'Woods-to-Wake' Life Cycle Assessment (LCA) of NARA Bio-Jet

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Things that will be covered

- Objective and importance of LCA for the project
- Where we started
- Intermediary Environmental Assessments
  - Location and logistics analysis
  - Intermediary products
- Environmental Assessments final IPK models
  - IPK only scenario (theoretical)
  - IPK and two co-products scenario (NARA-IPK)
- Conclusion

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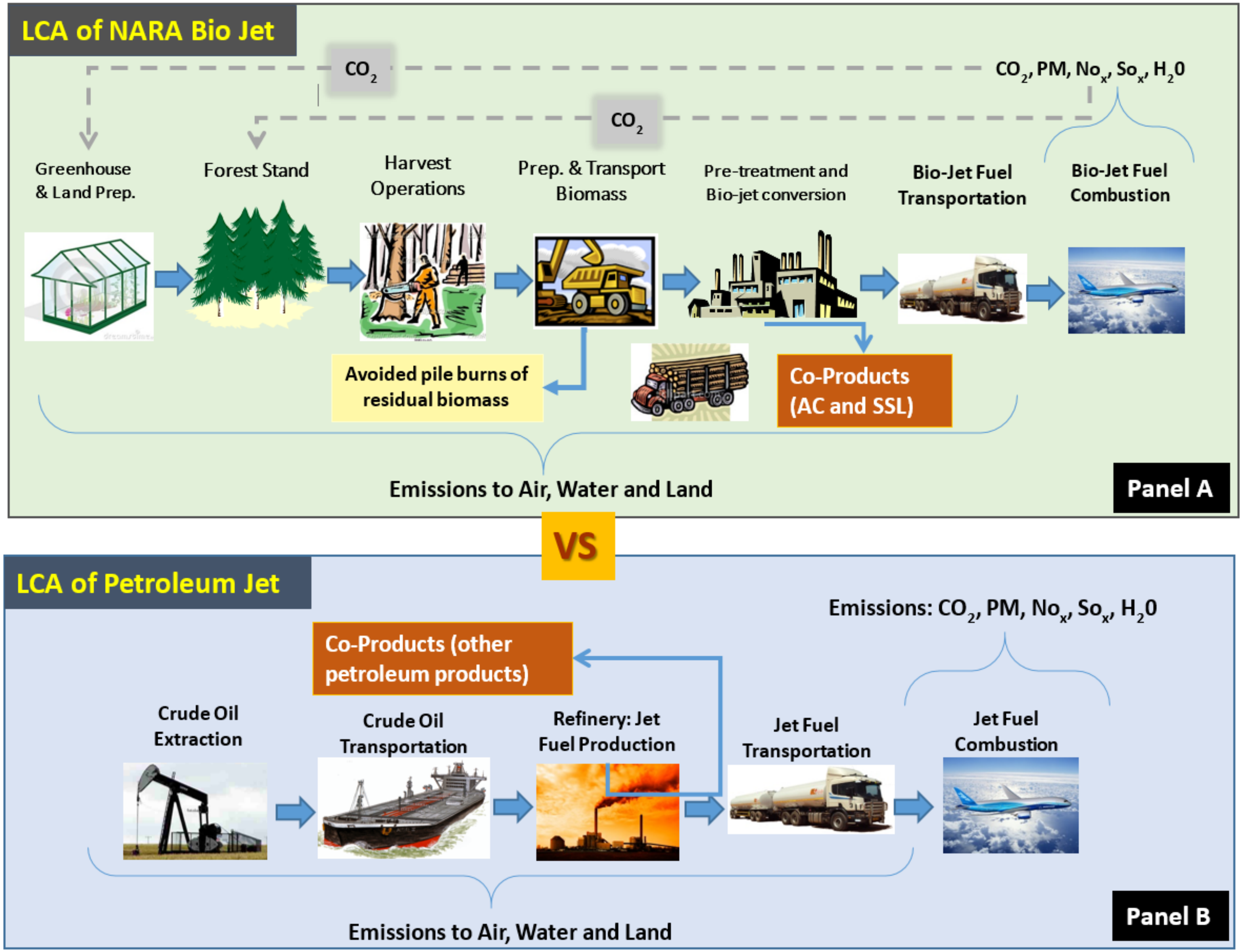
Why Conduct an LCA

- **US Energy Independence and Security Act of 2007:**
  - Public procurement (Federal agency) would require an assessment of lifecycle greenhouse gas (GHG) emissions associated with the production and combustion of biofuel
  - Must establish that the GHG emission is less than or equal to emission from the equivalent conventional fuel produced from petroleum sources.
- **Subtitle A of the Act (Renewable Fuel Standard):**
  - Fuel derived from any cellulose, hemicellulose, or lignin from renewable biomass must demonstrate 60 percent reduction in greenhouse gas emission compared to the baseline greenhouse gas emission (from fossil fuels) to be considered for government contracts.

