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Innovation Technology Outlook of Advanced Biofuels

production and deployment in the next three decades

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IITC-IRENA
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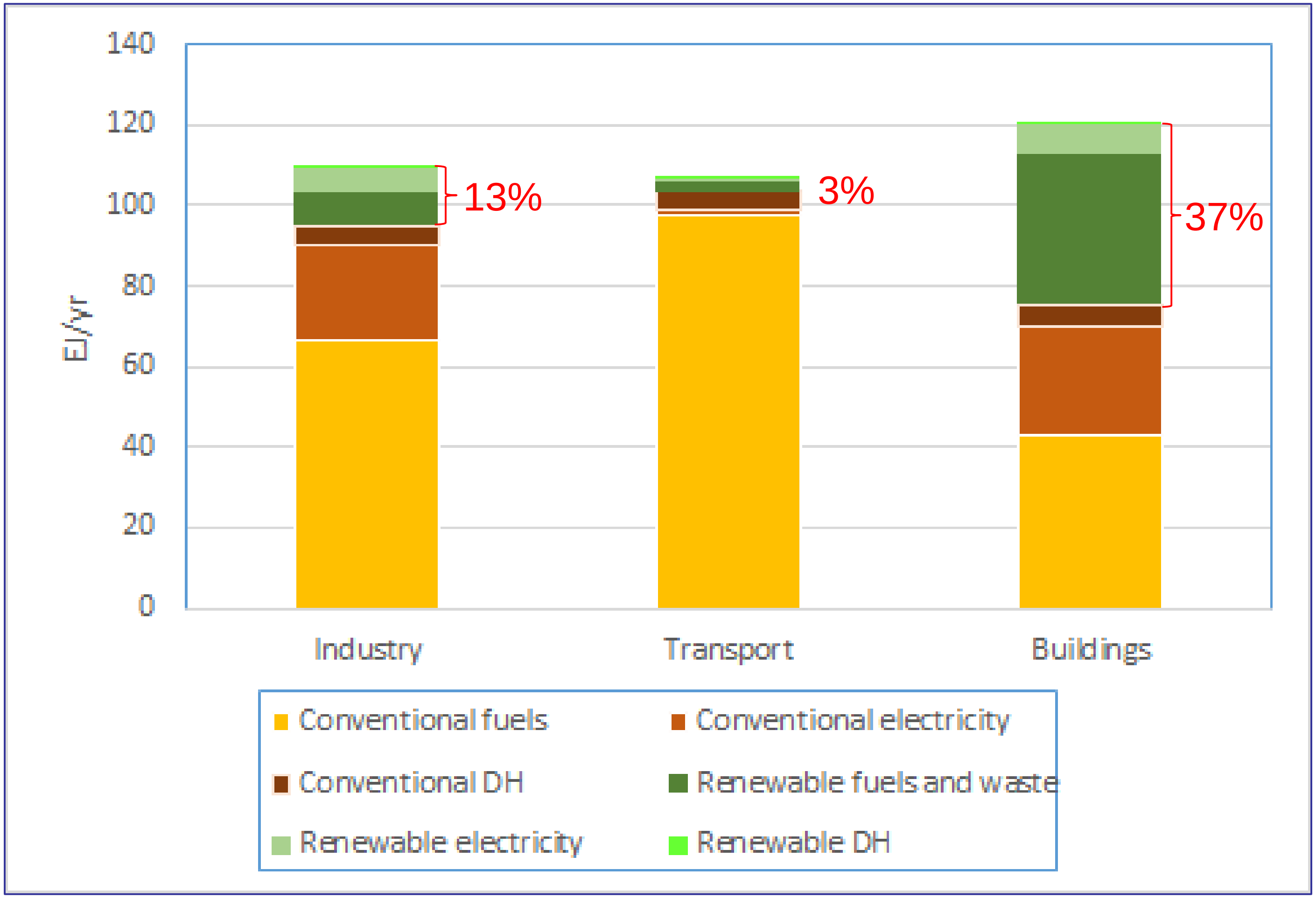
1. Why advanced biofuel?

RE Penetration is the lowest in transport sector

Energy consumption in three endues sector (2013)



- Liquid biofuel will be the only option in transport sector for coming decade or two

