

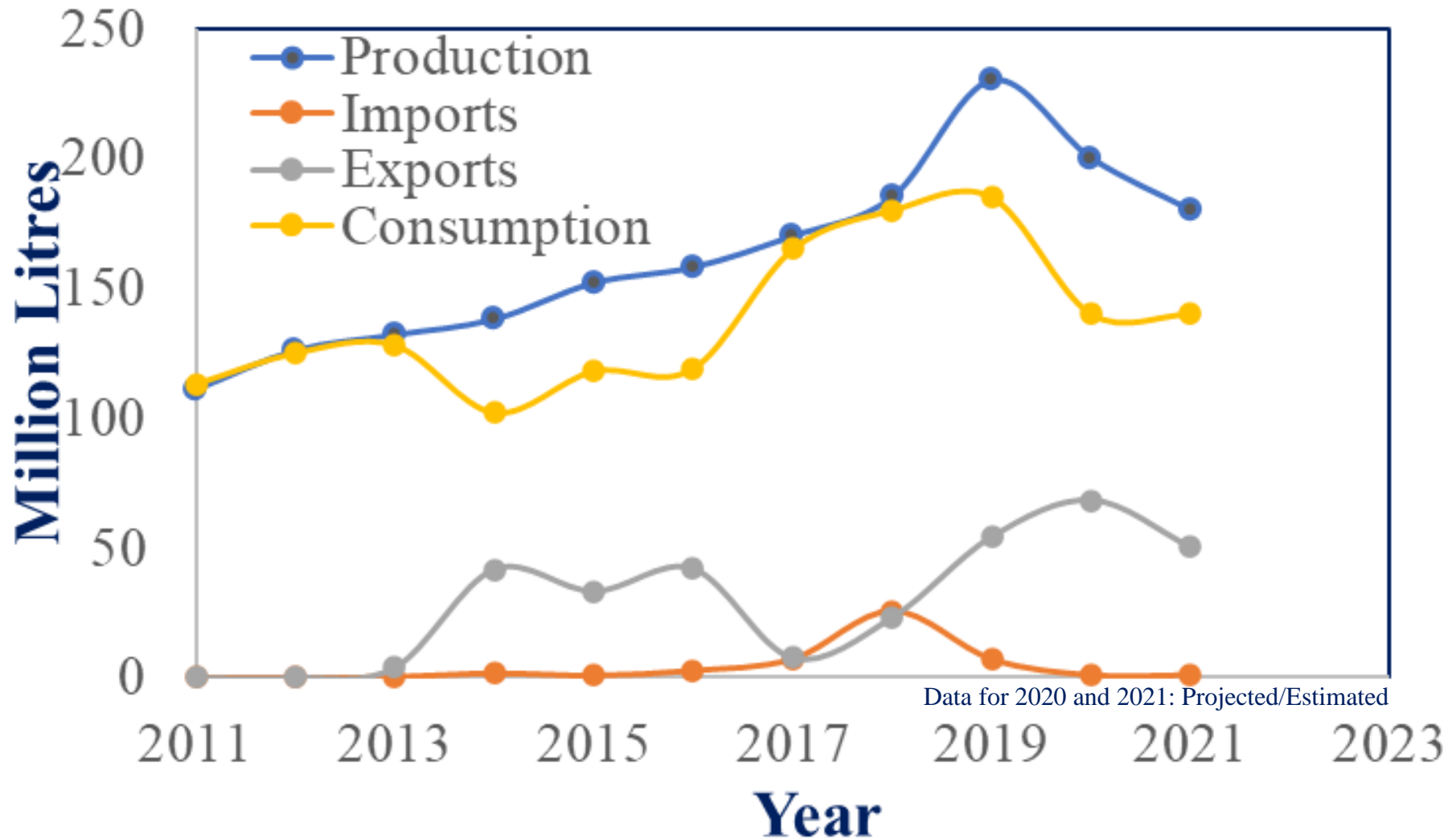
Biodiesel

- ❑ Biodiesel is defined as mono-alkyl esters of long chain fatty acids derived from vegetable oils or animal fats and alcohol with or without a catalyst
- ❑ Biodiesel is renewable, non-toxic, non-flammable, portable, readily available, biodegradable, sustainable, eco-friendly and free from sulfur and aromatic content, this makes it an ideal fuel for heavily polluted cities
- ❑ Biodiesel has a massive potentiality to be a part of a sustainable energy mix in the future
- ❑ Biodiesel may not require engine modification up to B20. However, higher blends may need some minor modification
- ❑ Biodiesel serves as climatic neutral in view of the climatic change that is presently an important element of energy use and development