Objective: Comparative Assessment of Petro-Jet to NARA Bio-Jet



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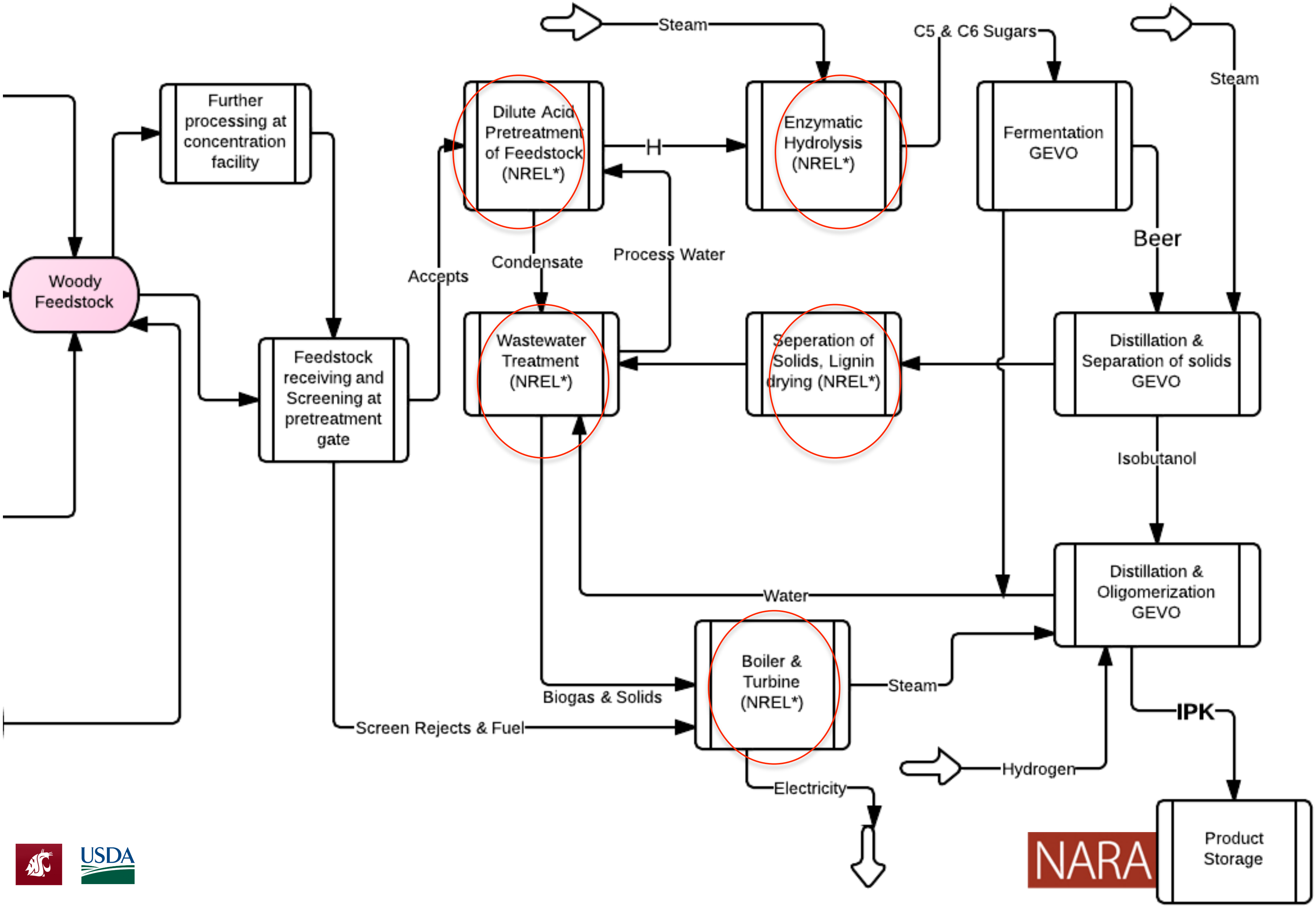
When we started with the project …

First cut: by modifying the NREL 2011 model



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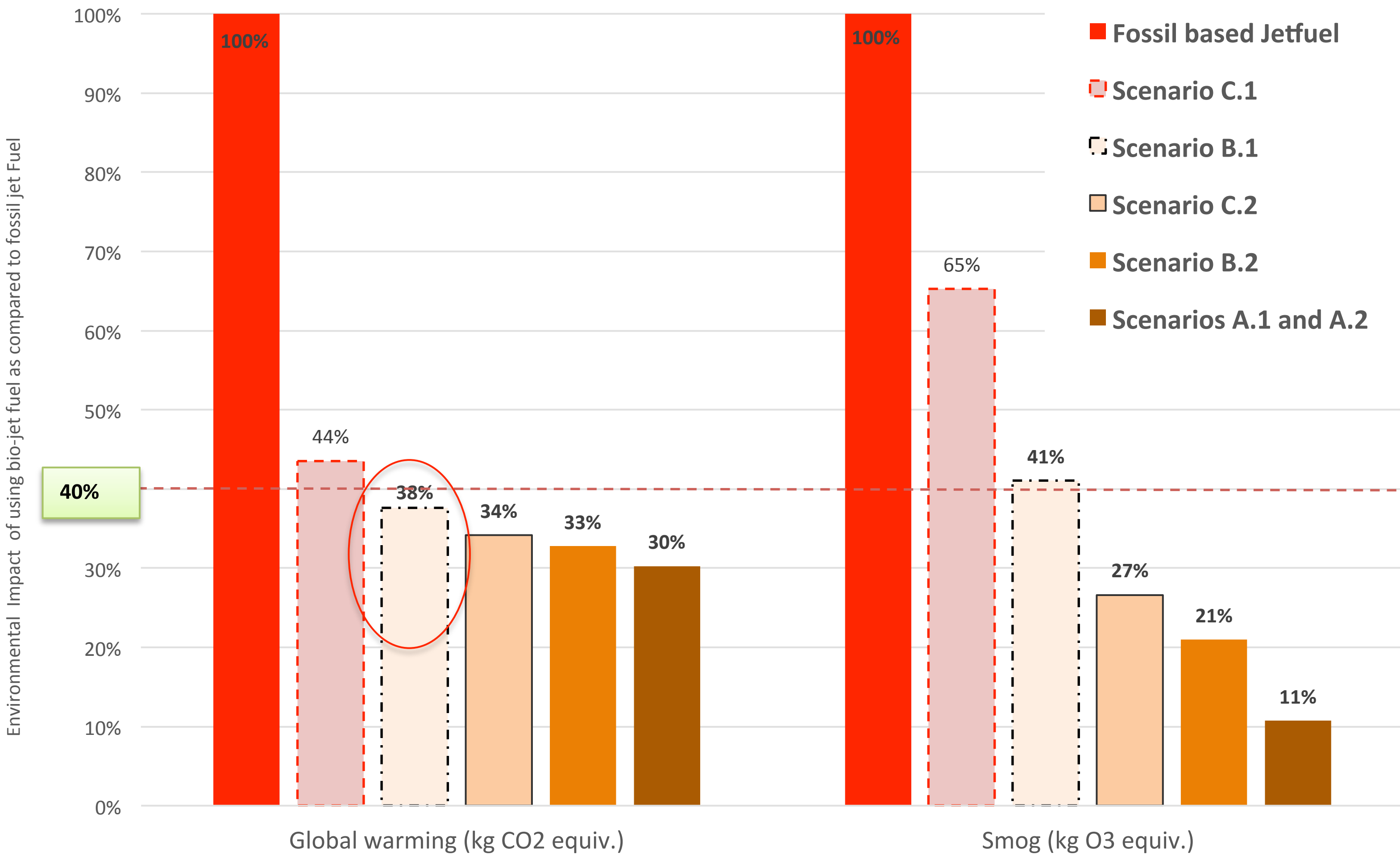
Preliminary results: modified NREL 2011 model using feedstock assumptions