Liquid biofuel can grow up to 15% by 2030, technically

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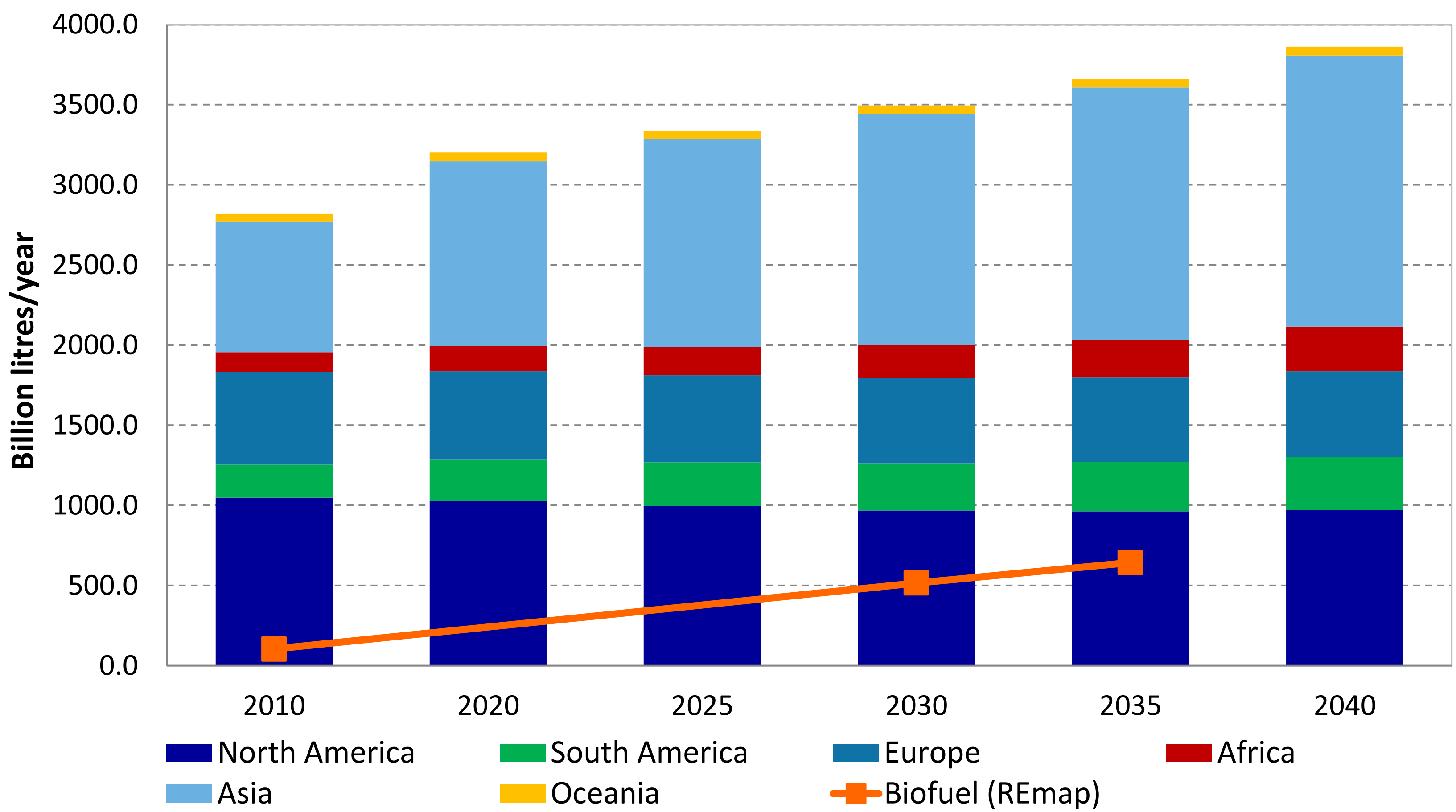
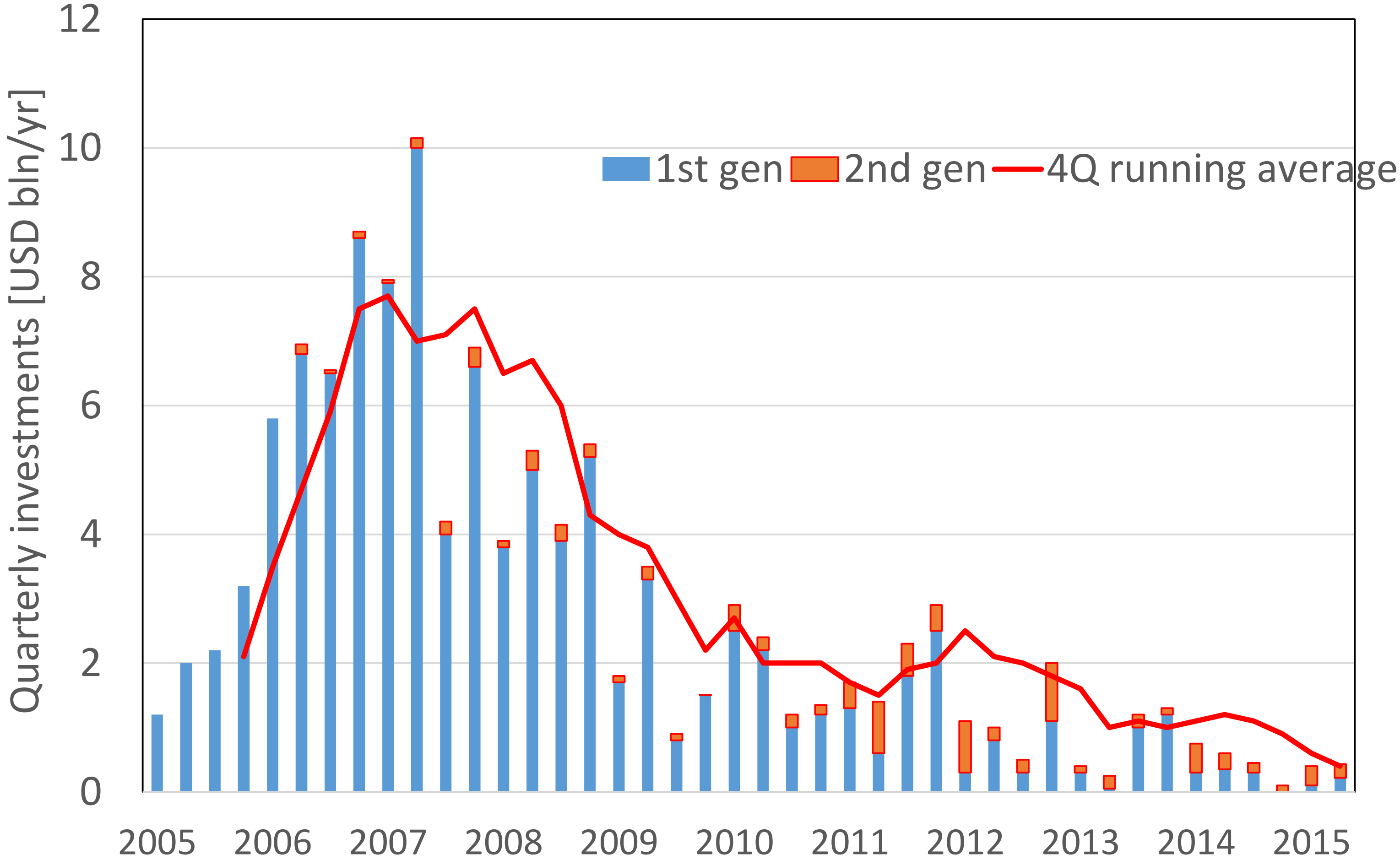


- There is a potential to increase RE share in transport sector to 10 – 15% by 2030, from current 3%. Yet, significant investment, market development required. Advanced biofuel account for only 1% of current liquid biofuel

Global Investments in Biofuels is very low and even decreasing



Source: BNEF

Stalling investment for liquid biofuel, Why?

- Stagnant investment due to unclear policy support in longer term which reflects public concern including,
  - **Impact of land use change**
    - ✓ GHG emission
    - ✓ Loss of biodiversity
  - **Competitive use of natural resource - land and water -**
    - ✓ Food security
    - ✓ Resource depletion: forest, water
  - **Social impact**
    - ✓ Land grabbing
    - ✓ Equal benefit sharing

- Advanced biofuel have a potential to overcome above issues – still technology development and investment is needed

2. IRENA Innovation Technology Outlook of Advanced Biofuels

Objectives

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This study provides a global technology outlook for advanced biofuels from 2015 to 2045, specifically liquid transport fuels.

