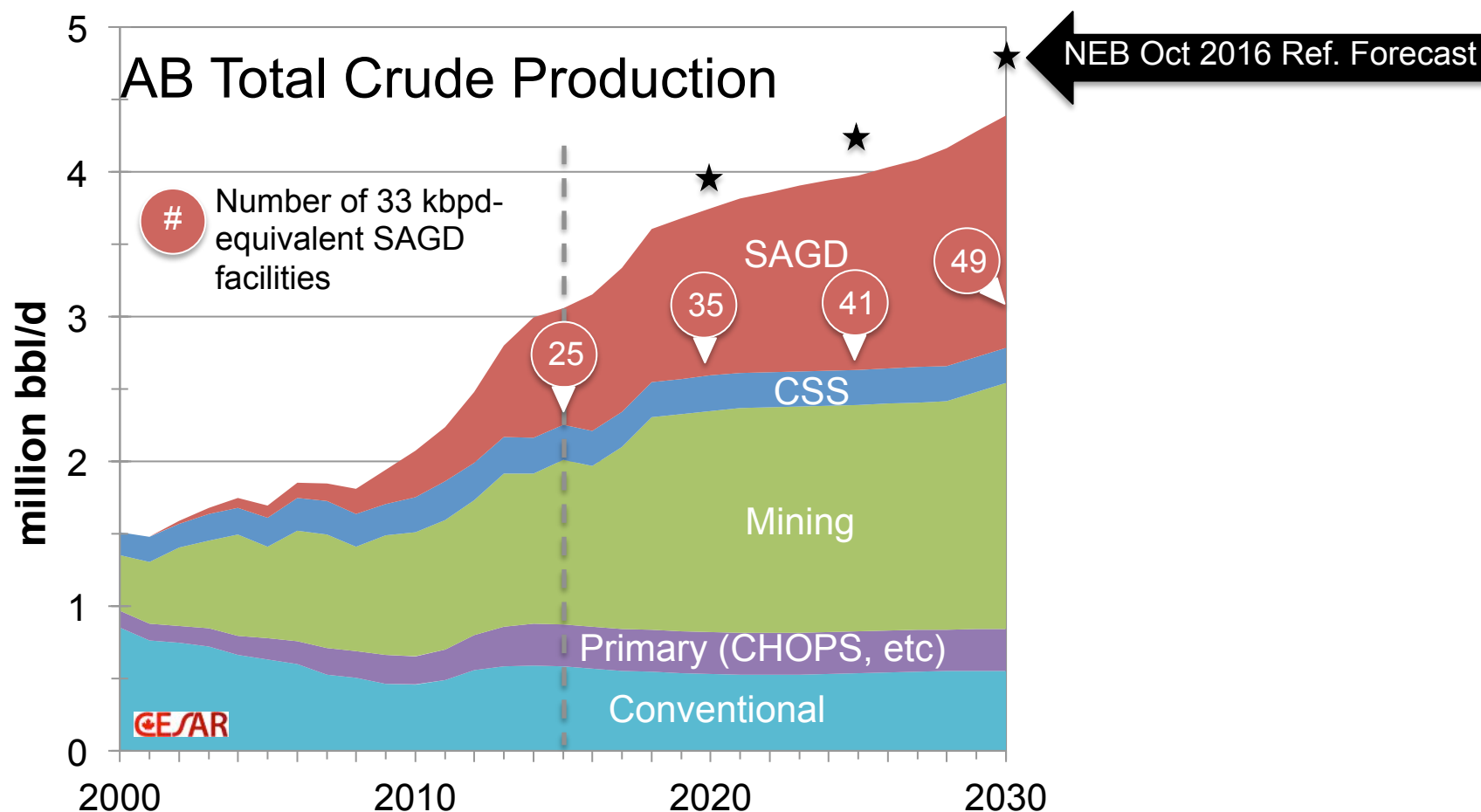
Early Coal retirement:

 - S3: w/NGCC
 - S4: w/SAGD Cogen Max
 - S5: w/SAGD Cogen Rnw

Free download
from:

www.cesarnet.ca

Oil Production Forecast





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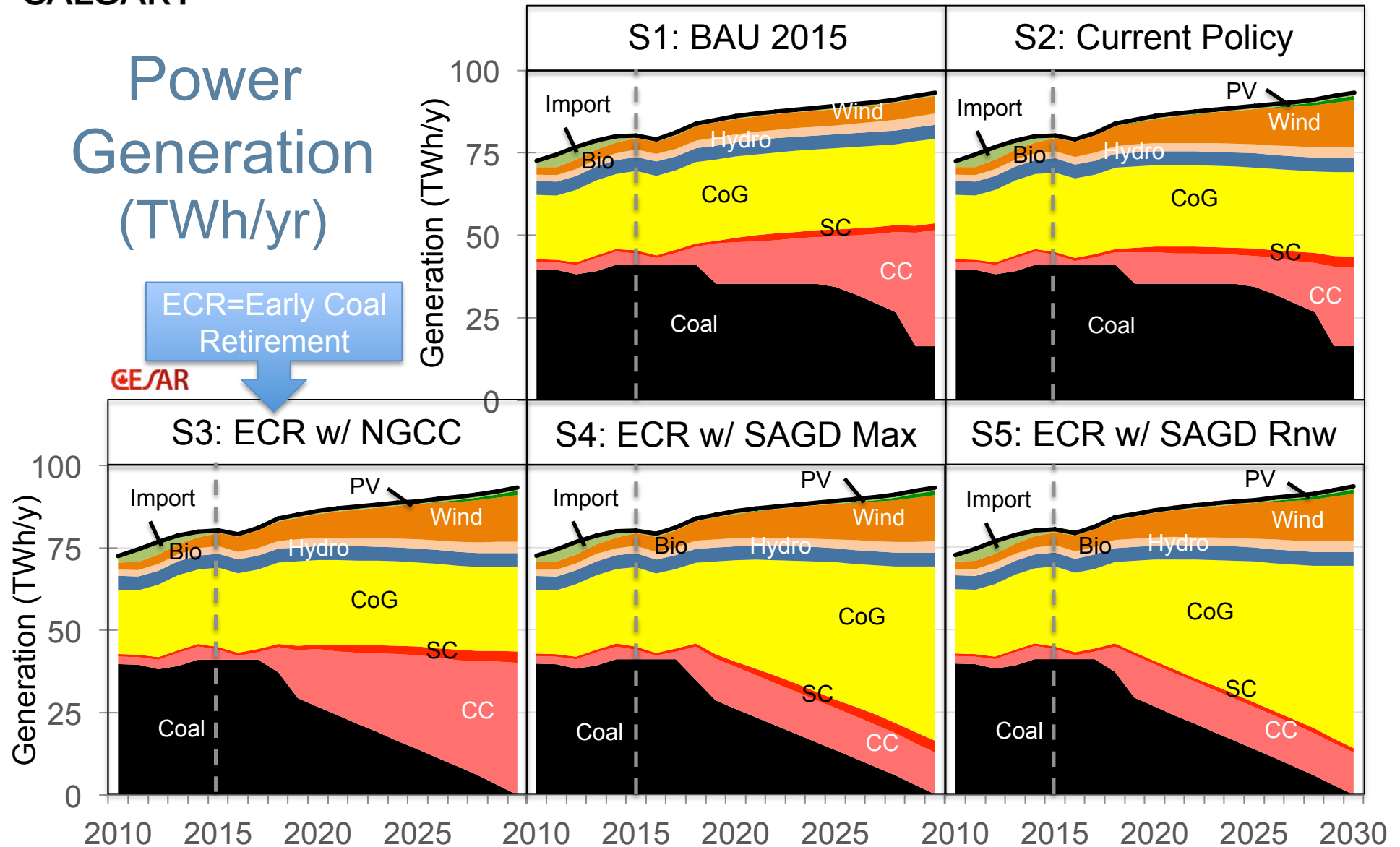
The Five Scenarios...