- We also developed environmental assessments associated with various in-woods feedstock handling and transportation systems and published those results in academic journals and industrial publications

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Environmental Assessments Intermediary products

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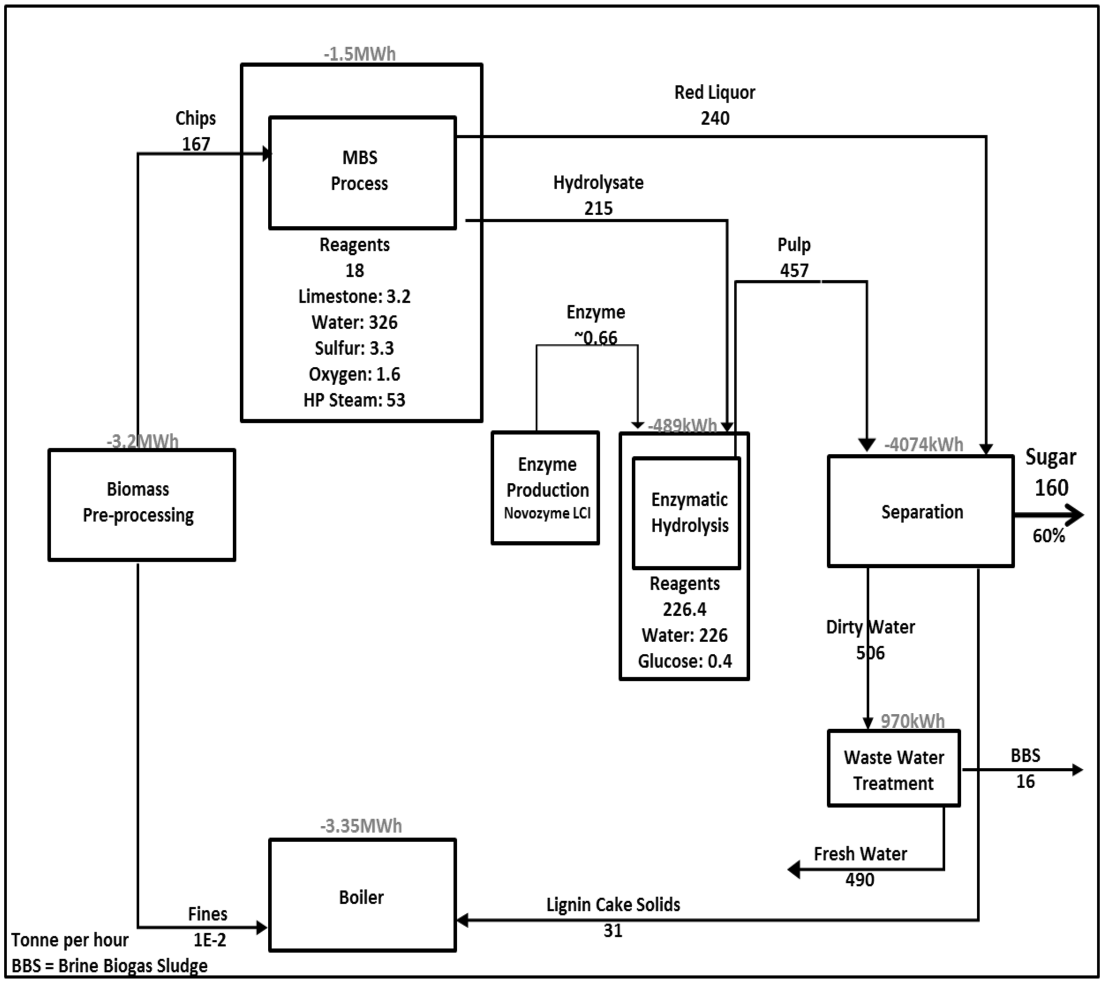
LCA of Fermentable Sugars for Biofuel Production



Nwaneshiudu et al. Biotechnol Biofuels (2016) 9:15
DOI 10.1186/s13068-016-0433-1
Biotechnology for Biofuels
RESEARCH Open Access

Environmental assessment of mild bisulfite pretreatment of forest residues into fermentable sugars for biofuel production

