


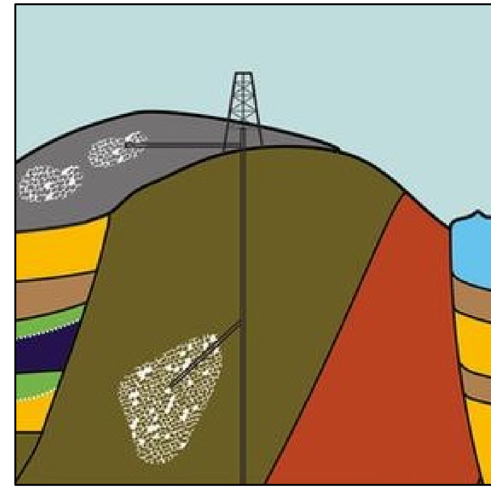

The role of Bioenergy coupled with Carbon Capture and Storage (BECCS) in Indonesia's Deep-Decarbonization Pathway

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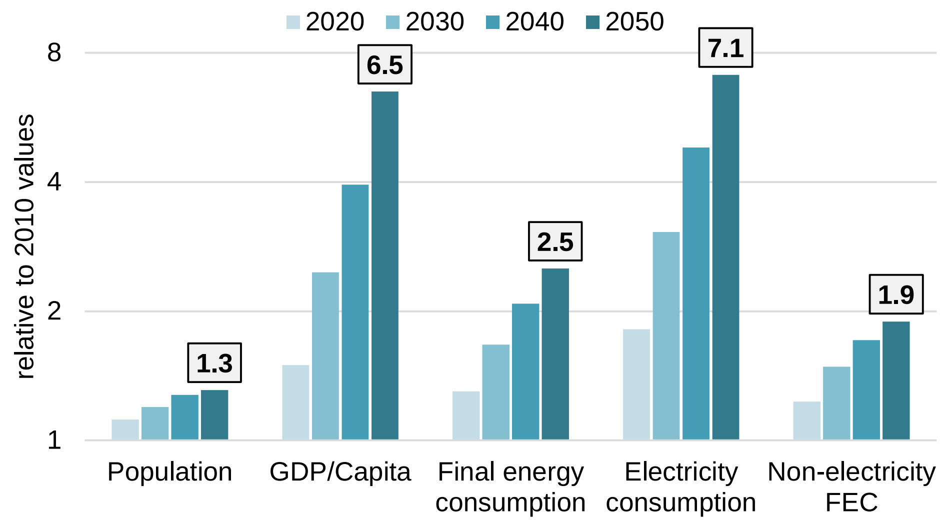
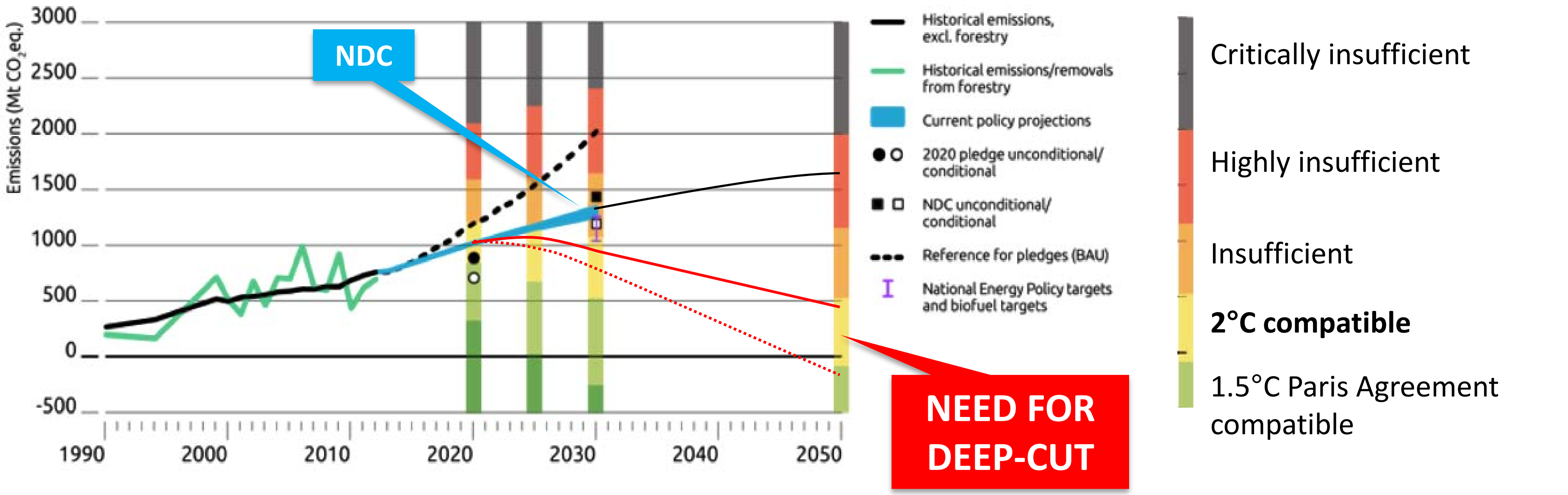
High economic growth means greater access for energy. Considering the use of baseline technologies, this could lead to a climb in future energy related emissions.