- Overview of market potential
- Comparative assessment of pathways
- Technology gaps and opportunities for R&D
- Non-technical gaps and opportunities for deployment
- Innovation prospects on promising production pathways
- Commercialisation strategies

Report coming up in 2015

3. Status of deployment

There are significant opportunity for advanced biofuel

- Road transport:
- Aviation: 6% advanced biofuel by 2020 (IATA)
- Fleet: US Navy, 50% of energy from non-conventional by 2020, special focus on drop in biofuel
- Nov. 2015, DuPont opened world largest cellulosic ethanol plant with over 100 mil. litter cellulosic ethanol production, which 500 local farmers provide feedstock, create 85 full time job, and over 150 seasonal job

Deployment:
Advanced Biofuel Market Potential

90 INNOVATIVE PROJECTS IDENTIFIED

Source: Preliminary findings from IRENA Advanced Biofuels Technology Outlook (work-in-progress)

Market of advanced biofuel is growing, yet far more growth is required

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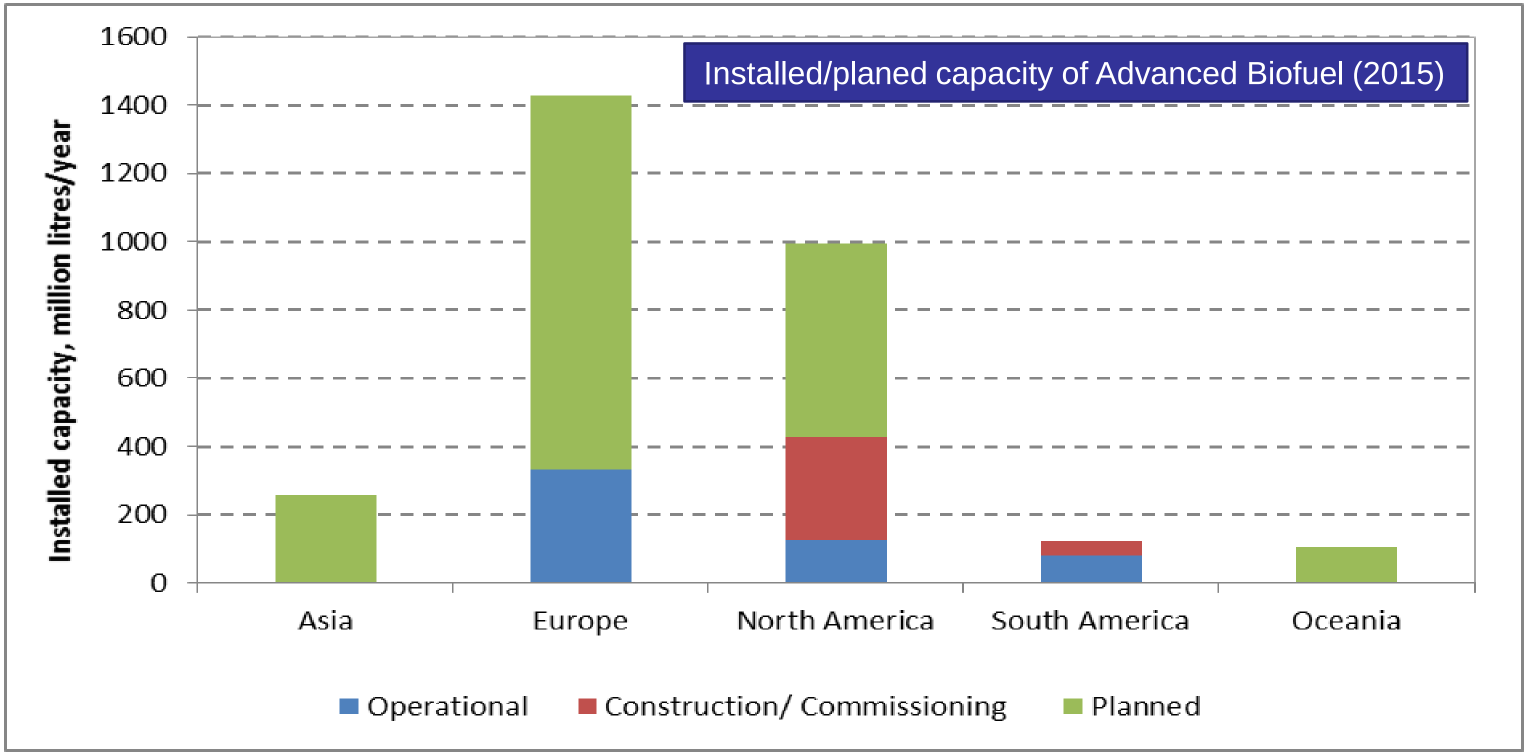
Current



Projection

REmap 2030	WEO 2035	OFIC 2030
37% of total biofuel production 42% annual growth	18% of total biofuel production 22% annual growth	12% of total biofuel production 31% annual growth

4. Supply potential of advanced biofuel

What is Advanced Biofuel?