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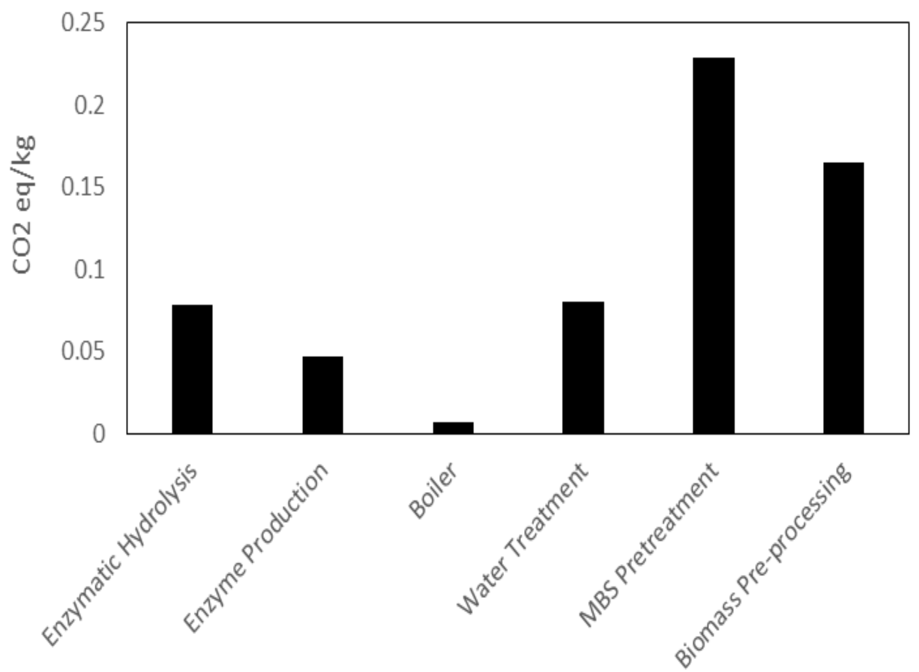
Block flow diagram of the MSB process. Negative signs on power denotes usage.

LCA of Fermentable Sugars for Biofuel Production



Process Contribution to Global Warming. Six main unit of the sugar process are shown with their corresponding GW impacts (measured in CO_2 equivalents/kg).

During life cycle of forest residual sugar, we show that the impact to global warming is within the range of other sugars made via sugar beet and sugar cane

- S. beet sugar: 0.505 kg CO2 eq
- NARA sugar: 0.353 kg CO2 eq
- S. cane sugar: 0.153 kg CO2 eq

We also show that the impacts on eutrophication were significantly low when compared to beet and cane sugars.

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Environmental Assessments final IPK models