- ❑ Fast-growing economy – rapidly increasing growing and fast-changing demand for energy.
- ❑ National Energy Policy: Security & Independence.
    - ✓ Moving away from Oil, reducing Oil to 25% of total supply in 2025
    - ✓ Utilization of strategic assets (Coal and Natural Gas)
    - ✓ Energy efficiency improvements
    - ✓ New (nuclear, CBM, shale-gas) & Renewable energies.
- ❑ Distribution challenge for a nation of thousands island



Source: National Energy Policy (DEN 2014), The World Factbook (CIA 2018)



Indonesia NDC (Nationally Determine Contribution)

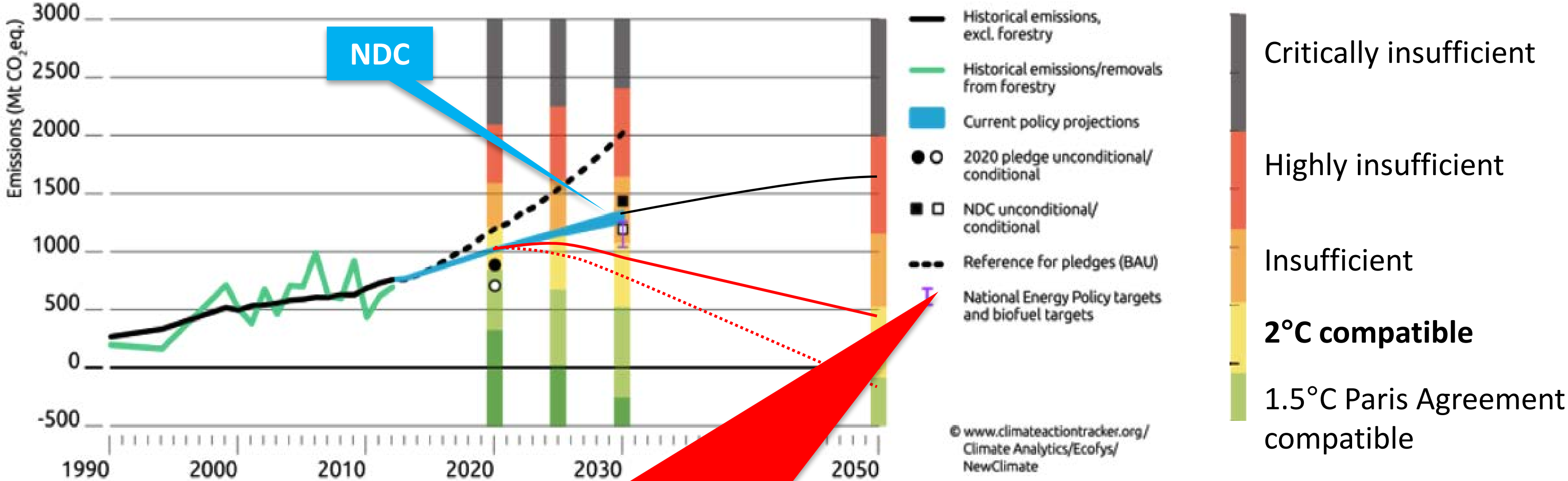
Sector	Base Year, 2010 (MTon CO2-e)	GHG Emission 2030 ($Mton\ CO_2$-e)			% reduction of BaU	
		BaU	CM1	CM2	CM1	CM2
Energy*	**453.2**	**1,669**	**1,355**	**1,271**	**11%**	**14%**
Waste	88	296	285	270	0.38%	1%
IPPU	36	69.6	66.85	66.35	0.10%	0.11%
Agriculture	110.5	119.66	110.39	115.86	0.32%	0.13%
Forestry**	647	714	217	64	17.20%	23%
Total	1,334	2,869	2,034	1,787	29%	38%

*Including fugitive; **Including peat fire; CM1 = unconditional, CM2 = conditional