CE/SAR
CANADIAN
ENERGY SYSTEMS
ANALYSIS RESEARCH

Power
Generation
(TWh/yr)

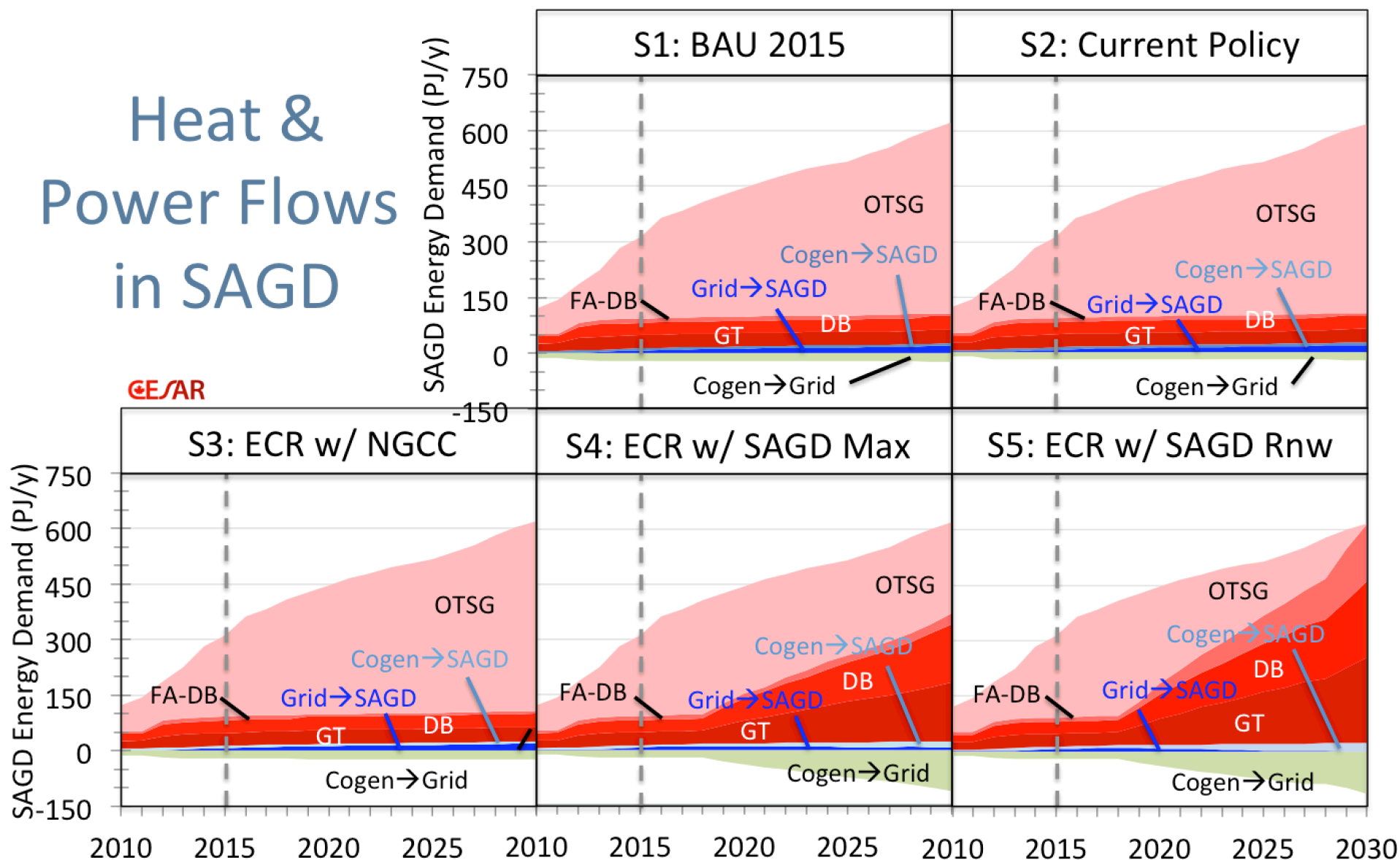