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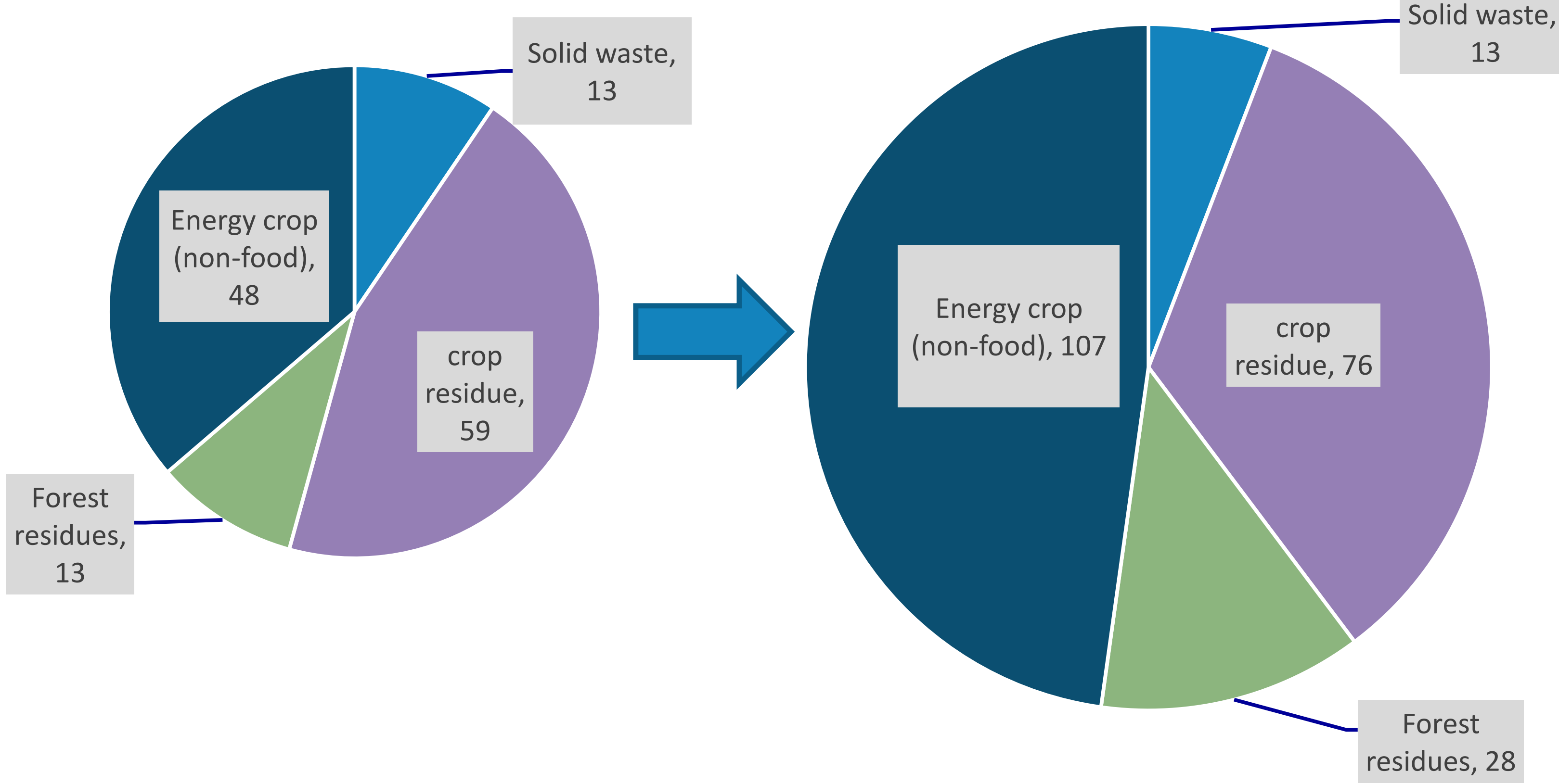
- Type of feedstock
  - Food crop / non-food crop
- GHG emission reduction
  - Lifecycle GHG saving >50% (US-RFS)
- Technology maturity
  - Matured / R&D status
- Product quality
  - Similar properties to gasoline, diesel, jet fuel and bunker fuel, either neat or blended in high proportions

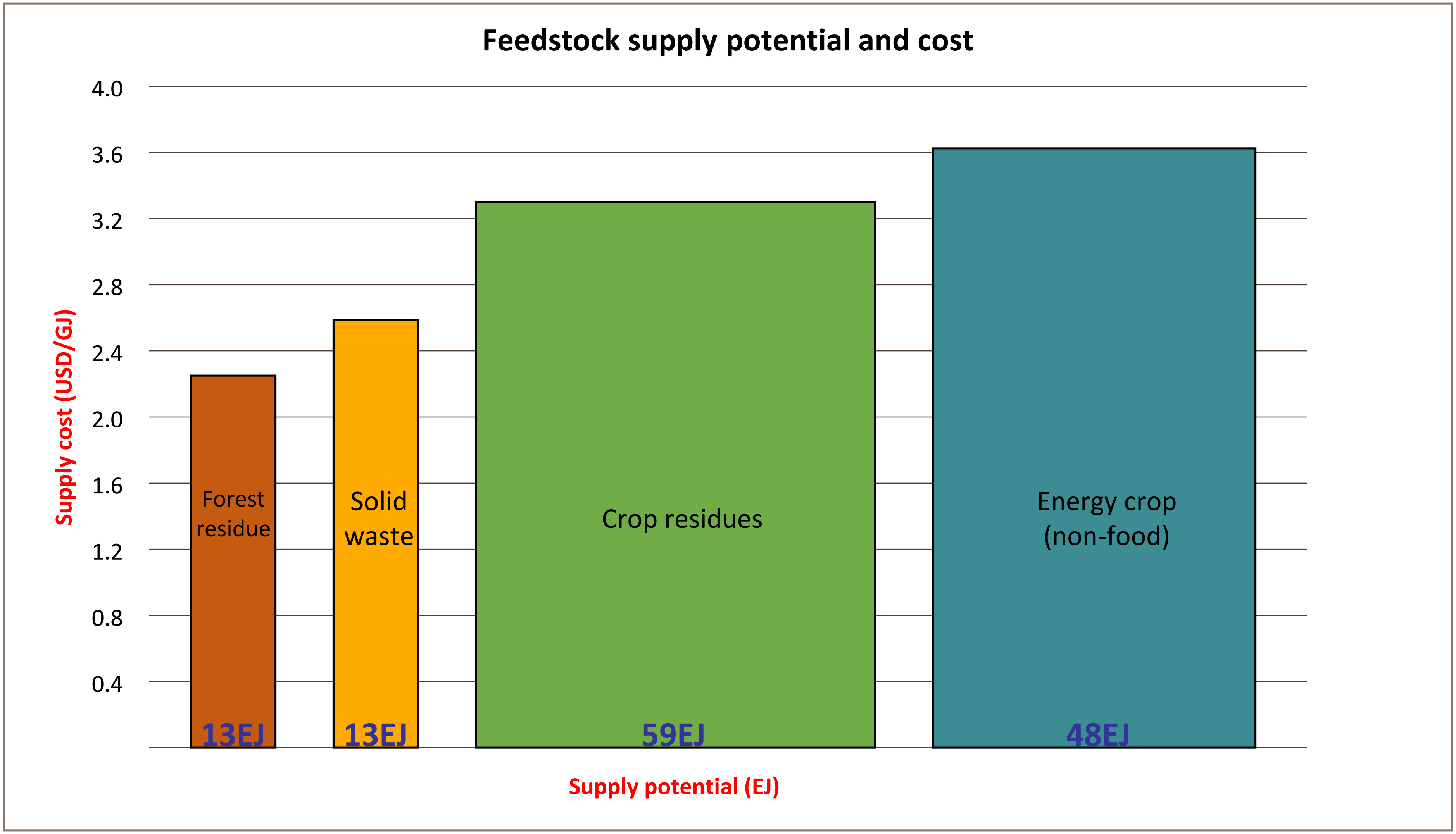
How much biomass can be available for advanced biofuel?