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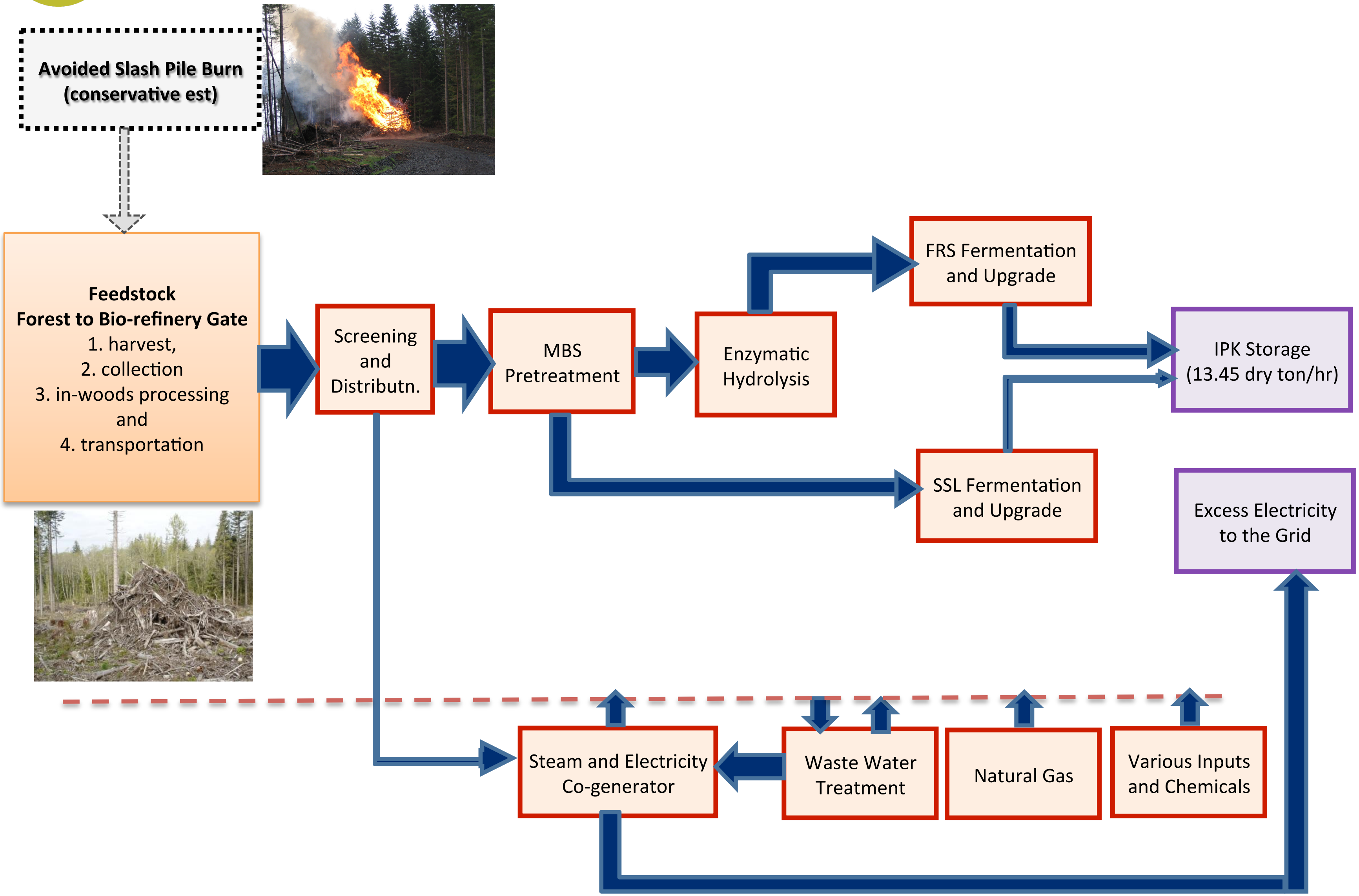
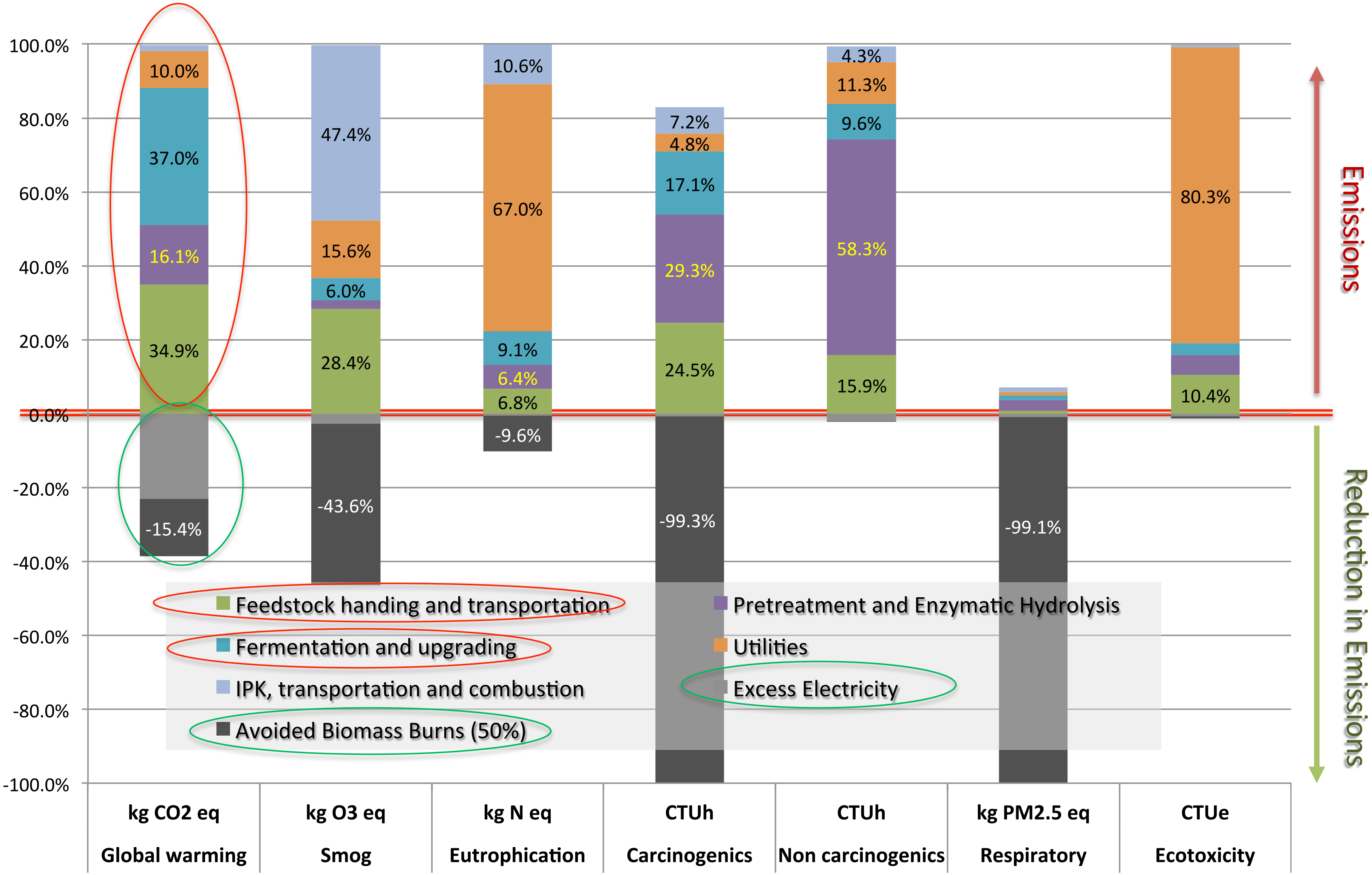
System boundary for the **IPK only scenario**