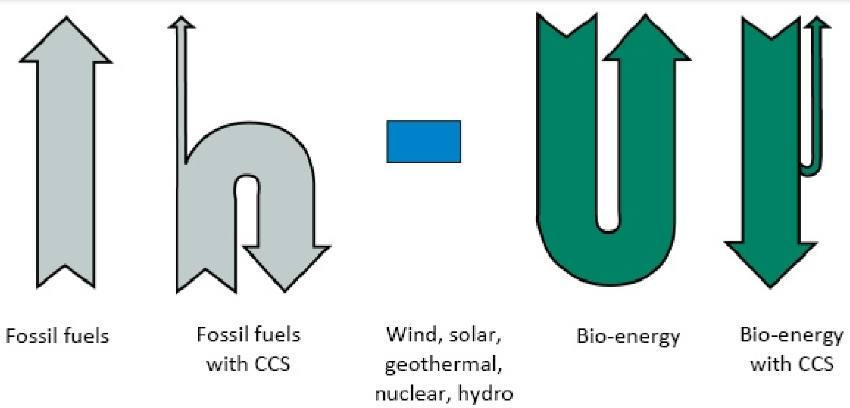
Remarks

BaU	**Development Path not deliberated the mitigation policies**
CM1	Mitigation scenario & considers sectoral development target (Unconditionally)
CM2	Ambitious mitigation scenario + additional International support available (conditionally)

Source: Climate Action Tracker (2017); Indonesia first NDC (2016)



Deep Decarbonization: Needs for Negative Emissions Technology

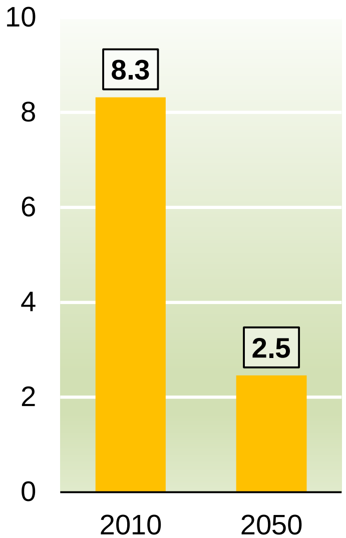


- ❑ 344/400 scenarios that have **≥50% chance of no more than 2 °C of warming, assuming large-scale negative emissions technologies in place.** (Anderson, 2015).
- ❑ 101/116 scenarios for 430-480 ppm require net-negative emissions. **Most scenarios have BECCS** providing 10-30% of the world's primary energy in 2100 (Fuss et al, 2014).

Source: Climate Action Tracker (2017), Global CCS Institute (2016)

THREE PILLARS OF DEEP DECARBONIZATION

I. Energy efficiency and conservation

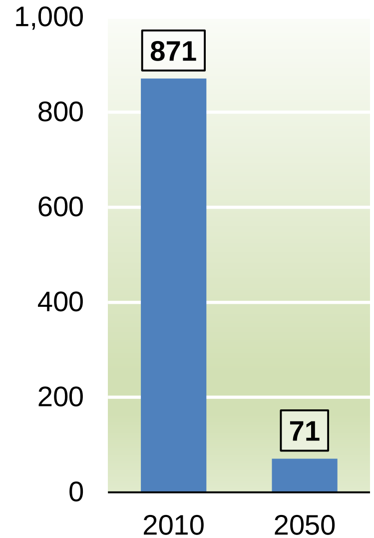


70% red.

Energy intensity of GDP (MJ/$)

- ❑ Promoting the use of energy efficient technology and energy conserve lifestyle.

II. De-carbonization of energy carriers

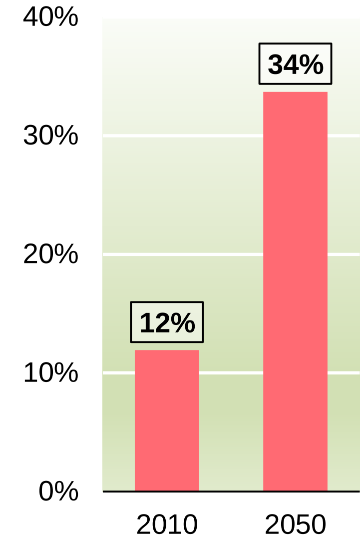


92% red.

Electricity emissions intensity (gCO_2/kWh)

- ❑ Promoting renewables
- ❑ Carbon Capture and Storage (CCS) technology
- ❑ **Bioenergy coupled with CCS (BECCS)**

III. Switch to low-/zero-emitting energies



+22 pts.