ECR=Early Coal
Retirement

CE/SAR



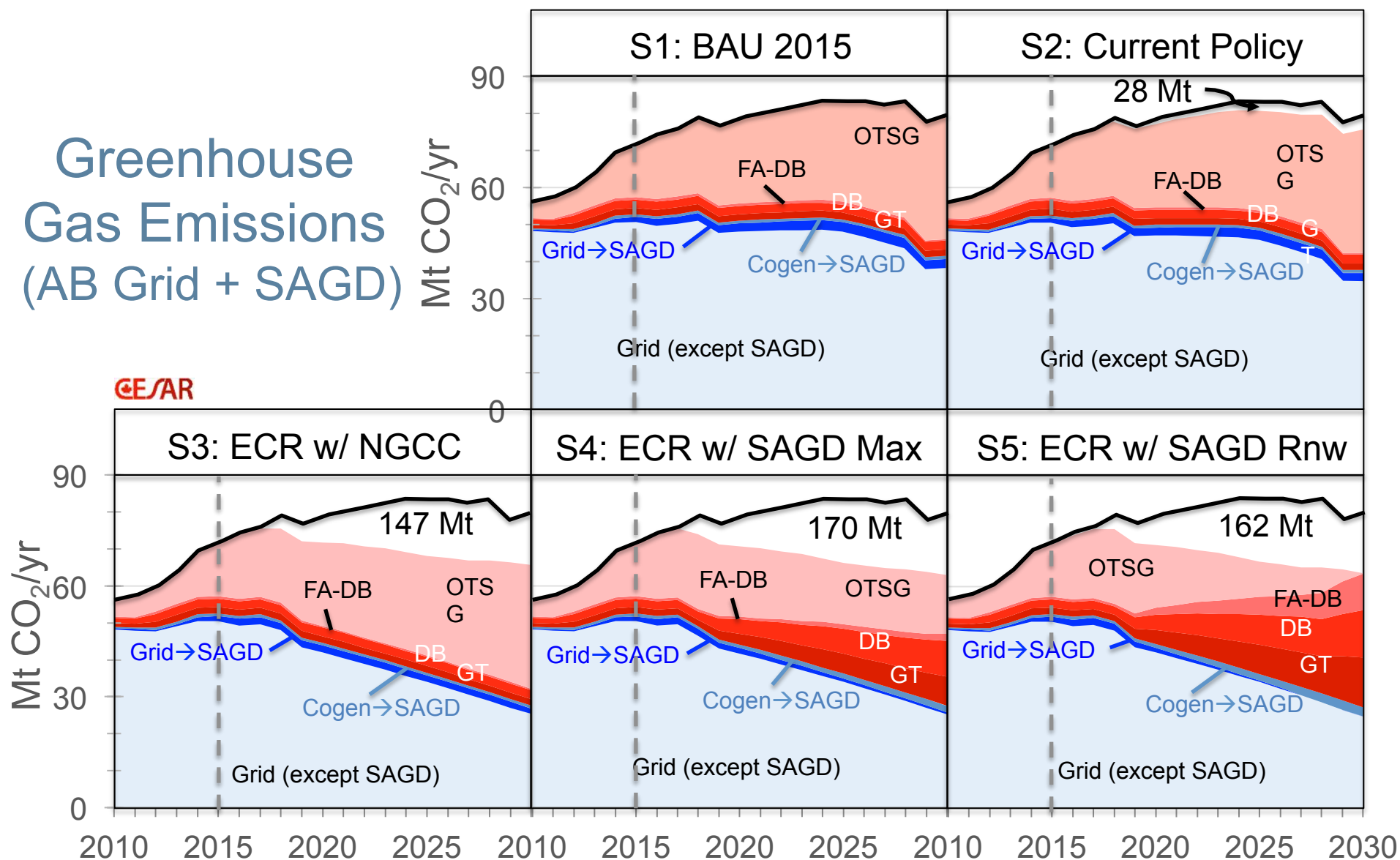
The Five Scenarios...