WoTW Contribution Analysis



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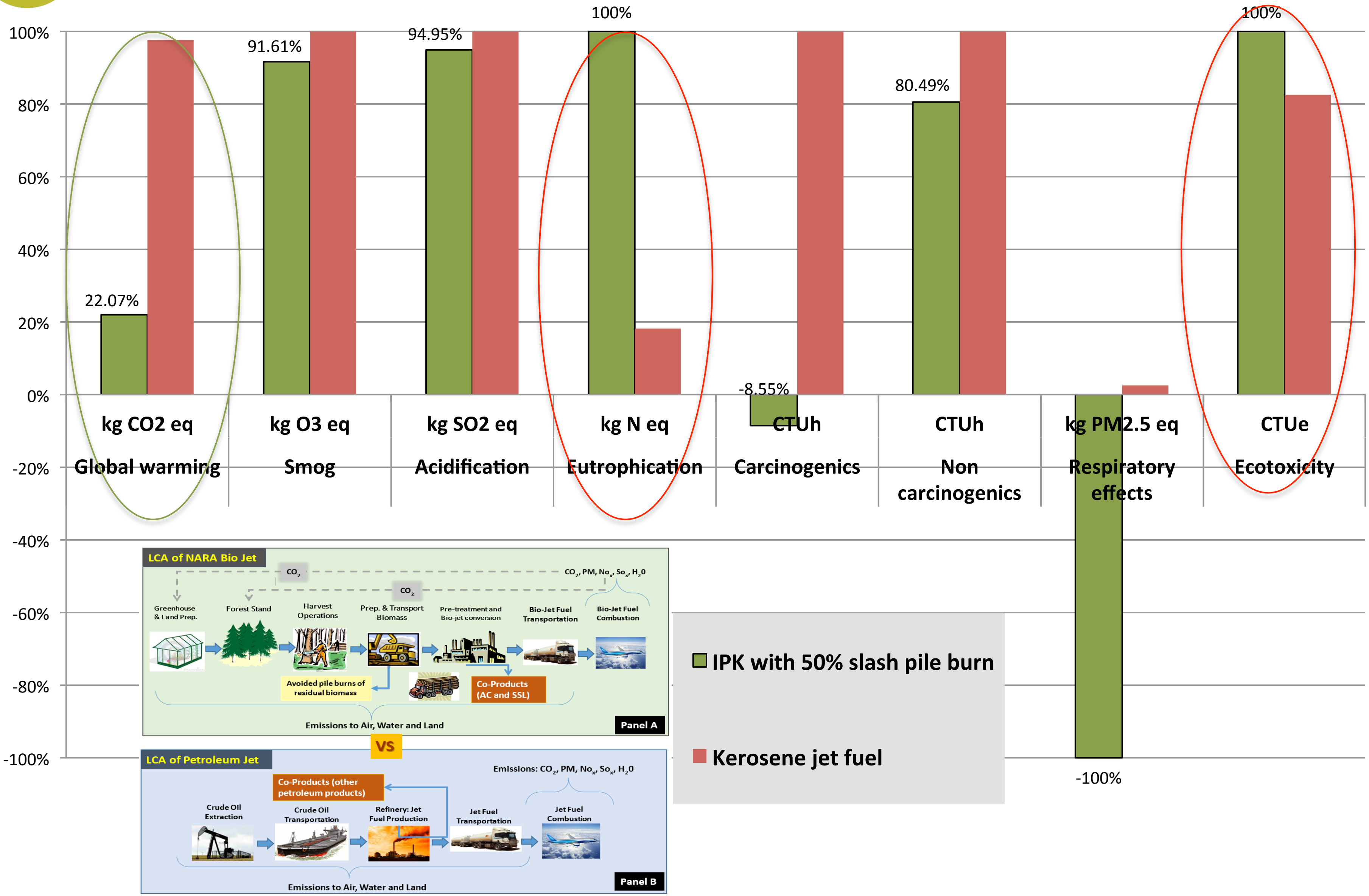
IPK only scenario: Comparative Analysis of NARA Jet vs Fossil jet