Electricity % of final energy consumption

- ❑ Substituting combustion with electricity system
- ❑ Switch to natural gas
- ❑ Biofuels in transport

Innovative strategies that integrates multiple sectors are required to mitigate climate impacts and getting around the development constraints.

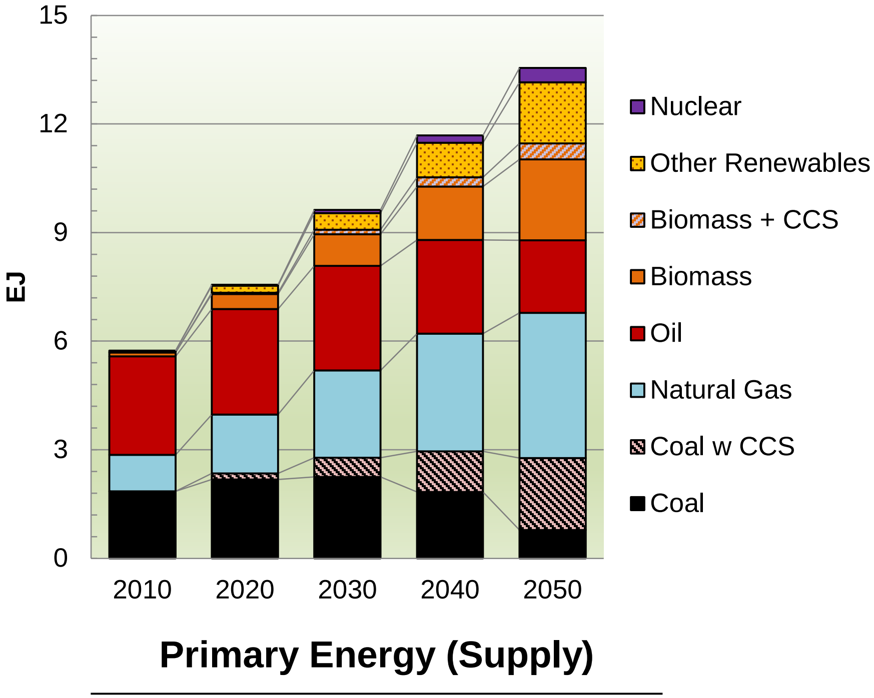
Challenges in Energy Sector Transformation

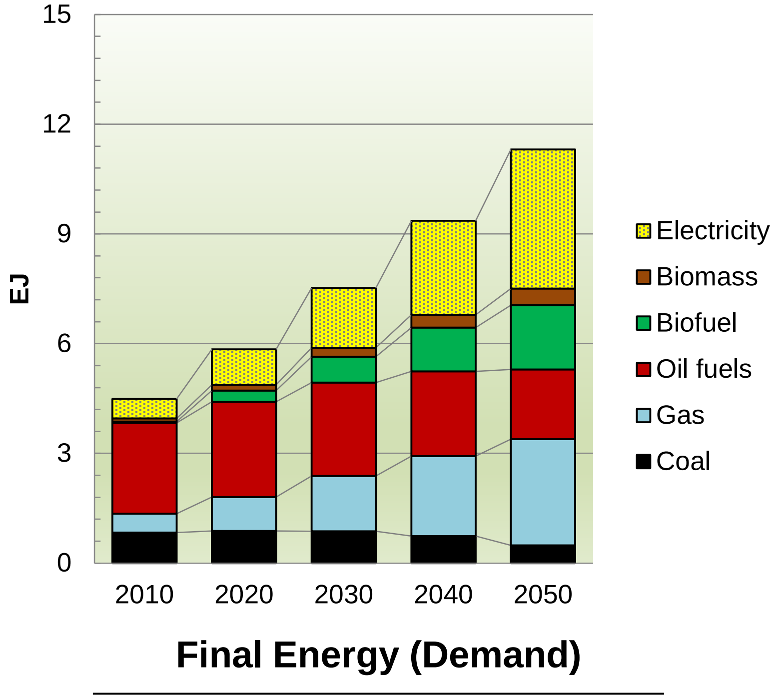
- Limited renewables deployment due to **competition with low-cost fossil fuel** and **distribution infrastructure limitation.**
- Consideration in maintaining coal-related industries; national stakeholders are not interested **in leaving strategic assets stranded.**
- **Bioenergy production target (CPO-Biofuel) induced risks of deforestation** through land competition with food crops.

Challenges in Land-Based Mitigation

- Improvement of land and forest management may require **high investments and institutional changes.**
- **Optimizing the use of unproductive land** is also one of the main challenges, particularly in addressing land tenure issues.
- Incentive system for **accelerating the development of timber plantation on degraded land.**

Capitalizing on land-based mitigation through integration with valuable bioenergy market is an option. Need to be addressed in a portfolio approach between land-based and energy sectors climate change mitigation strategies.