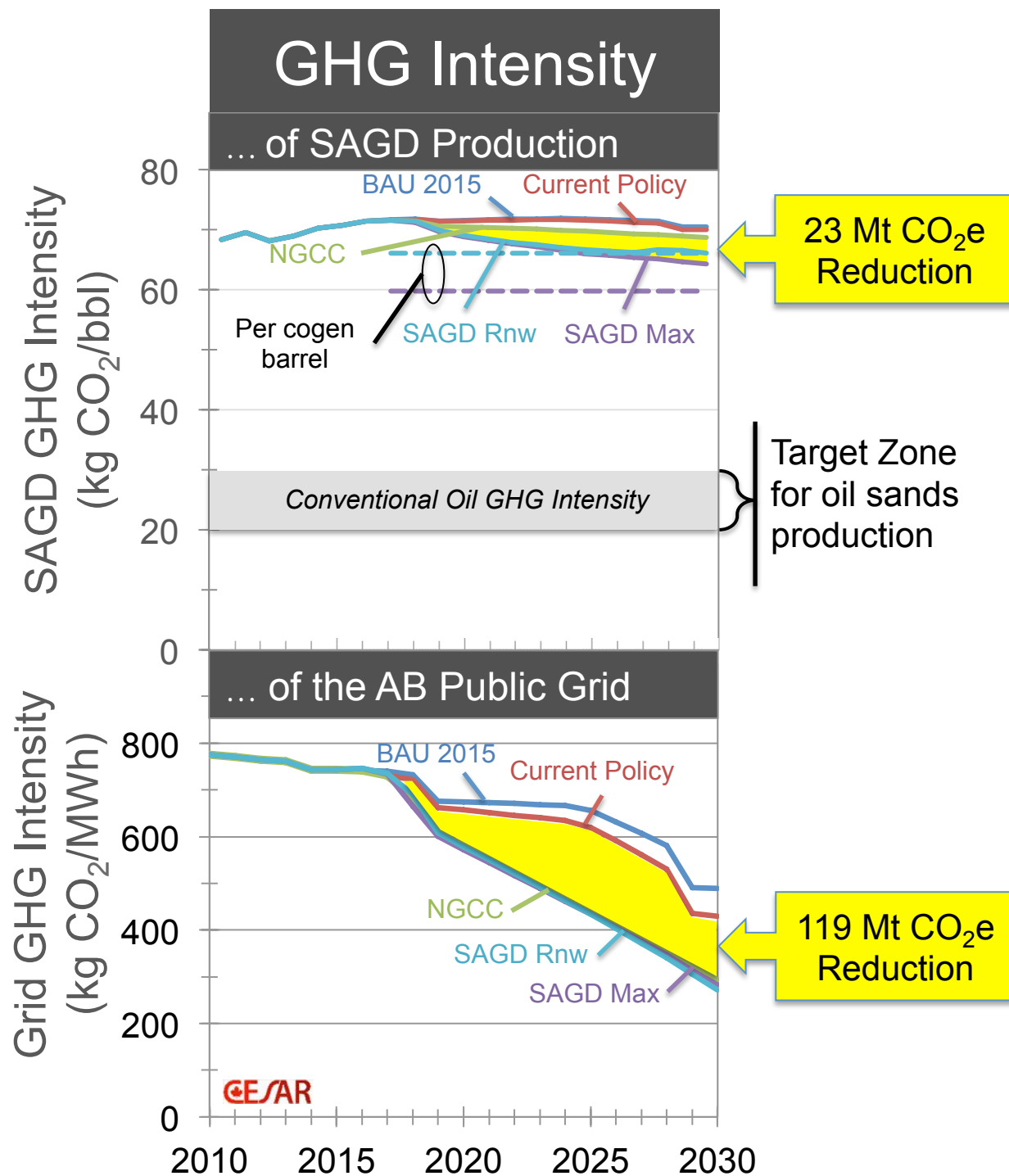
Heat & Power Flows in SAGD



The Five Scenarios...

Greenhouse Gas Emissions (AB Grid + SAGD)

