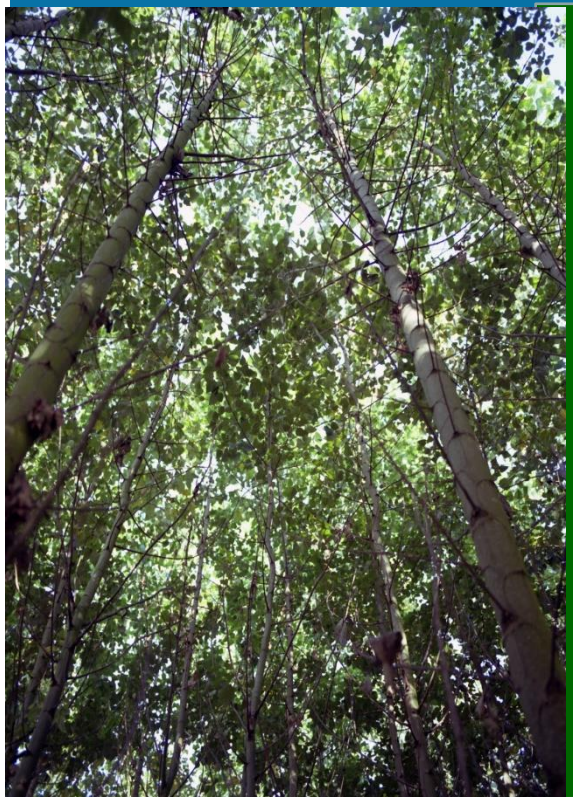
Approaches to Sustainable Bioenergy



IRENA - University of Bonn Lecture Series

November 23, 2017

Jeff Skeer, IRENA

International Renewable Energy Agency

IRENA
International Renewable Energy Agency

Established: April 2011

Mission: Accelerate deployment of renewable energy

Strategy: Hub, voice and objective information source for RE

Members: 180 countries engaged; 153 ratified (late 2017)

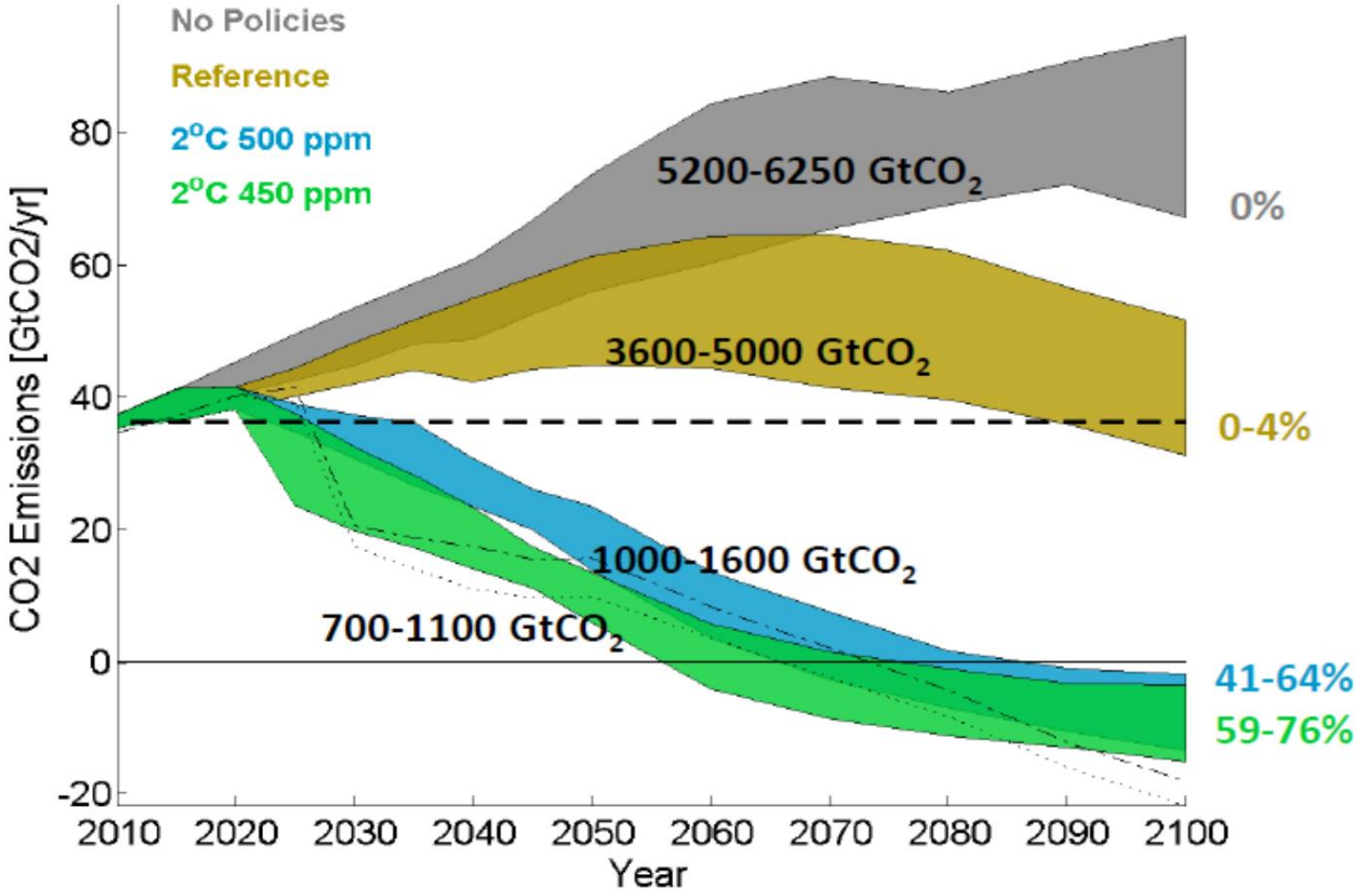
Mandate: Sustainable deployment of the six RE resources (Biomass, Geothermal, Hydro, Ocean, Solar, Wind)

Location: Headquarters in Abu Dhabi, United Arab Emirates
Innovation and Technology Centre: Bonn, Germany