Overall potential 133 (EJ/year) in 2030

Overall potential 224 (EJ/year) in 2050



Comparison of Adv. Biofuel Feedstock - Cost and Supply potential for 2030



5. Technology development status and prospects

Advanced biofuels pathways

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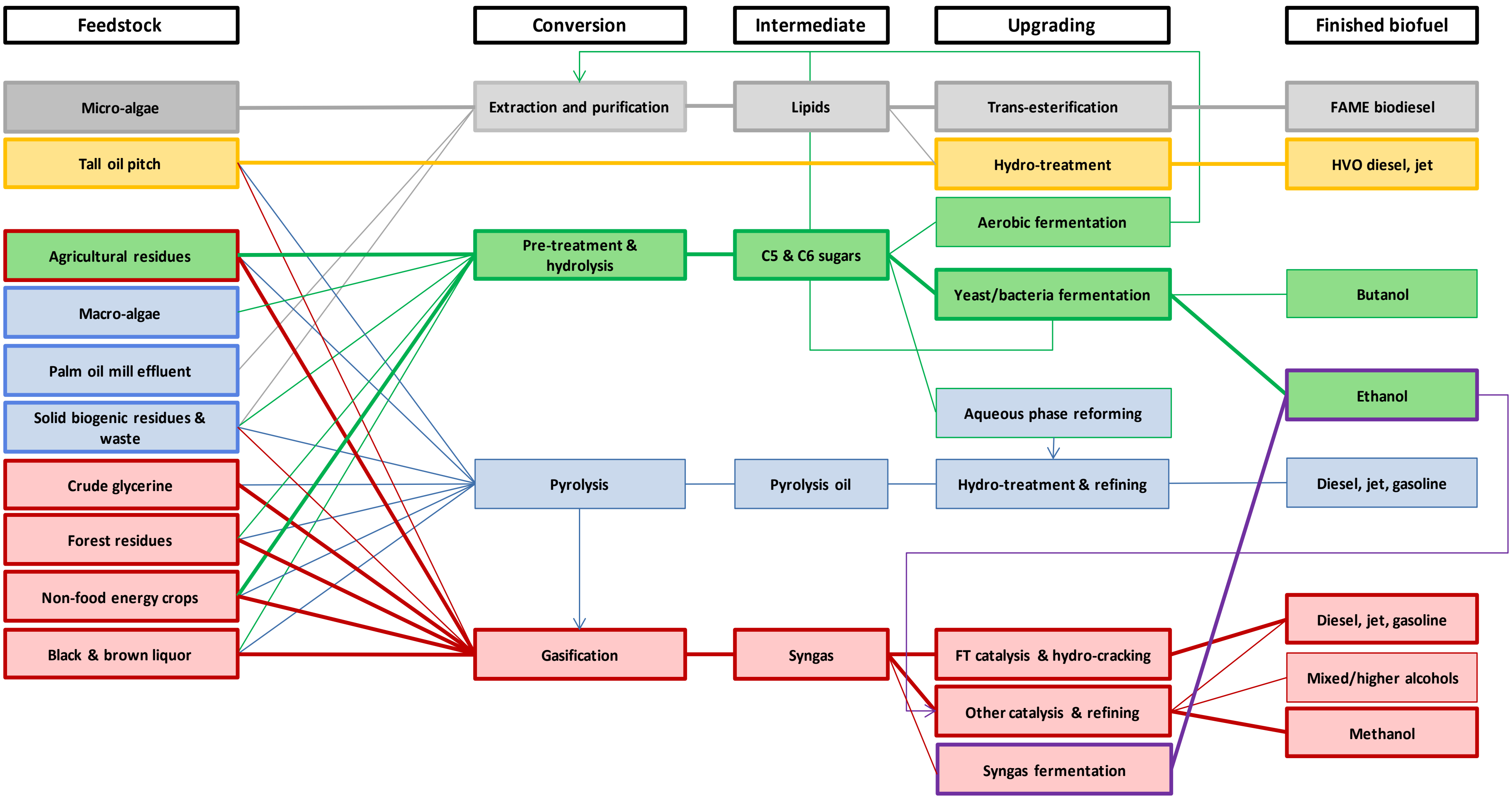
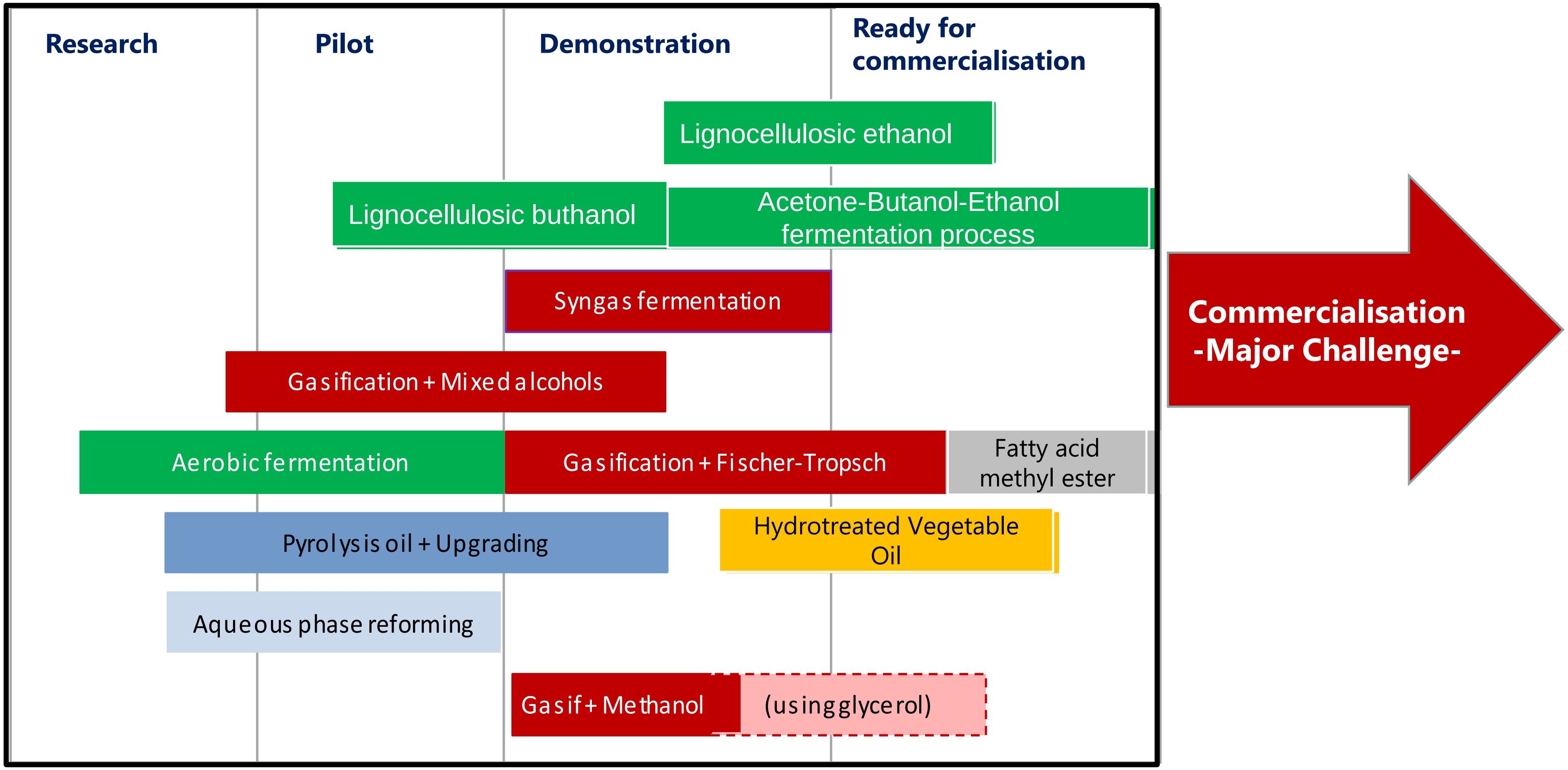