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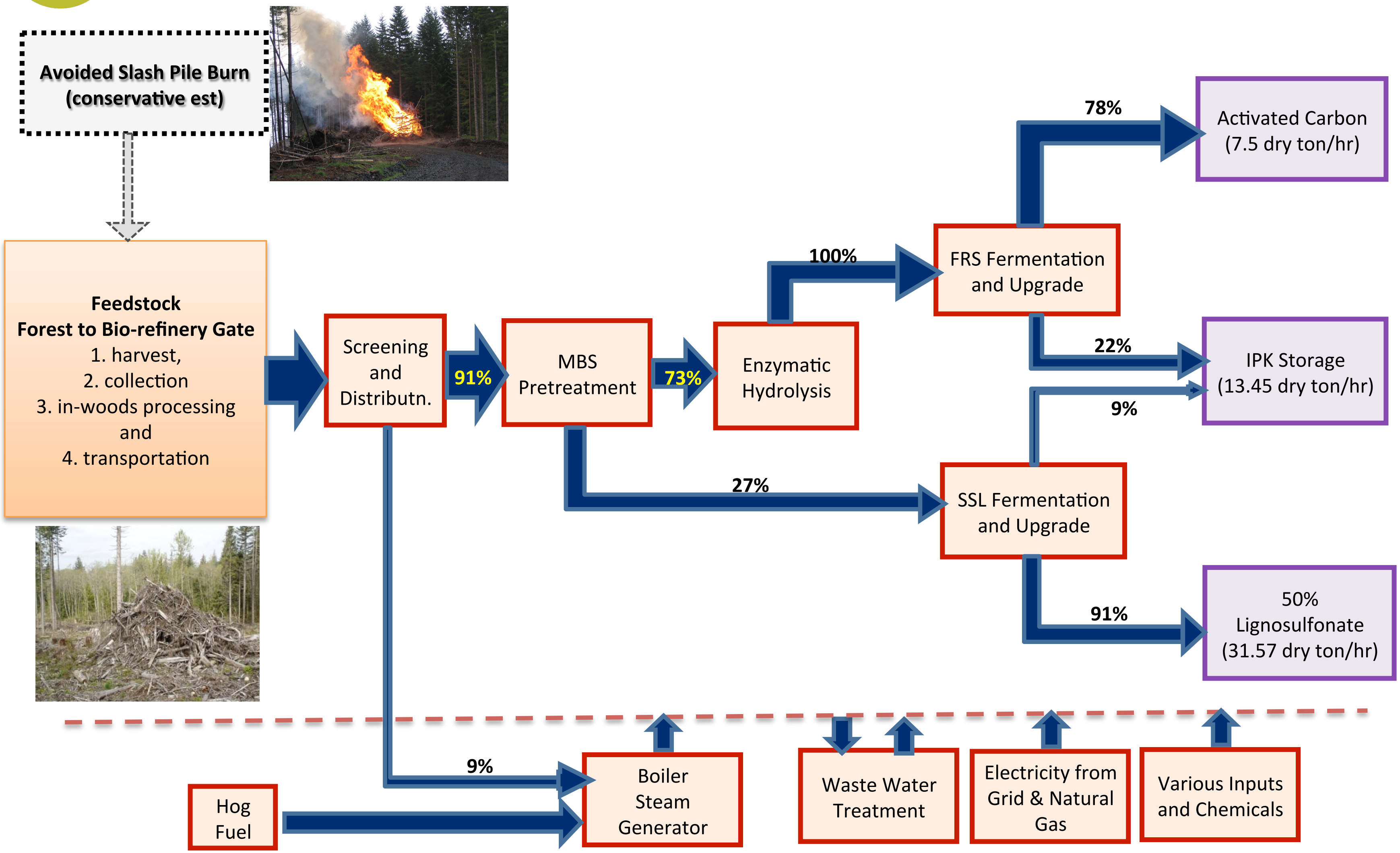
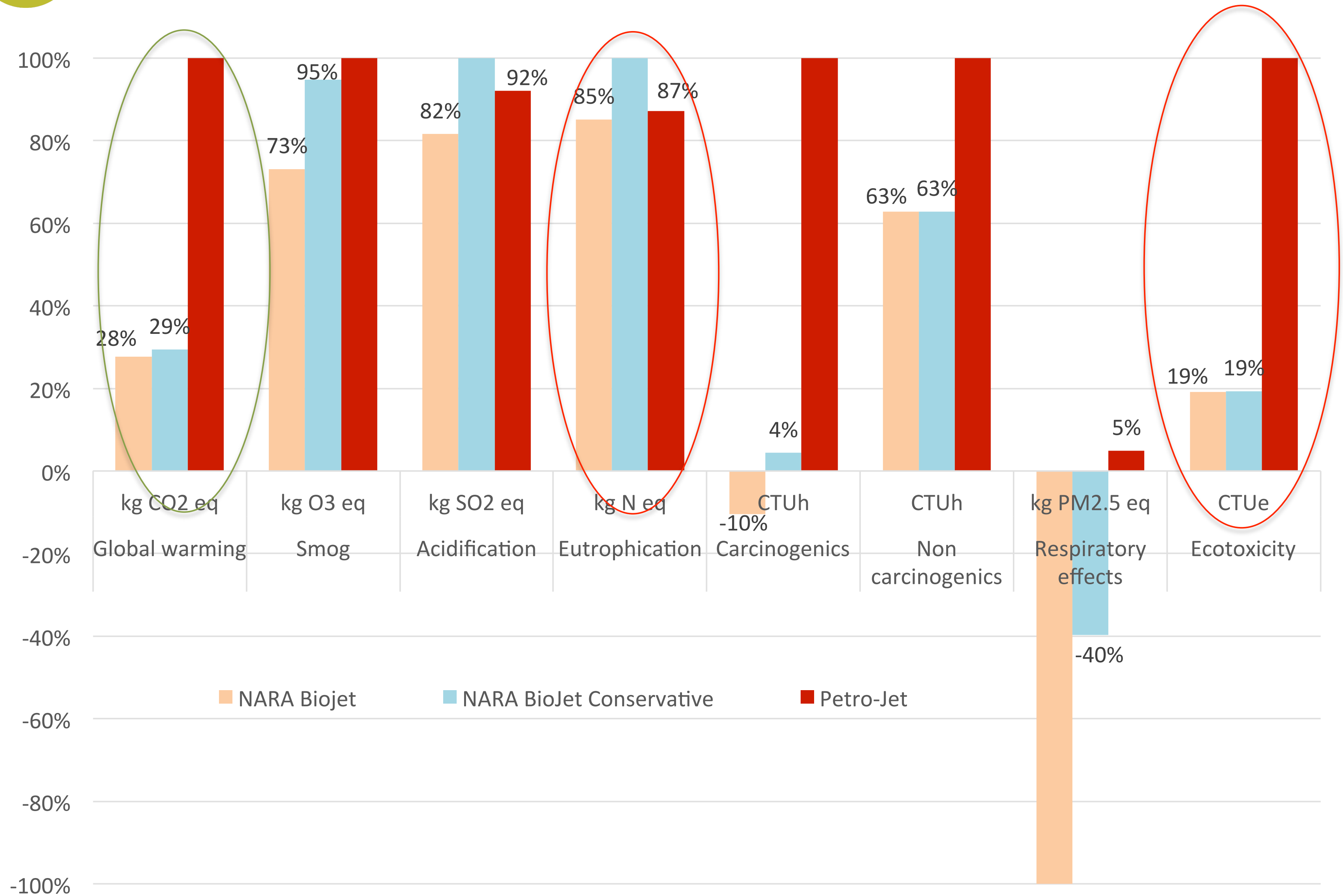
Incorporating Avoided Impact of Slash Pile Burning