Lead: Director-General, Adnan Amin

I.
INTRODUCTION

The Huge Climate Challenge



Source: D. P. Van Vuuren 2017, Negative Emissions

Renewables as Largest Primary Energy Source

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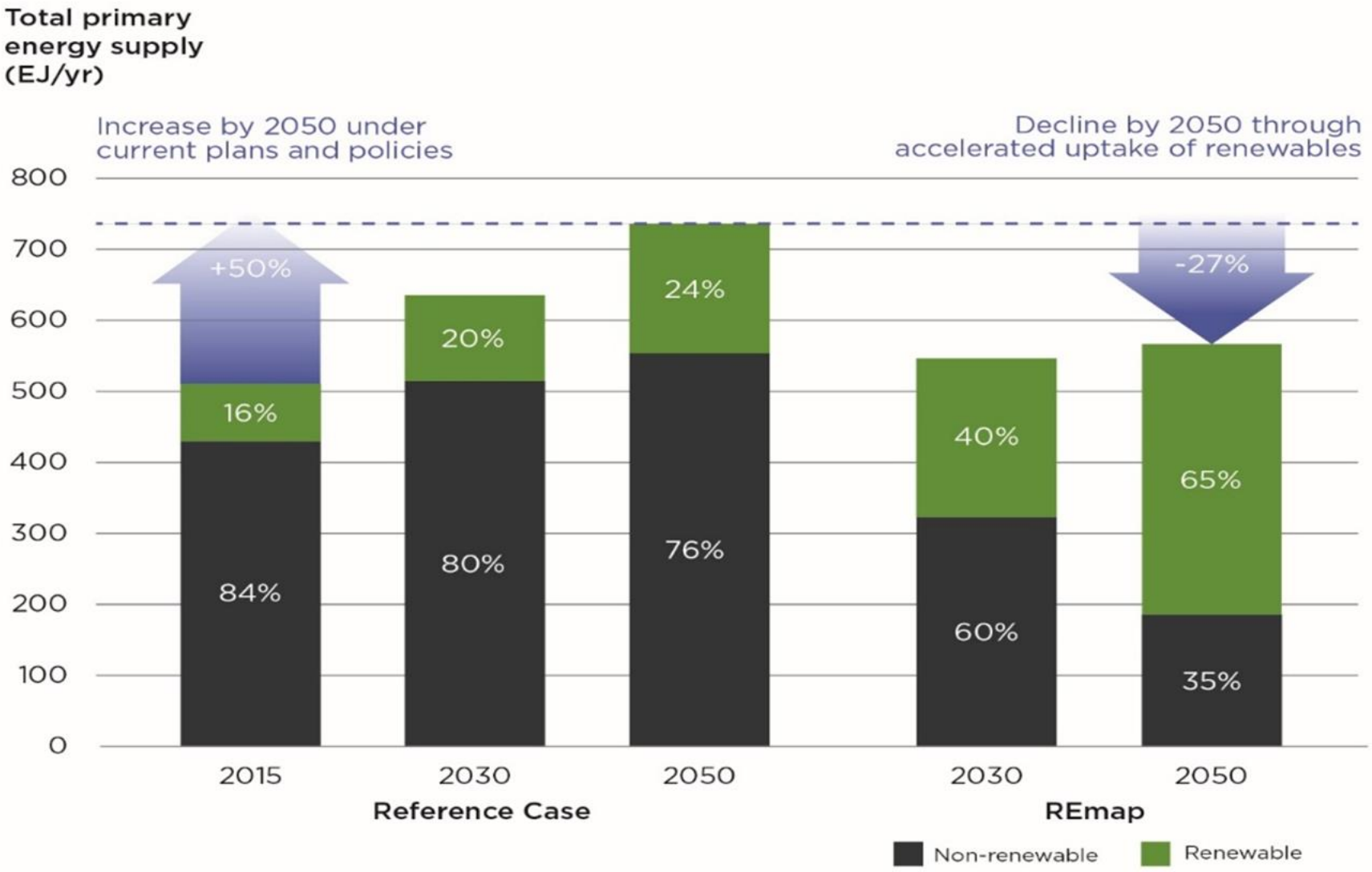

Major Modern Biomass Needs in 2050

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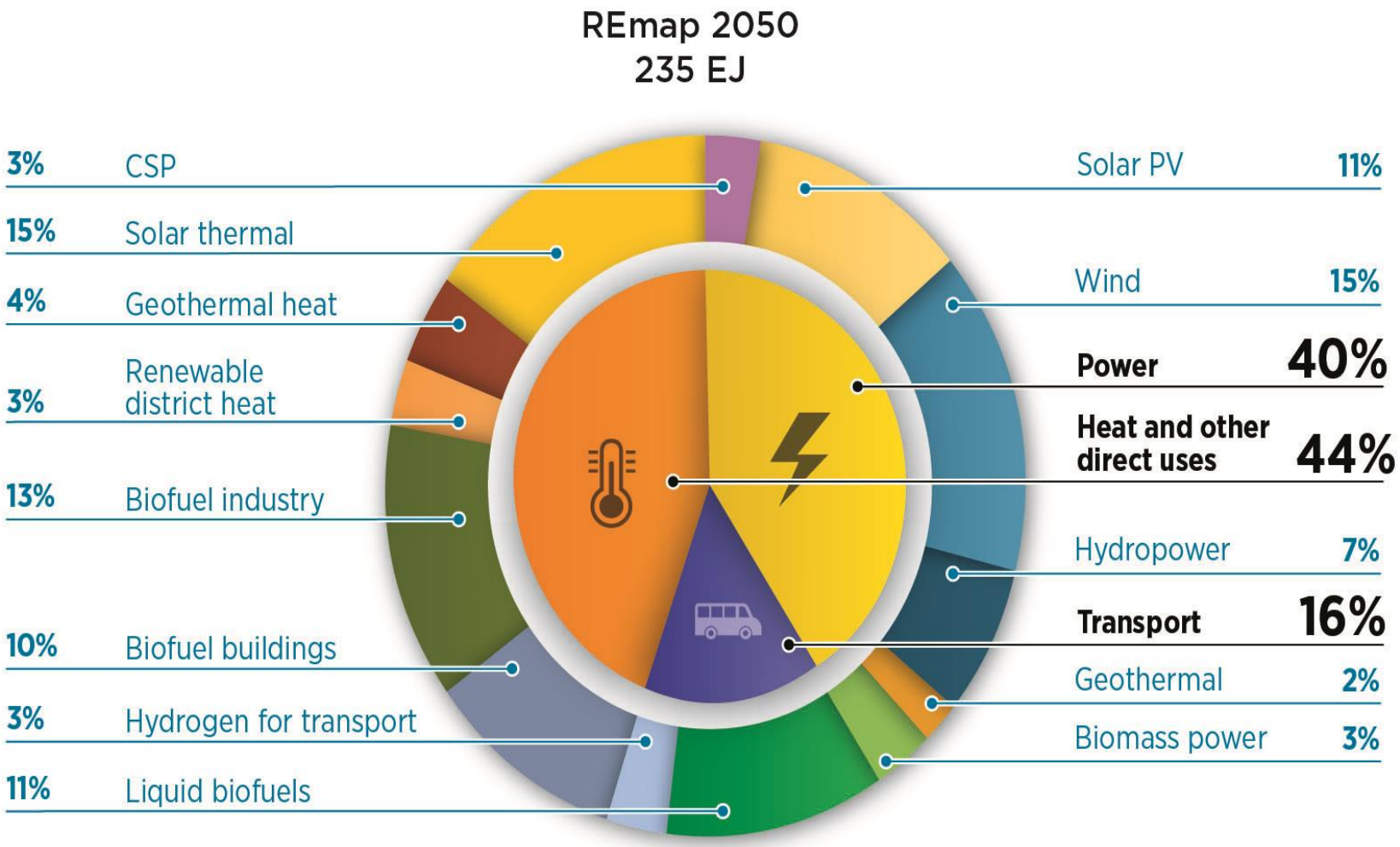

