Negative Emissions on South East Asia: Renewable Energy Optimization with BECCS for Indonesia

Florian Kraxner
*International Institute for Applied System Analysis, Austria, kraxner@iiasa.ac.at*

P. Yowargana
*International Institute for Applied System Analysis, Austria*

P. Patrizio
*International Institute for Applied System Analysis, Austria*

S. Leduc
*International Institute for Applied System Analysis, Austria*

S. Mesfun
*International Institute for Applied System Analysis, Austria*

See next page for additional authors

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Authors
Florian Kraxner, P. Yowargana, P. Patrizio, S. Leduc, S. Mesfun, and S. Fuss

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Negative Emissions in South-East Asia: Renewable Energy Optimization with BECCS for Indonesia

Florian Kraxner
P. Yowargana, P. Patrizio, S. Leduc, S. Mesfun, G. Kindermann, S. Fuss, and many more...

Co2 Summit III: Pathways to Carbon Capture, Utilization, and Storage Deployment
22-26 May 2017, Cetraro, Calabria, Italy
MODELING BACKGROUND & THE LAND-BASED CHALLENGE
Biophysical forest model G4M

- Forest parameters from G4M
  - Provides annual harvestable wood (for sawn wood and other wood)
  - Afforestation/Deforestation (NPV)
  - Forest management (rot/spec)
  - Forest Carbon stock
    - Downscaling FAO country level information on above ground carbon in forests (FRA 2005) to 30 min grid (Kinderman et al., 2008)
  - Harvesting costs
  - Forest area change
  - Spatially explicit
Input Data Sets for the Global Forestry Model (G4M)

- NPP
- Population Density
- Land cover
- Agricultural suitability
- Forest Biomass
- Price level
- Discount rate
- Corruption
- Product use

Source: Kindermann (2010)
Forest Area Development (2000 – 2035)

Source: IIASA, G4M
THE GLOBAL AGRICULTURE MODEL
EPIC
The Biophysical Agriculture Model - EPIC

Cropland - EPIC

Processes

- Weather
- Hydrology
- Erosion
- Carbon sequestration
- Crop growth
- Crop rotations
- Fertilization
- Tillage
- Irrigation
- Drainage
- Pesticide
- Grazing
- Manure

Major outputs:

Crop yields, Environmental effects (e.g. soil carbon, )

20 crops (>75% of harvested area)

4 management systems: High input, Low input, Irrigated, Subsistence

Source: Schmid (2008)
EPIC – Management Change (conventional → minimum tillage)

- **SOC**
  - Increase SOC 0.18 t/ha/year

- **Crop Yield**
  - DM Crop Yield -0.30 t/ha, or -7.9%

*Average absolute changes of topsoil SOC (< 30 cm) from conventional to minimum tillage (10 years simulation)*

EPIC - Relative Difference in Means (2050/2100) in Wheat Yields

Source: Data: Tyndall, Afi Scenario, simulation model: EPIC
THE SITUATION IN INDONESIA
Why Indonesia?
Long term targets: how do we get there?

Energy savings from energy efficiency measures/technologies
Required scale of energy supply from RE

Source: IIASA-BCEF, 2016
THE MODELING APPROACH
BeWhere Model

- Techno-economical model, geographic explicit
- Mixed integer linear program (GAMS)
- Spatially explicit - 0.2° to 0.5° grid cell
- Static - periodic basis (fluctuation of demand over the period)
- Minimize the total cost of the whole supply chain for the region’s welfare

\[ \min \left[ \text{Cost} + \text{Emissions} \times (\text{Carbon Tax}) \right] \]

- Does not maximize the profit of a plant

Source: IIASA-BeWhere, 2016
Modeling new (RE-) power plants

Optimize location, capacity and technology of renewable power generation sites

Source: IIASA-BeWhere, 2016
BOTTOM-UP MODELING
E.G. FOREST-BASED BECCS
BECCS in Indonesia

Forest Biomass

[Map of Indonesia showing forest biomass distribution with color coding for tC per year]
Managed Forest

- Produced from G4M
- Harvest potential per year
- 10% used for biofuel production
Protected Areas
Population

[Map showing population distribution in Indonesia with cities like Medan, Padang, Palembang, Jakarta, Surabaya, Bandung, Semarang, Balikpapan, Ambon, and Manado marked.]
Transport
Pulp & Paper Mills

Indonesian pulp mills
wood demand (t/a)

- Green: 500 - 255,000
- Orange: 255,001 - 665,000
- Red: 665,001 - 2,000,000
Implication for Biomass Harvesting Intensity

Least cost

23% RE

Source: IIASA-BCEF, 2016
Being more sustainable

23% RE

Excluding primary forest

Source: IIASA-BCEF, 2016
First BECCS Results

CHP - only managed 20% increment

# plants with suitable storage access  
Captured CO2 at 80% capture efficiency

1,185 MW  
2.5 Mt CO2/yr

Resulting amounts could be substantially higher if allowing for bundling, taking into account other feedstocks (only managed forest used now) and adding other technologies (relatively low cooling demand now).
BIOMASS CO-FIRING AS A KICK-OFF OPPORTUNITY
The sizes of the coal plants have been aggregated, as many were at the same location.
Most of the plants are located close to sequestration geographical basin, just 6 minor ones are not.
50% co-firing / managed forest
### First Results on Co-Firing with Biomass

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<td>154</td>
<td>199</td>
<td>148</td>
<td>51</td>
<td>-51</td>
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</tbody>
</table>

With BE/CCS
Conclusions

• This is work in progress
• First real bottom-up methodology for Indonesia
• Better data in → more detailed/reliable results
• More technologies to be included (consistent methodology)
• More social and environmental safeguards to be considered
• Should serve as a first approximation for planning (policy making), impact assessment and investment
• Detailed on-the-ground planning by engineering companies
• Methodology can be expanded to the wider region SEA

→ more realistic potentials for sustainable biomass feedstock
POSSIBLE STEPS AHEAD
E.G. COMBINATION WITH RESTORATION
Bonn Challenge targets: 150 million hectares of deforested and degraded land by 2020, and additional 200 million hectares by 2030

“Global estimates of degraded area vary from less than 1 billion ha to over 6 billion ha, with equally wide disagreement in their spatial distribution.” (Gibbs and Salmon, 2015)

How do we assess large scale FLR potential?

Realistically ambitious and operational to ensure environmental and social benefits?
REALISTIC ESTIMATES OF LAND AVAILABILITY USING CROWDSOURCING

Cai et al., 2011
1107 mil. ha

Fritz et al., 2013
375 mil. ha

Fritz et al., 2013, Environmental Science and technology
Contact

Dr. Florian Kraxner

Deputy Director
Ecosystem Services and Management Program
International Institute for Applied Systems Analysis, IIASA
Laxenburg, Austria
kraxner@iiasa.ac.at
http://www.iiasa.ac.at