Comparative environmental assessment of Jet-A vs NARA IPK



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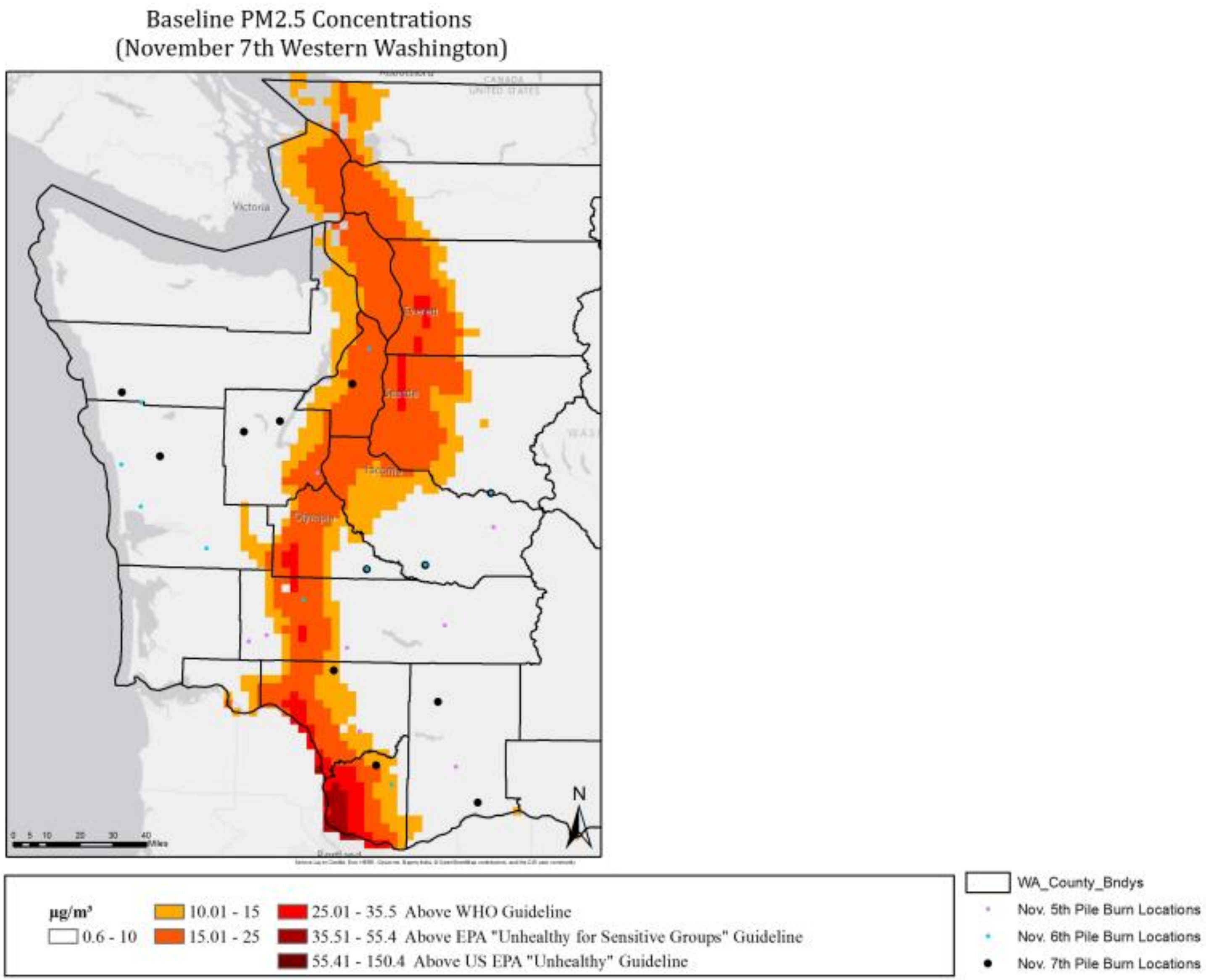
Geo-Spatial air pollution for slash burn



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Additional population impacted as a result of slash pile burns

People affected by PM2.5 greater than 25 micrograms/cubic meter (μg/m³)				
Burn Date	Burn Day	Baseline w/out burns affected people	Baseline with burns affected people	Additional people affected from the added piles burns PM2.5 >25 μg/m³
Nov. 1	305	245,028	259,650	14,622
Nov. 2	306	0	14	14
Nov. 3	307	0	21	21
Nov. 4	308	371,046	375,026	3,980
Nov. 5	309	0	5	5
Nov. 6	310	885,655	904,431	18,776
Nov. 7	311	815,933	1,093,547	277,614
Nov. 8	312	3,600	5,049	1,449
Nov. 9	313	0	10,487	10,487
Nov. 10	314	0	14,590	14,590
Nov. 11	315	283,039	284,041	1,002
Nov. 12	316	0	172	172
Nov. 13	317	0	1,646	1,646
Nov. 14	318	0	6,813	6,813
Nov. 15	319	2,588	4,308	1,720
Nov. 16	320	0	64	64
Nov. 17	321	0	0	0
Nov. 18	322	0	1,070	1,070
Nov. 19	323	28,525	40,577	12,052
Nov. 20	324	698,644	699,926	1,282
Nov. 21	325	0	2	2
Nov. 22	326	0	97	97
Nov. 23	327	0	0	0
Nov. 24	328	0	51	51
Nov. 25	329	0	0	0
Nov. 26	330	0	280	280
Nov. 27	331	0	386	386
Nov. 28	332	421,535	461,346	39,811
Nov. 29	333	1,430,332	1,460,917	30,585
29 Day total number of additional affected people from pile burns=				438,591

A NARA bio-refinery established at the proposed scale will avoid 400,000 person-days of exposure greater than WHO recommended air pollution

3 of the days during the burn period contributed ~80% of the population impact

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Concluding remarks

- The comparative analysis of petroleum and residual biomass-based jet fuel reveals 70% - 80% reduction in global warming potential (GWP)
  - This result is significantly better than the US Environmental Protection Agency mandated 60% GWP reduction.
- Important environmental benefits associated with avoided slash pile burns are
  - Improved local air and water quality
  - Beneficial local health impacts
- NARA biojet fuel results in substantial reduction in the 'carcinogenics', 'non carcinogenics', 'smog' and 'ecotoxicity' impacts.

The positive local environmental benefits make residual woody biomass a much more environmentally appealing feedstock for bio-energy production than fossil fuel-based alternatives.

Thank you

Acknowledgement

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