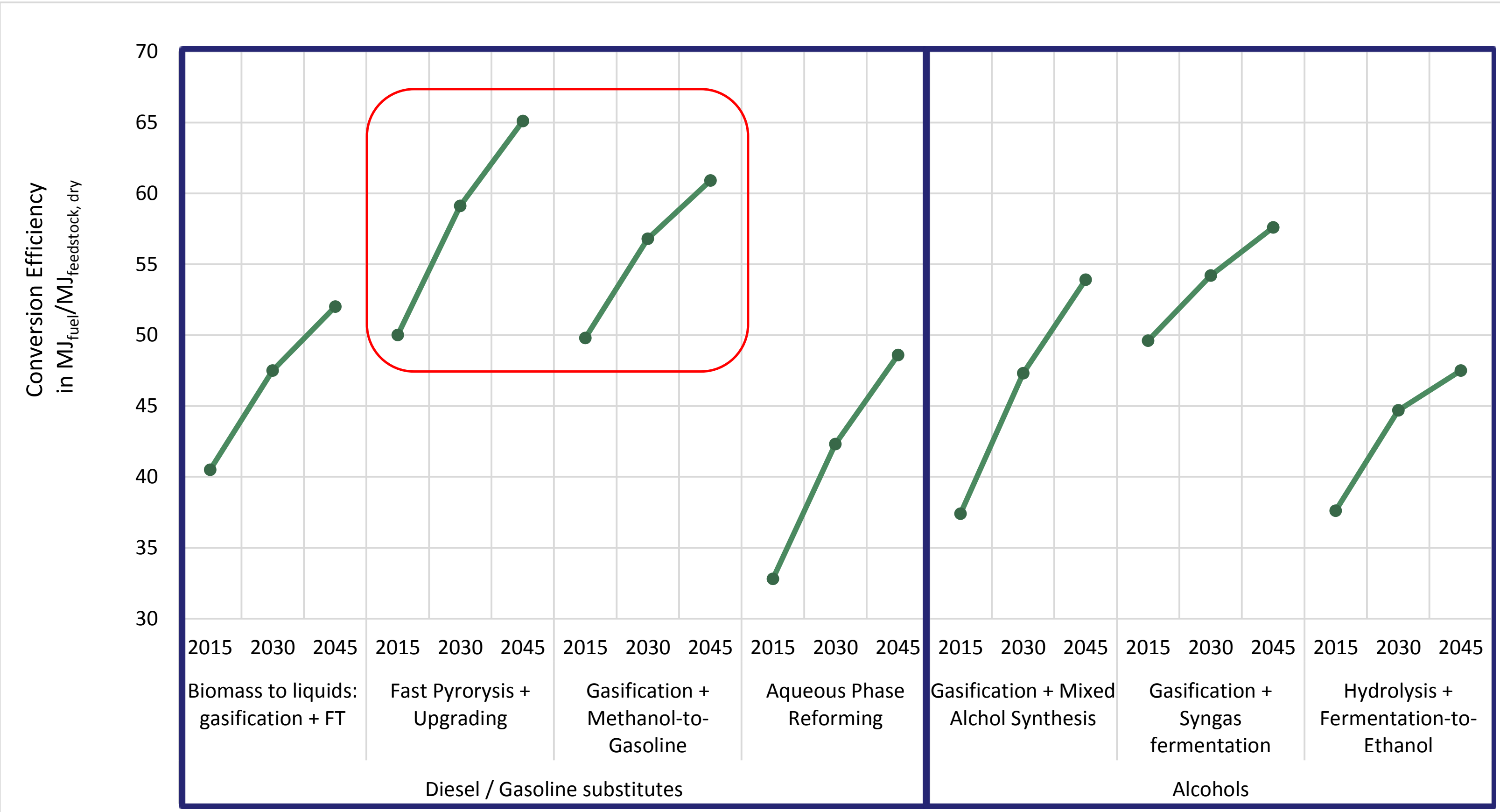
Principal pathway for each feedstock shown by **bolder** lines. Feedstocks are colour-coded by finished biofuel type