II.
IS THERE ENOUGH SUSTAINABLE BIOMASS?

Meeting the Challenge Sustainably

- Social Challenge: Food vs Fuel
  - Sustainable intensification: higher yields
  - Allows to produce more food AND fuel.
- Environmental Challenge: Land Use Change
  - Sustainable intensification: energy crops
  - Avoid forest loss, encourage forest expansion
  - Convert degraded land to productive use
- Economic Challenge: Low Price of Oil
  - Efficient use of biomass for cooking, heat, power
  - Competition not mainly with oil in these sectors
  - Count value of reducing atmospheric pollutants

Pockets of Sustainable Bioenergy

- Agriculture
  - Residues associated with growing food production
  - Higher yields on cropland (sustainable intensification)
  - Efficient livestock husbandry: freeing up pastureland
  - Reduced food losses and waste: freeing up farmland
- Forestry
  - Residues (complementary fellings on timberland)
  - Higher yields in planted forests (better management)
  - Afforestation of degraded forest and marginal lands

Yield Gap: Illustrated by Maize

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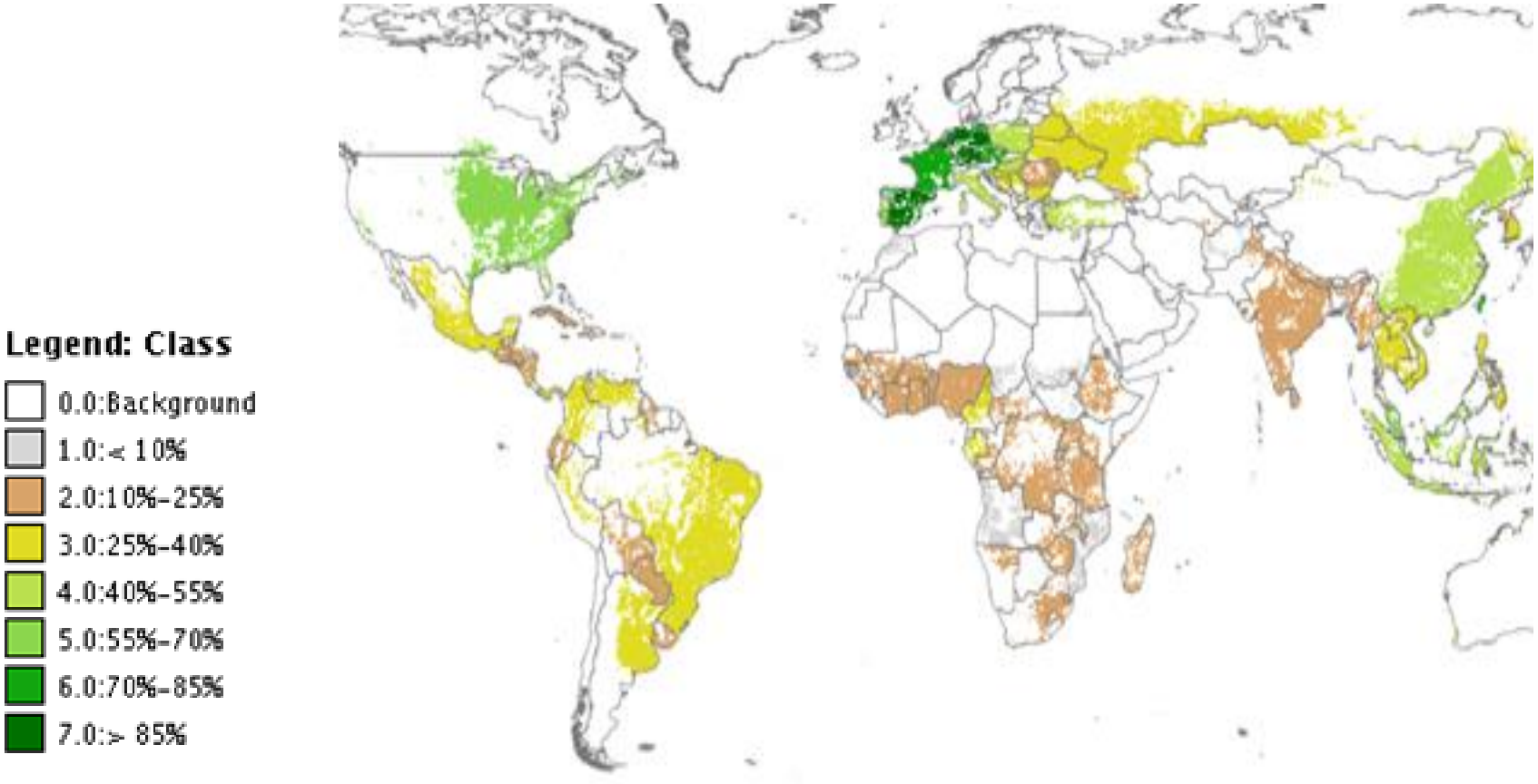
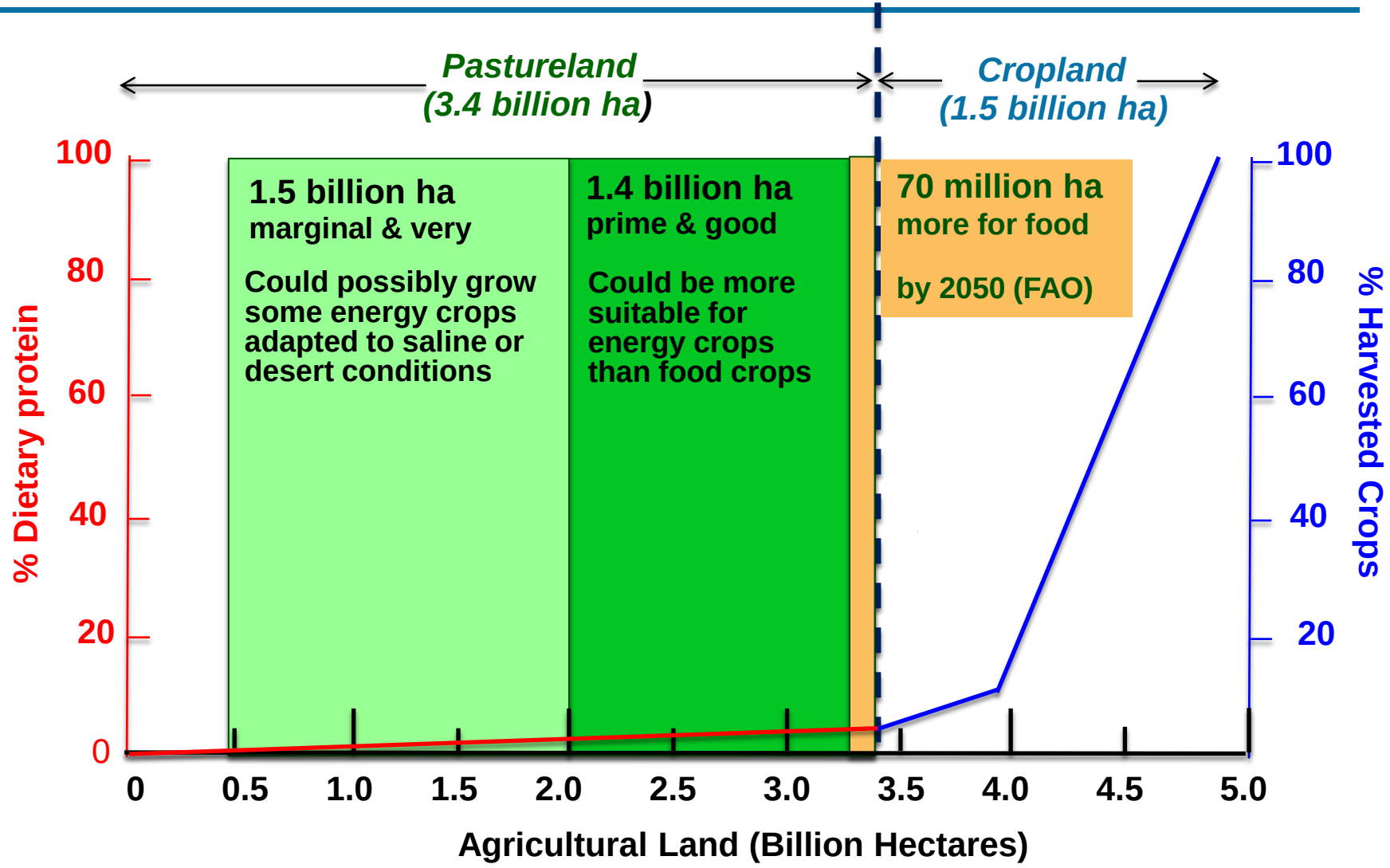
Ratio of Actual to Potential Yield for Maize (Year 2000)