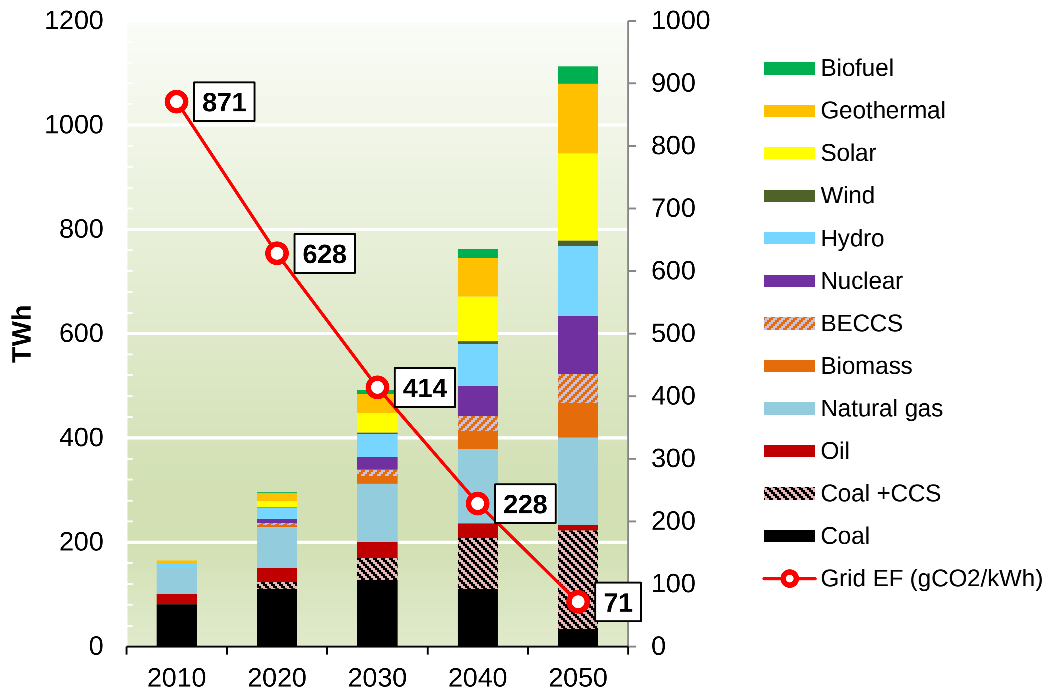


- ❑ **Reduce oil & coal share**
- ❑ **Equip most of the remaining coal plants with CCS**
- ❑ **Increase Natural Gas share**
- ❑ **Significant increase in Renewables**
- ❑ **Nuclear power**
- ❑ **BECCS**

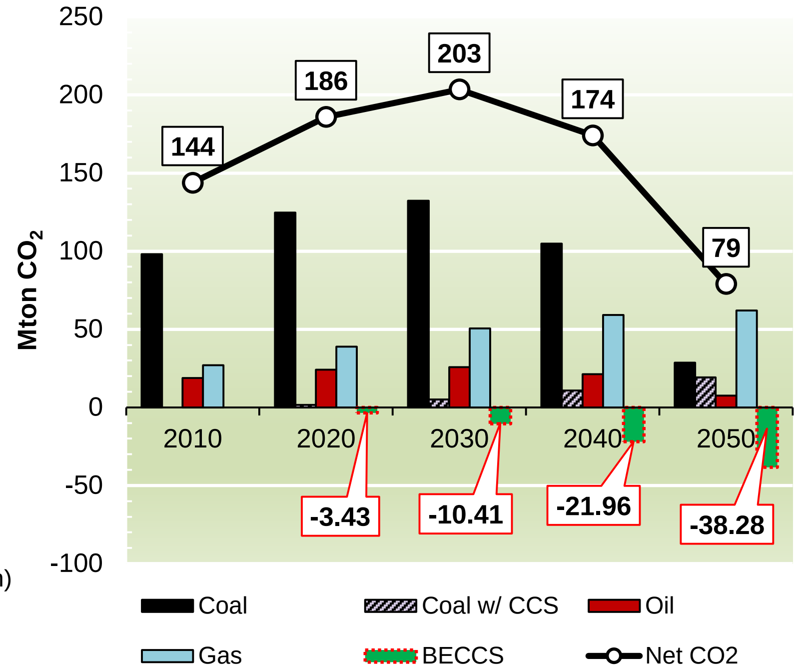
- ❑ **Energy efficiency improvement** and conservation measures
- ❑ **Low- and zero- carbon energy carriers** in intensive energy sectors (electrification of industries and biofuels in transportation)

BECCS have large potential for emissions reduction while maintaining a safe landing for conventional fossil fuels (coal).