Pathways: Technology readiness



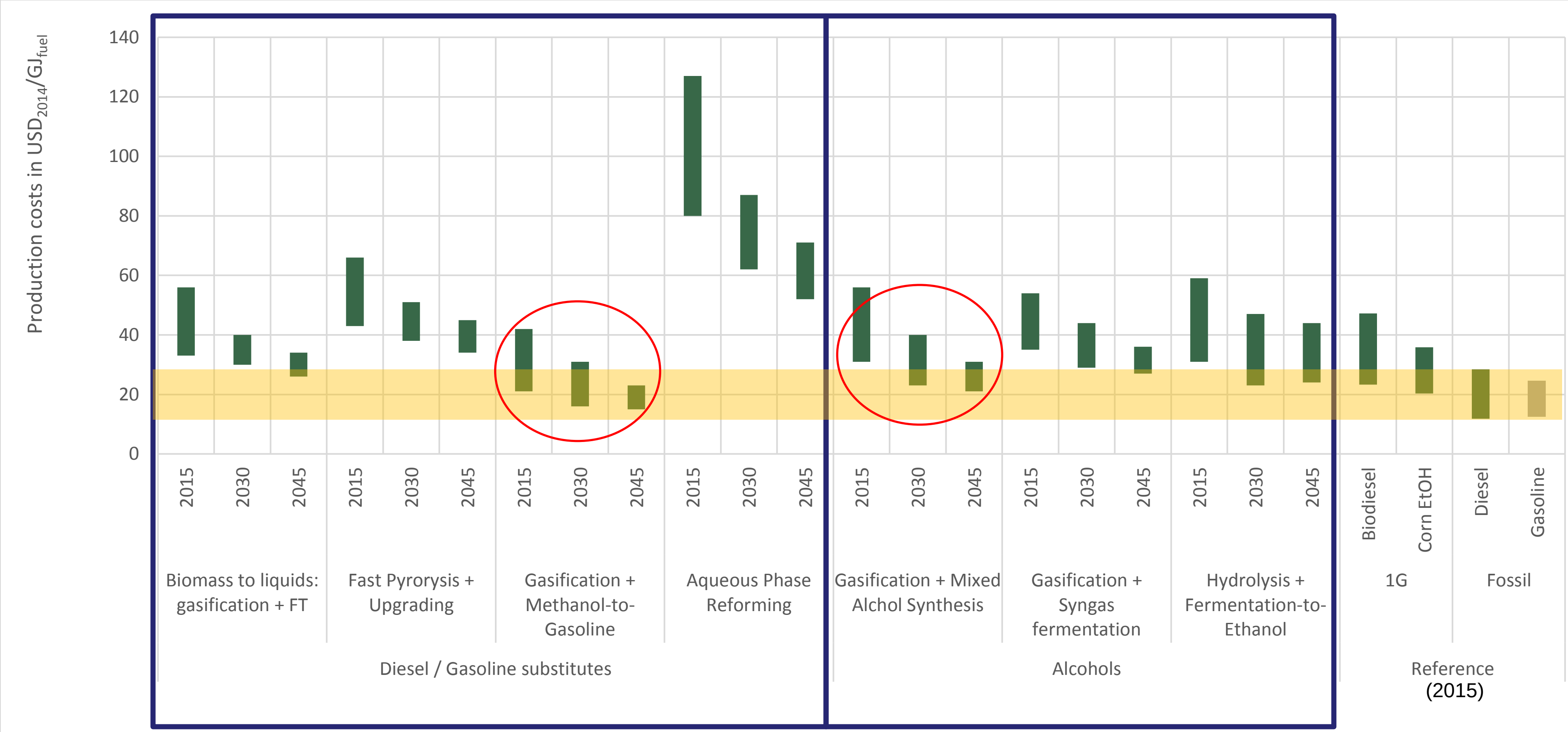
Source: Preliminary findings from IRENA Advanced Biofuels Technology Outlook (work-in-progress)

Conversion efficiency



- Thermochemical pathway have higher efficiency theoretically, including pyrolysis and Gasification. (For hydrorysis + fermentation, co-products energy use outside the process is not included)

Cost reduction



- Lower capital investment make "Gasification + MtG" and "Gasification + MAS" most competitive. High conversion efficiency of "Gasification + MtG" also contribute cost reduction
- Conventional biofuel is almost at the same level with cheapest advanced biofuel. It still in the middle to higher range of fossil fuel

Environmental performance

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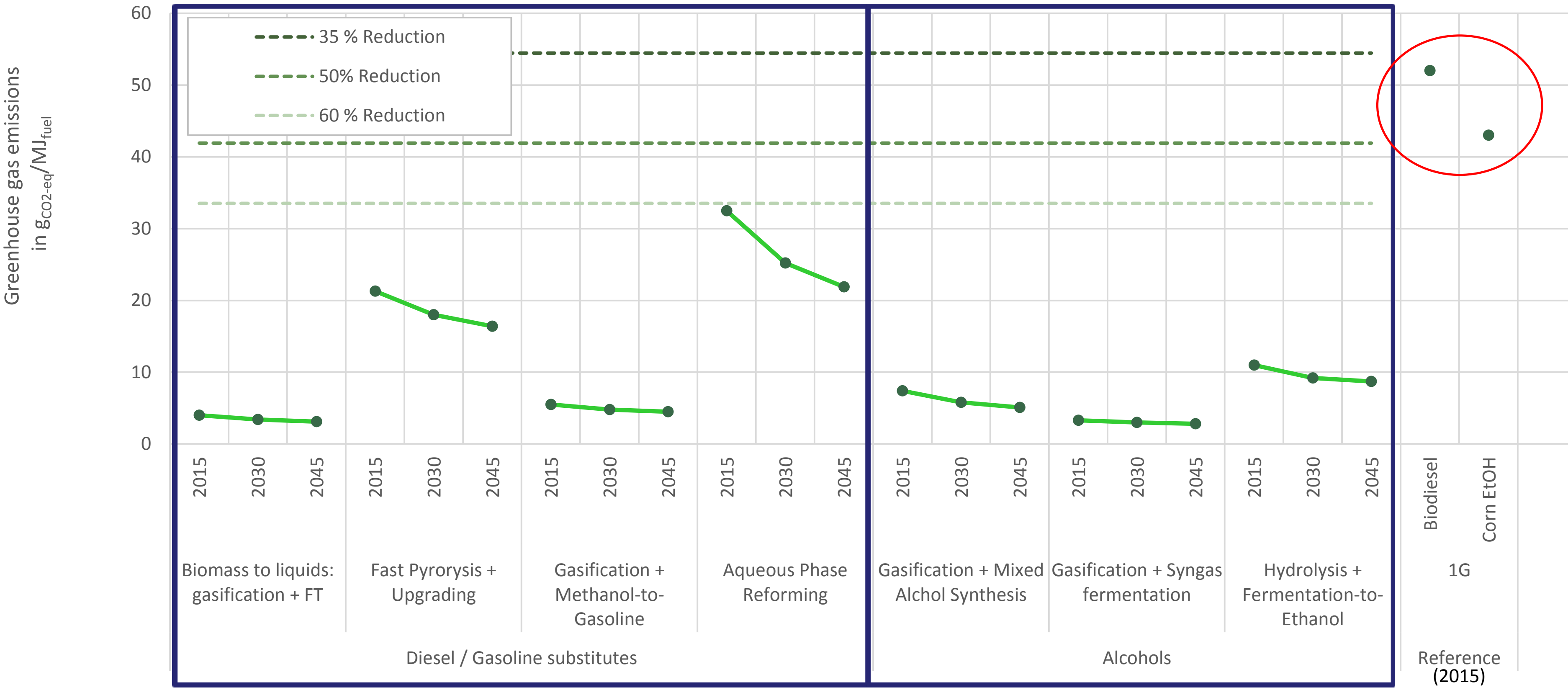