Source: Global Agro-Ecological Zones

Pastureland Available Globally for Biofuel Crops



Best Practice Losses by Food Chain Stage

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Food Type	Agricultural Production	Postharvest Handling & Storage	Processing and Packaging	Distribution: Supermarket Retail	Consumption
Cereals	2%	2%	3.5%	2%	1%
Roots & Tubers	6%	7%	10%	3%	2%
Oilseeds & Pulses	6%	0%	5%	1%	1%
Fruits & Vegetables	10%	4%	2%	8%	5%
Meat	2.9%	0.2%	5%	4%	2%
Milk	3.5%	0.5%	0.1%	0.5%	0.1%

Measures to Reduce Food Waste

- Developing countries
  - Harvesting techniques to reduce production losses
    - Extension services
  - Storage, cooling and packaging to reduce spoilage
    - Health regulations, PV fridges
  - Better transport to bring food to market faster.
    - Development Assistance
- Developed countries
  - Food pricing and labels
  - Public awareness campaigns

Degraded Landscape Restoration

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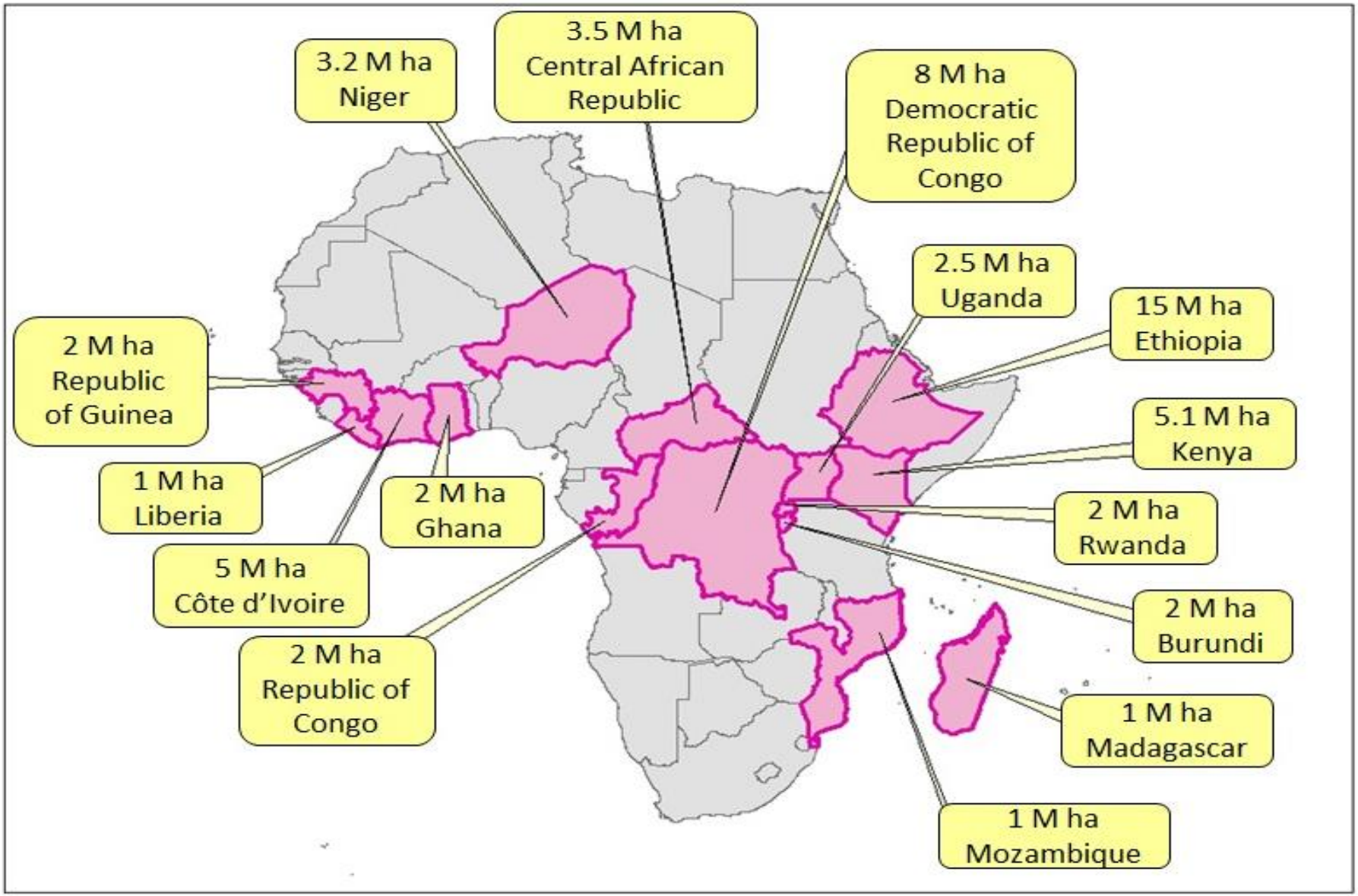