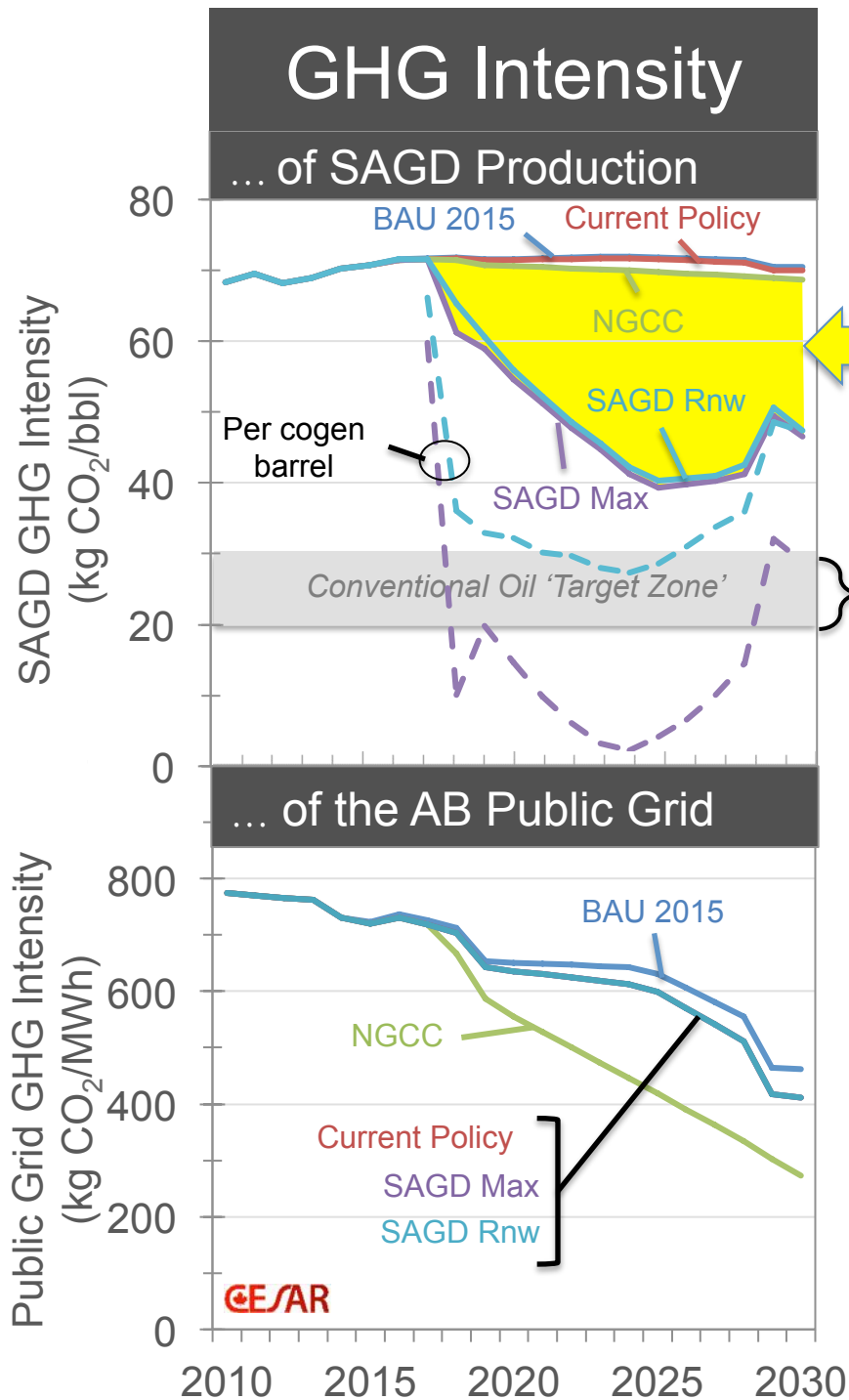




NOTE:

- The majority (84%) of the 142 Mt CO₂e GHG benefit associated with early Coal retirement by SAGD Cogen flows to the AB public Grid.

But... lower GHGs from oil sands production is more important to the AB / Cdn economy than the GHG intensity of the AB Grid.



ASSUMING TRANSITIONAL CREDIT TO SAGD FOR EARLY COAL RETIREMENT

142 Mt CO₂e
Reduction

If GHG reductions are only assigned to oil produced via heat from SAGD Cogen, SAGD GHG Intensity could be equivalent to / lower than conventional oil.

Benefits:

- ❑ 142 MtCO₂e additional GHG reductions by 2030 (+ more after 2030);
- ❑ 'Buy time' for oil sands producers to develop and implement more GHG- friendly recovery technologies
- ❑ Show that oil sands can be part of the Solution to Climate Change;
- ❑ Enhanced public support

Recommendations

Recognize Alberta as a province dominated by industries with large thermal loads, so in the transition off coal:

- ☐ *Don't settle for NG-CC (or repowered coal plants!) that throws away 50% (or 65%) of fuel energy as waste heat;*
- ☐ *Require all new base load power generation capacity to be at least ~68% efficient (% of HHV);*
- ☐ *Allow companies that achieve EARLY Coal retirement to assign 'beyond regulation' GHG credits to their prod'n.*

Take Home Messages

- 1. Thermal power generation is inefficient.**
 - *50% to 70% of fuel energy discarded since waste heat is too large to be used;*
 - *Primarily in the Oil Sand's SAGD industry;*
- 2. Alberta could use the waste heat.**
- 3. Now is the time to transform AB's power generation.**
 - *Aligns with 'off coal' & '30% renewables' policy*
- 4. By 2030, 142+ Mt CO₂e GHG reductions that could make SAGD oil = conventional**
 - *Needs appropriate policies*

Thank you

Collaborators:

Eric Shewchuk (Electrical Engineer)
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Madhav Narendran (Electrical Engineering & Economics)
& Manfred Klein (Mechanical Engineer)

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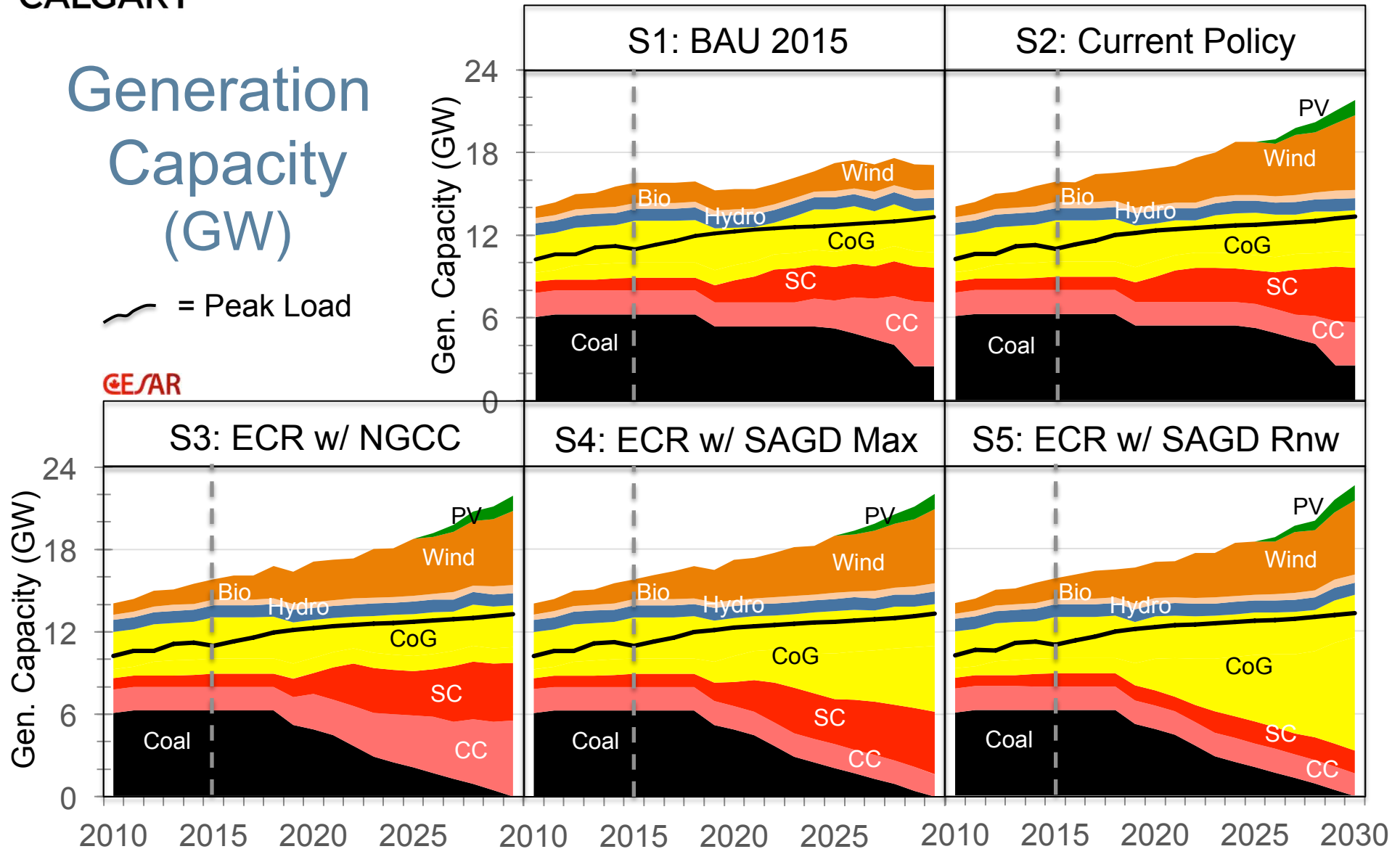
The Five Scenarios...

CESAR
CANADIAN
ENERGY SYSTEMS
ANALYSIS RESEARCH

Generation Capacity (GW)

— = Peak Load

CE/SAR



The Five Scenarios...

SAGD Electricity Production and End Use