- In terms of GHG emission reduction, all advanced biofuel show significantly higher performance mainly due to the difference in feedstock. It is also energy self-sufficient in conversion process using by-product as a heat source

Pathways comparison

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	Efficiency	Cost	GHG emission
	%	USD/GJ	gCO2/MJ
Biomass to liquids: gasification + FT	48	35	3
Fast Pyrorysis + Upgrading	59	45	18
● Gasification + Methanol-to-Gasoline	57	24	5
Aqueous Phase Reforming	42	75	25
● Gasification + Mixed Alchol Synthesis	47	32	6
Gasification + Syngas fermentation	54	37	3
Hydrolysis + Fermentation-to-Ethanol	45	35	9

- Numbers represent projection for 2030
- Color indicates: ● best ● worst

6. R&D Opportunities

Innovation impact: Preliminary results

- Gasification and syngas cleaning: (Quality control of syngas, adaptation to diverse feedstock)
  - Energy integration: 15% savings on production costs for FT
  - Greater feedstock tolerance:
- Fischer-Tropsch synthesis: (Quality control of syngas, scale down of FT system)
  - Modular micro channel reactor: 8% gain in efficiency and 10% saving in CAPEX
  - Co processing of FT waxes: 15% savings in CAPEX
- Fast pyrolysis and upgrading: (Oil yield improvement, quality control of pyrolysis oil)
  - Hydro deoxygenation upgrading, pyrolysis oil co-feeding in existing infrastructure, co-cracking of pyrolysis oil: 10-30 % fuel cost reduction
- Pre-treatment and hydrolysis: (Separation of lignin/celluloce, cost and sensitivity of enzyme)
  - Optimization and dosage requirements: 10% of current enzyme costs (by 2050)
- Fermentation to ethanol and upgrading: (Energy intensive distillation process)
  - Membrane separation/osmosis or induce phase separation techniques: 50% energy savings compare to distillation
  - Control systems for plant optimization: 37-42% efficiency increase
  - One processing step for pretreatment, hydrolysis and fermentation: 80% reduction in production costs
- Fermentation to butanol and upgrading: (Fermentation inhibitor)
  - Acid recovery: 15% yield gain
- Aqueous phase reforming: (Low yield of liquid hydrocarbon, short lifetime of catalyst)
  - Hydro treating catalyst development: Increase efficiency from 25% to 55%

Advanced Biofuels Commercialisation

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TRL	Barriers	Intervention
8	Lack of market and high costs	**Mandate or subsidy** **Public procurement**
	High credit risks	**Loan guarantee**
	Lack interest in lending, limited knowledge of market demand	**Loan softening programme**
	Insufficient loans for projects, lack of long-term lending capacity	**Project loan facility**
6/7	Commercial expansion, financial restrictions, market integration	**Brokered partnership**
	Technology proving, testing and evaluation of claims	**Demonstration (research and evaluation)**
	Lack of technology proving, investor and public apprehension	**Demonstration project (High profile)**
	Investment risk in new technologies	**Project investment insurance**
	Financing gap during project development	**Public/private co-financed debt** **Soft loan programmes**
4/5	Risk of investing in start-ups	**Investment tax incentives**
	Protecting IP ownership	**IP protection - Legal frameworks and assistance with protection**
<4	**Lack of funding for research**	**Research framework**
	Lack of funding for innovation organisations	**Grants**

7. Conclusion

Conclusions and recommendation

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✓ **Advanced biofuel advantages**

● supply potential ● energy security ● environmental impact ● food security

✓ **Number of commercial scale project are on the way**

R&D Opportunities for deployment in the next 3 decades

1. Lignocellulosic fermentation is closest to full commercialization, with complemented by butanol fermentation in the longer term
2. Gasification can be a main source of different tech. pathway, which still require improvement in energy efficiency and syngas cleaning
3. Among different upgrading, syngas fermentation may achieve earlier commercialization. FT attracts high interest. the key is system downsizing
4. Fast pyrolysis + upgrading are still in the early stage, however cost reduction opportunity can be seen in upgrading

Current obstacles

- High production cost because of early development stage
- Uncertainty in policy framework to prioritize advanced biofuel causes
- Slow investments in the sector

Conclusions and recommendation

- Technical and non-technical factors needed:

  - Support policy framework to cover four key area:
  - ✓ technology research and development,
  - ✓ company development,
  - ✓ market formulation and
  - ✓ integrated policies (energy, transport, agriculture, environment,…)

  <u>developed in close collaboration/coordination with all relevant stakeholder, primarily industry research and project developers</u>

- IRENA will support the sector through
  - ✓ Networking stakeholders from different sector, region
  - ✓ Providing key information to support member countries
  - ✓ Guiding countries for policy development, project guidance







Thank You

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