Potential Land for Solid Biomass

- **Closing the Yield Gap: 550 M ha**
- **Better Use of Pasture Land: 950 M ha**
- **Reduced Food Chain Losses: 270 M ha**
- **Landscape Restoration: 350 M ha**
- **TOTAL: OVER 2 BILLION HECTARES, 300 EJ**

Farm and Forest Residues

- **Farm Residues** (46-95 EJ of bioenergy)
- **Forest Management** (27 EJ of bioenergy)
- **Forest Residues and Waste** (15-30 EJ of bioenergy)
- **Modern Cookstoves** (8-17 EJ of bioenergy conserved)

Wood Focus: Planted Forest Model

- Harvest Most Wood As Long-Lasting Lumber
  - Strong land tenure allows long-run investment
  - About two-thirds of wood extraction as lumber
    - Far more valuable than energy wood
    - Lasts up to a century, sequestering carbon
    - Displaces carbon-intensive concrete
- Use Wood Residues for Heat and Power
  - Highly efficient (80-90%) combined heat and power, district heating systems, home furnaces
  - Displaces carbon-intensive fossil fuel

Wood Focus: Short Rotation Model

- Harvest Most Wood from Fast-Growing Trees
  - Traditional land tenure may well suffice.
  - Compatible with agro-forestry approaches.
  - Carbon uptake and release in balance.
- Use Wood Residues for Cooking, Heat and Power
  - Highest priority use in modern cookstoves
    - Reduced indoor pollution
    - Reduced wood collection time
    - Reduced pressure on local forests
  - Efficient heat and power uses as with forest wood

How Large Is the Biofuel Potential?

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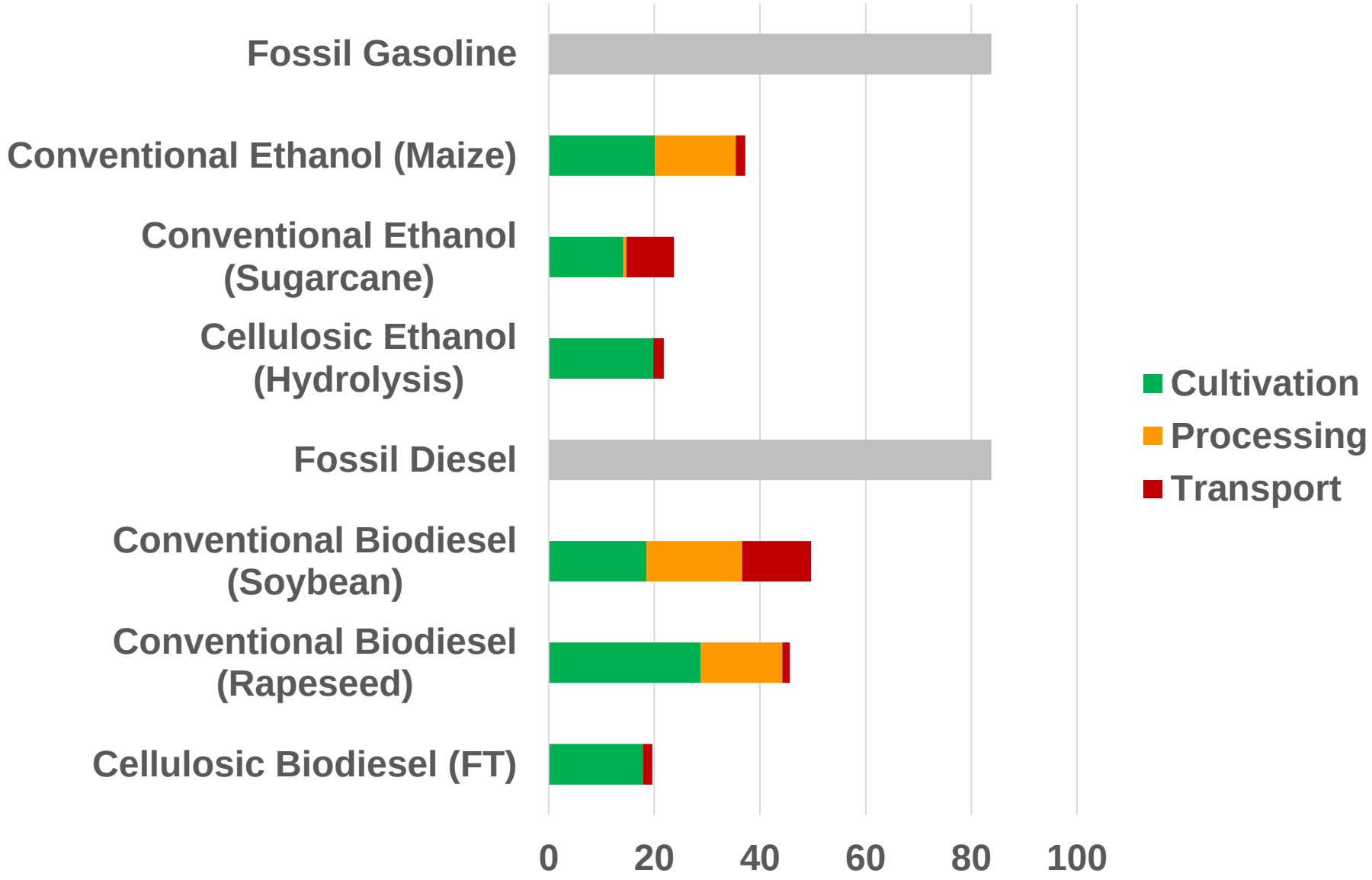
Category	Primary Biomass Energy Content	End Use Bioenergy with 1st/3rd Generation Biofuel or Combined Heat and Power (80% Efficiency)	End Use Bioenergy with 2d Generation Biofuel Conversion (40% Efficiency)	REMAP 2030 Assumptions for Primary Biomass Energy (Reference)
Agricultural Residues	46 - 95 EJ	36 - 76 EJ	18 - 38 EJ	19 - 48 EJ
Cultivating Forests	83 - 141 EJ	66 - 112 EJ	33 - 56 EJ	41 - 58 EJ
Subtotal A	*128 - 236 EJ*	*102 – 188 EJ*	*51 – 94 EJ*	*60 –106 EJ*
Higher Crop Yields	47 - 88 EJ	37 - 70 EJ	19 - 35 EJ	0 EJ
Pasture Land	71 - 142 EJ	57 - 114 EJ	28 - 57 EJ	33 - 39 EJ
Reduced Food Waste	40 - 83 EJ	32 - 66 EJ	16 - 33 EJ	18 EJ
Subtotal B	*159 – 313 EJ*	*126 – 250 EJ*	*63 – 125 EJ*	*51 – 57 EJ*
Total	**287 - 549 EJ**	**228 - 438 EJ**	**114-219 EJ**	**112-162 EJ**

How to Get the Biomass?