Electricity generation and Grid EF



Power sector emission

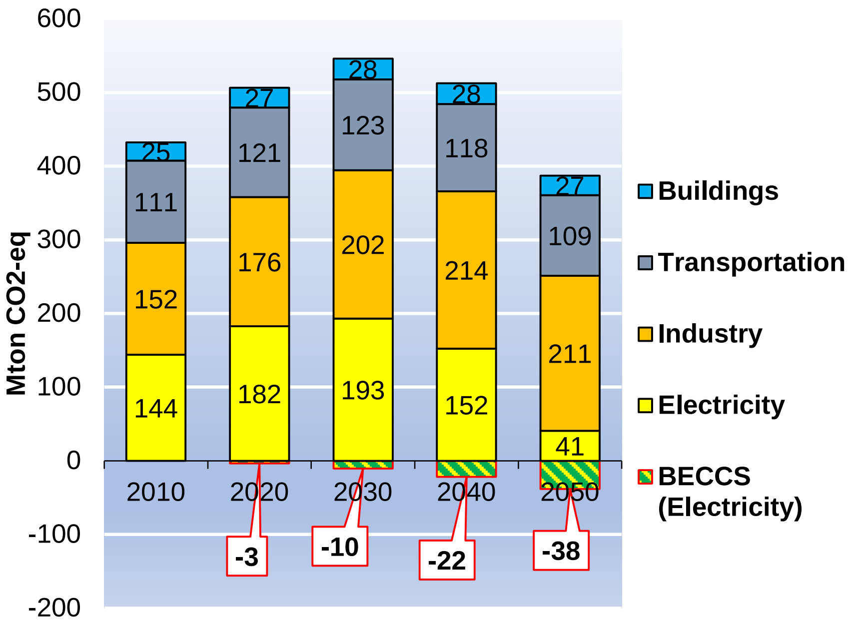


By 2050, electricity emissions factor reduced to 71 gCO_2/kWh (2010: 871 gCO2/kWh) is achievable by adding new (nuclear) and renewable (mostly Solar, Hydro, Geothermal, and Biomass) energies, and deployment of CCS and BECCS.

modified from Indonesia's DDPP Calculator Dashboard

BECCS is seen as a promising tool to deliver large quantities of negative emissions needed to comply with ambitious climate stabilization targets.

CO2 Emissions Development Scenario



By 2050, 1.14 ton CO_2/cap is compatible with world 2DS (2.2 ton CO_2/cap*) under BECCS scenario