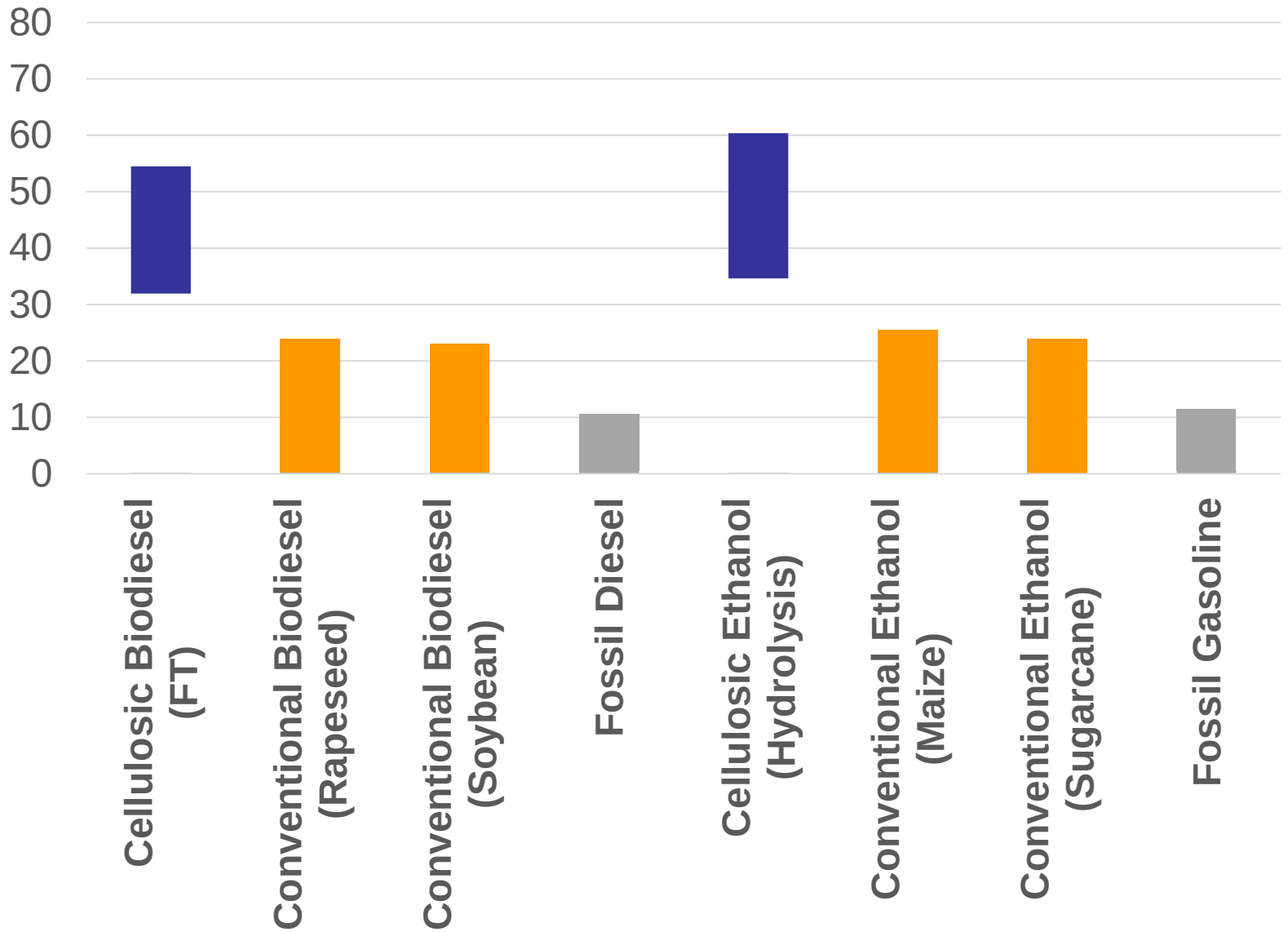
- Yes, there is enough biomass, but..
- How quickly can the resources be mobilised?
- How get the integrated land use planning to encourage productive use of farms and forest (i.e. to encourage sustainable intensification)?
- What logistical arrangements are needed to sure an adequate and sufficient supply of feedstock to advanced biorefineries, in view of the significant economics of scale that apply?

III.
CONVERSION PATHWAYS AND COSTS

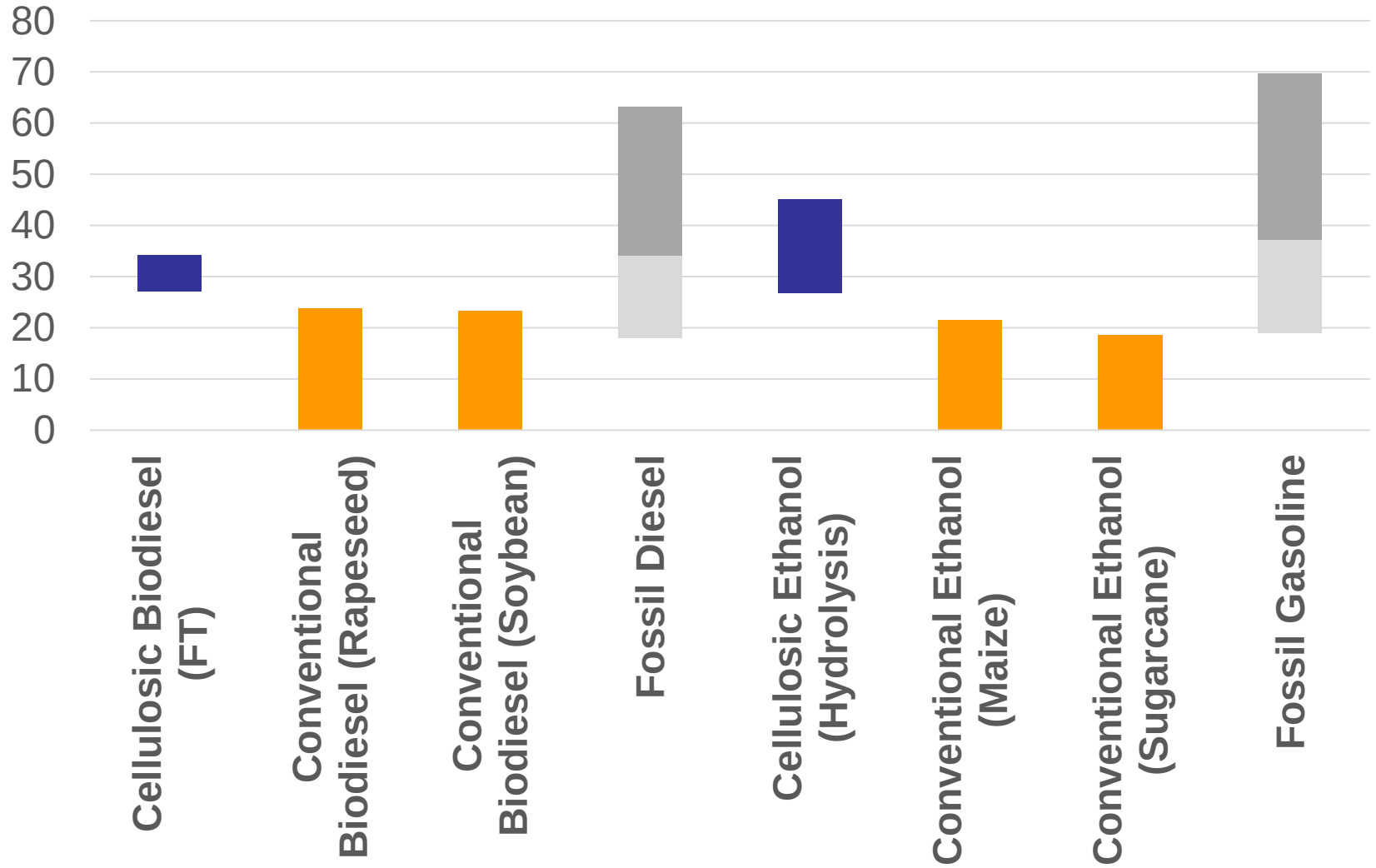
Carbon Benefits of Biofuels (gCO2/MJ)



Fuel Costs with Carbon Value Today ($/GJ)



Future Fuel Costs ($/GJ) with Carbon Value of $80/tCO2-eq



Advanced Biofuel Economic Potential

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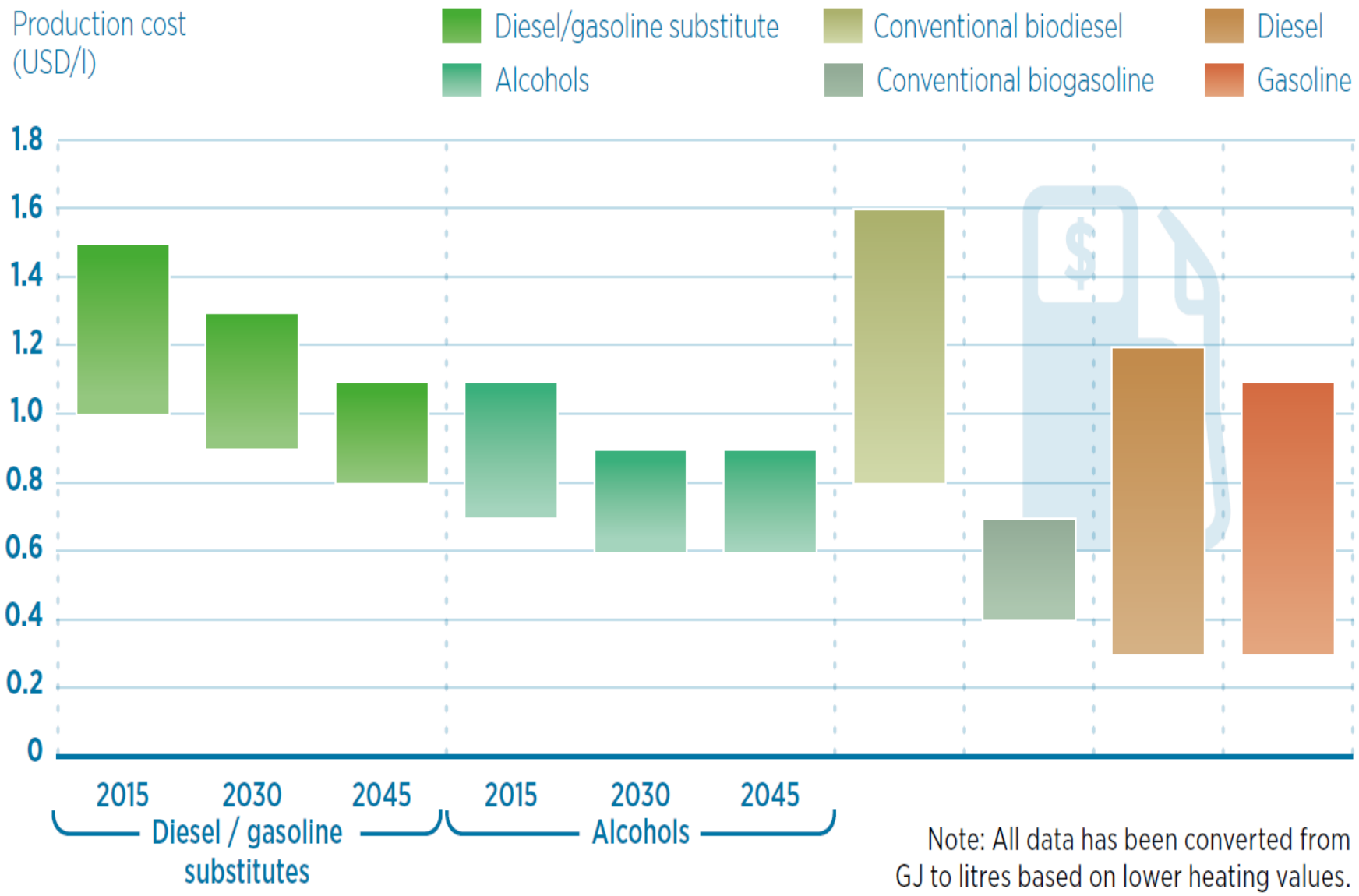