*world average DDPP

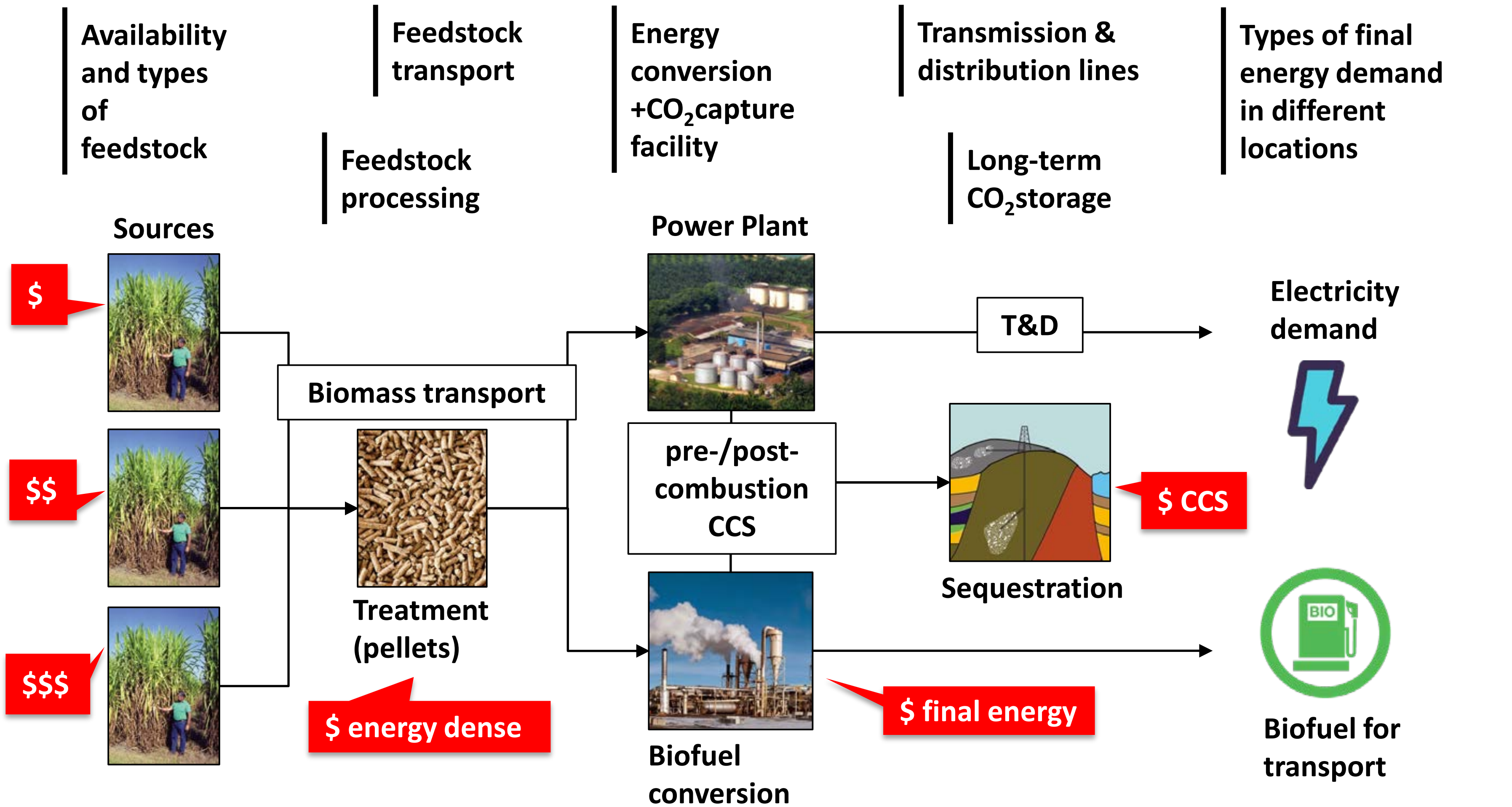
BECCS challenges:

- **Biomass availability** for a steady supply of feedstock (competition with other land-use)
- **Sustainable source** of biomass for negative emissions
- **Process and technologies** (feedstock collection & transport, energy conversion, CCS)
- **Losses of Soil Organic Carbon**
- **Implication to land-use sector** (food security, land-based climate change mitigation, etc.)
- **Financial sustainability & market readiness**
- **Social-institutional**

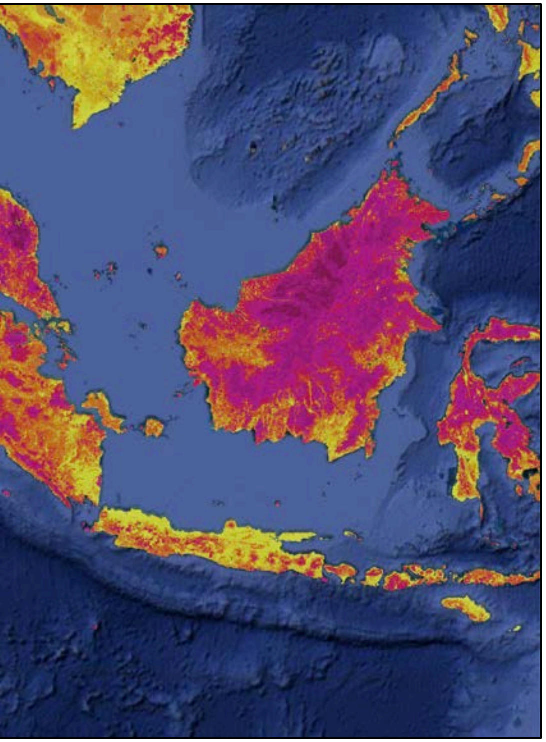
modified from Indonesia's DDPP Calculator Dashboard

How to optimally deploy BECCS system?

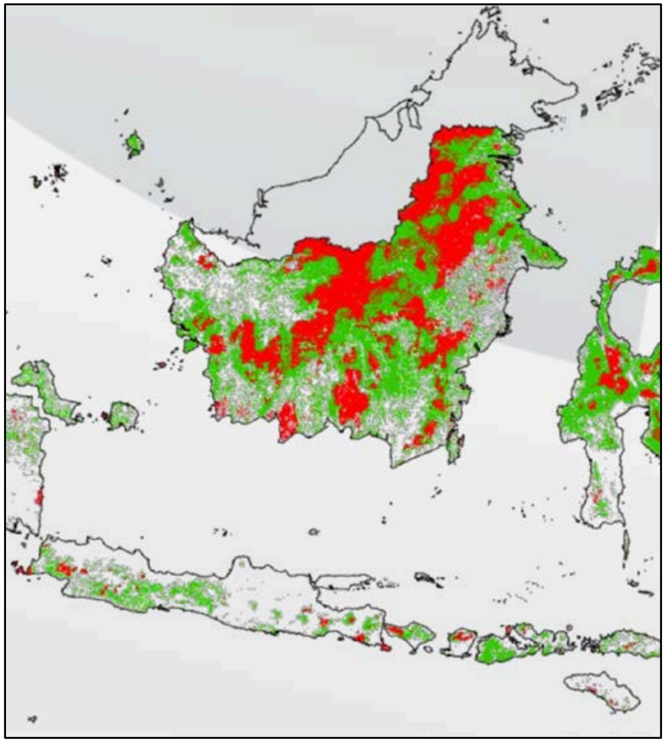
Minimizing total cost of BECCS final product (electricity or biofuel) for region welfare and minimizing cost for carbon capture and long-term storage (CCS)



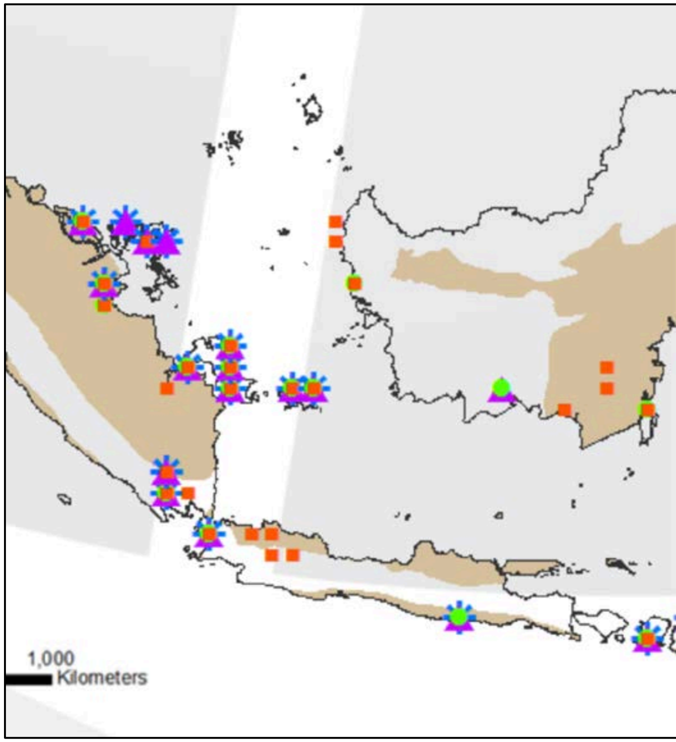
Optimal selection for source of feedstock (type and location), means of transportation, energy conversion technology, carbon capture technology, CO2 transport and storage.



Potential biomass resource map (GeoWiki IIASA) -biophysical model



Spatial data of available biomass resources for energy use under REDD+ constraints



Selected BECCS technology & location resulted from supply-chain optimization

KEY TAKE AWAYS

- Paris Agreement targets in limiting global warming to below +2˚C by the end of century (relative to pre-industrial era) requires deep-cuts of anthropogenic GHGs
- Most +2˚C scenarios requires BECCS to curb down emissions in achieving net-zero emissions and negative carbon.
- Power Generating Sector and Industries (Pulp Paper and CPO Production) are the first places to explore BECCS potential, considering the potential size & flow of capture, and fast growing electricity market.
- Sustainable feedstock supply is key for a sustainable BECCS operation. LCOE sensitive to price of feedstock (including the transport).
- Spatial-explicit energy-economic model is required to optimize the energy system with least-cost approach.
- The readiness of the deployment of CCS Technology in Indonesia:
  - CCS implemented as EOR is common practice in Indonesia's oil & gas production
  - CCS as a storage is new, a PILOT project in Gundhih area (Central Java INDONESIA) is developed with support from ADB (Global CCS Network), JICA, and Satreps Project, etc.
  - CCS is still expensive, i.e. to prove the field is eligible or not, it costed 1 billion USD and processing facility for CO2 separation from flue gas and injected is also still expensive
  - The GoI is preparing the regulation, standard and policy instrument to speed up the implementation of CCS as storage as well as utilization)