Advanced Liquid Biofuel Pathways

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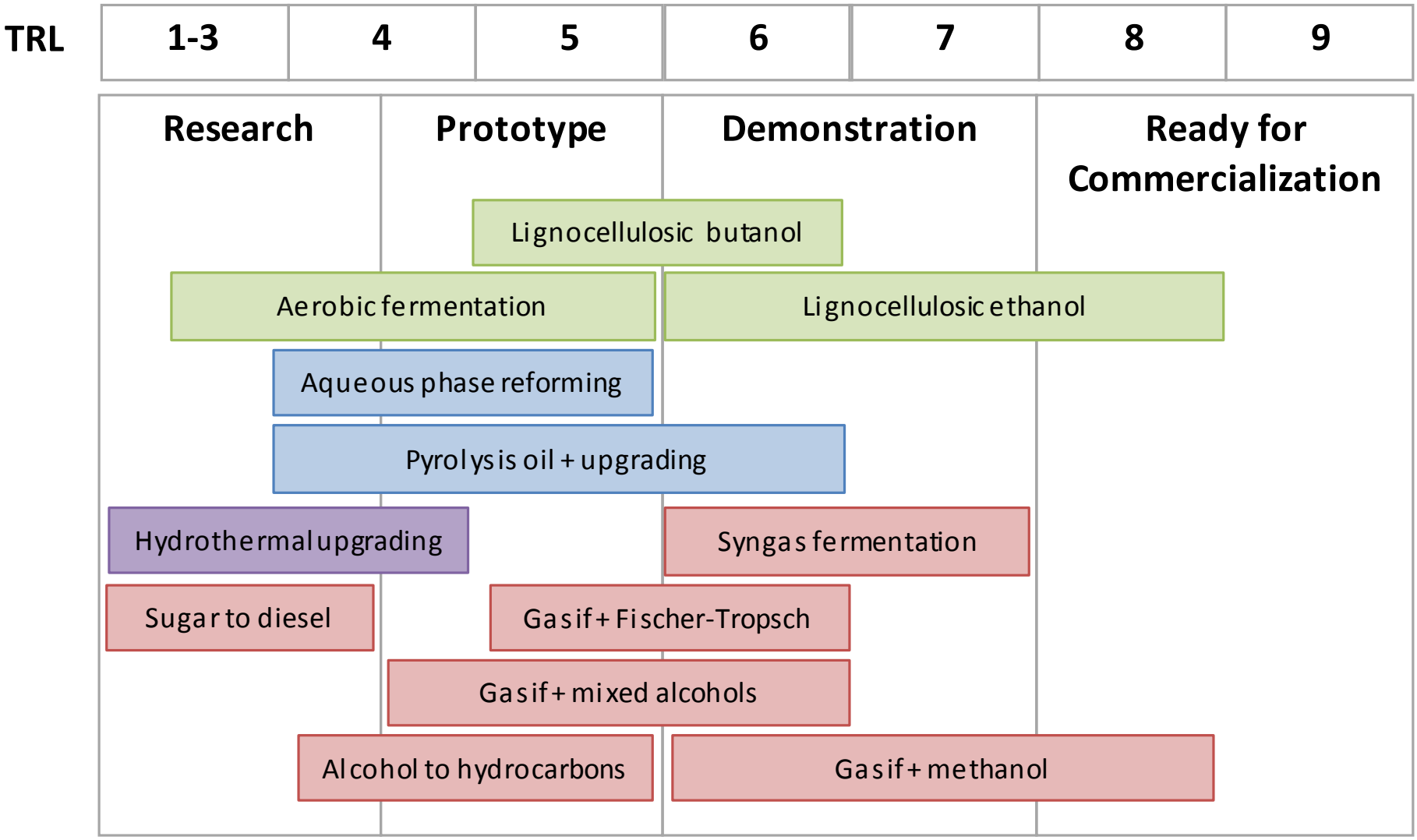

Supporting Technology

- The technology challenges can be overcome, but what policies can help to overcome them?
- Stable policies to secure investments in pilot plants of commercial scale, with appropriate public-private cost sharing of RD&D efforts to move towards the “nth” plants of each type.

IV.
MARKETS

Biofuel Markets Complex and Varied

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- Active engagement by **CONSUMERS**
- Complex **POLITICAL** setting
- Different **TRANSPORT MODES**
- Different geographic **REGIONS**

CONSUMER Setting for Biofuel Markets

- **Biofuel markets require more active consumer engagement than other renewable markets** due to a wide range of stakeholder concerns.
  - ***Wind and Solar:*** complex adjustments to power grid required, but can be handled by utility planners: customers plug in as usual.
  - ***Biofuel:*** requires active consumer choice to buy and fuel a biofuel-capable vehicle – unless biofuel is blended with fossil-based fuel or manufactures are required to make FFVs.

POLITICAL Setting for Biofuel Markets

- **Biofuel markets face a complex political setting** due to a wide range of stakeholder concerns.
  - ***Energy:*** impacts on fossil fuel production
  - ***Environment:*** impacts on land use, greenhouse gas emissions, biodiversity
  - ***Agriculture:*** impacts on farming practices, farmer and smallholder livelihoods.
  - ***Forestry:*** impacts on forestry practices.
  - ***Development:*** impacts on nutrition and rural livelihoods in development
  - ***Land Use and Transport:*** planning agencies
  - ***Shipping and Aviation***: international regulation

MODAL Transport Markets Differ

- **Transport modes differ in capacity to electrify** due to different energy density requirements.
  - ***Passenger Vehicles***: Electrify fast due to:
    - Better batteries – greater range, more demand, larger scale, lower cost.
    - Faster, more flexible charging options
    - Smart grid – charging when needed, helping grid when not needed
  - ***Road Freight:*** All but heaviest may electrify.
  - ***Marine Ships:*** May eventually electrify too.
  - ***Aviation:*** Biojet essential to decarbonise!.

Demand Driven by Blending – How Long?

	Number of Countries	Range of Mandates	Comments
Africa	11	2% - 20%	Mostly for bioethanol, ranging from 2% in South Africa to 20% in Malawi, many countries at 10%.
Americas	14	2% - 27%	Canada and USA policies based on fuel carbon intensity and volumes, not blending mandates.
Asia	9	1% - 20%	Range from 1% biodiesel in Taiwan to 20% in Indonesia.
Europe	22	3% - 10%	Most have blending mandates, others have carbon intensity targets or carbon taxes.
Oceania	2	2% - 10%	Australian mandates are at the state level, not national.

RE Transport Vision 2050

- Around 30% of transport energy demand is electric.
    - 1.3 billion electric vehicles in stock on the road.
    - 50 million electric delivery trucks sold 2015-2050
    - High-speed electric trains for long-distance travel
    - Self-driving EV taxis, buses, delivery vans
- Ten-fold increase in liquid and gaseous biofuels
    - 1,000 billion litres of liquid biofuels
    - …of which 500 billion litres advanced biofuels
    - …of which 300 billion litres advanced aviation fuel
    - 200 billion cubic metres of biogas

REGIONAL Transport Markets Differ

- **Transport markets** in different regions may develop in different ways due to specific economic and developmental characteristics.
  - ***North America***: What will happen to maize as EVs phase in and blending needs decline? Will ethanol be upgraded to jet fuel??
  - ***Brazil:*** Auto fleet could continue on ethanol.
  - ***Europe:*** EVs should penetrate rapidly with RE
  - ***Africa:*** EVs handicapped by weak power grids
  - ***Asia:*** EVs supported by hydro, biomass CHP for agro-processing, residues to jet fuel?

MAJOR CONCLUSIONS

- Renewable energy solutions to transport are key
  - inputs to power for electric vehicles
  - biofuels for light vehicles as EVs phase in
  - biofuels for aviation, marine and freight
- Advanced biofuel conversion technologies are needed to diversify the range of feedstocks to include farm and forest residues and wood crops.
- Advanced biofuels should become cost effective at expected oil prices and carbon values, if investment is made to get to “nth” plants.

Bioenergy for Sustainable Development

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http://www.irena.org/

IEA Bioenergy – International Energy Agency
Technology Collaboration Programme on Bioenergy
http://www.ieabioenergy.com/

FAO – Food and Agriculture Organization of the UN
http://www.fao.org/

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