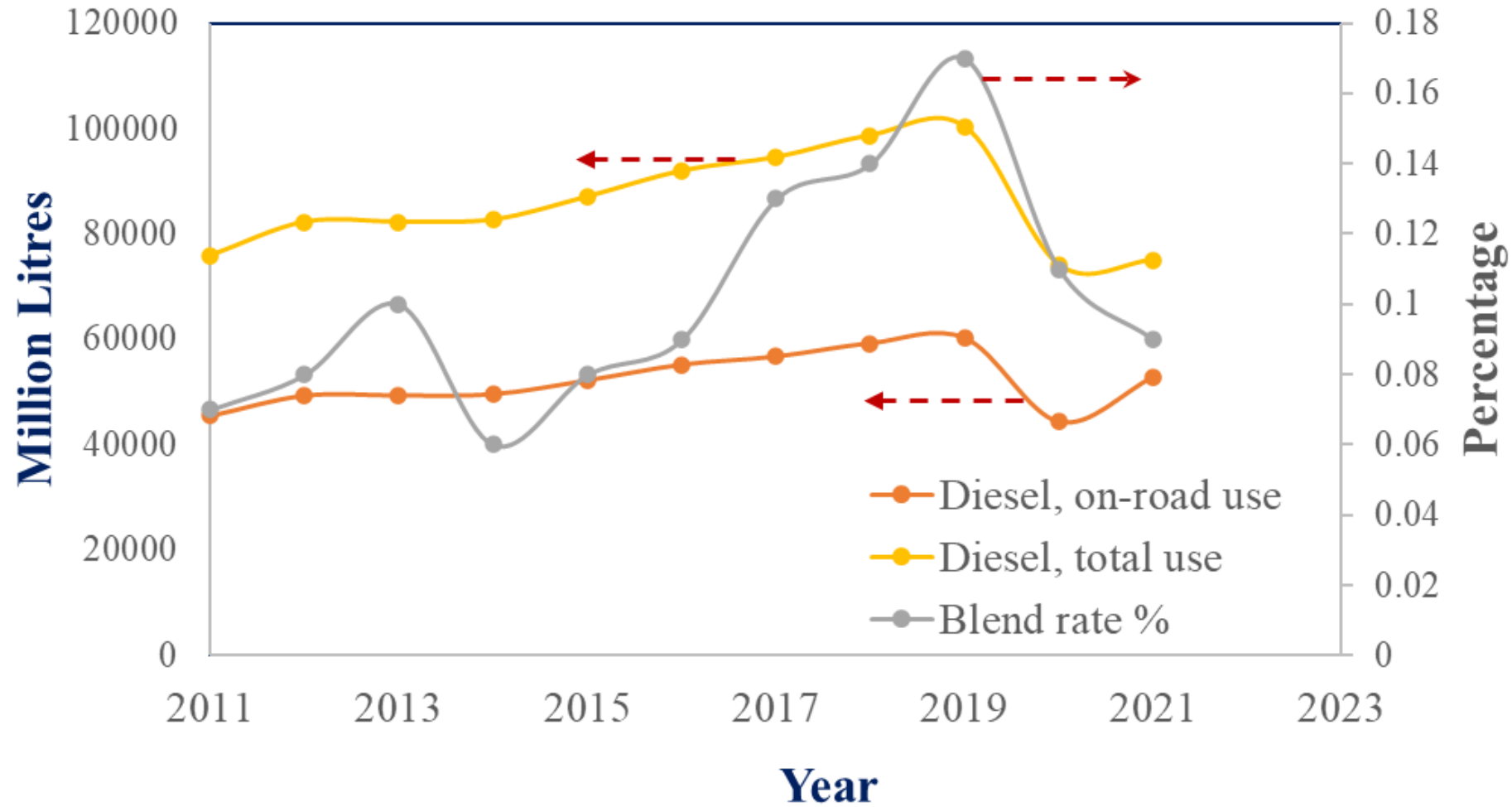
Biodiesel – Main Technologies

Technologies	Advantage	Disadvantage
Dilution (direct blending or micro-emulsion)	<input type="checkbox"/> Simple process	<input type="checkbox"/> High viscosity <input type="checkbox"/> Bad volatility <input type="checkbox"/> Bad stability
Pyrolysis	<input type="checkbox"/> Simple process <input type="checkbox"/> No-polluting	<input type="checkbox"/> High temperature is required <input type="checkbox"/> Equipment is expensive <input type="checkbox"/> Low purity
Transesterification	<input type="checkbox"/> Fuel properties is closer to diesel <input type="checkbox"/> High conversion efficiency <input type="checkbox"/> Low cost <input type="checkbox"/> suitable for industrialized production <input type="checkbox"/> No catalyst	<input type="checkbox"/> Low free fatty acid and water content are required (for base catalyst) <input type="checkbox"/> Pollutants will be produced because products must be neutralized and washed <input type="checkbox"/> Accompanied by side reactions <input type="checkbox"/> Difficult reaction products separation

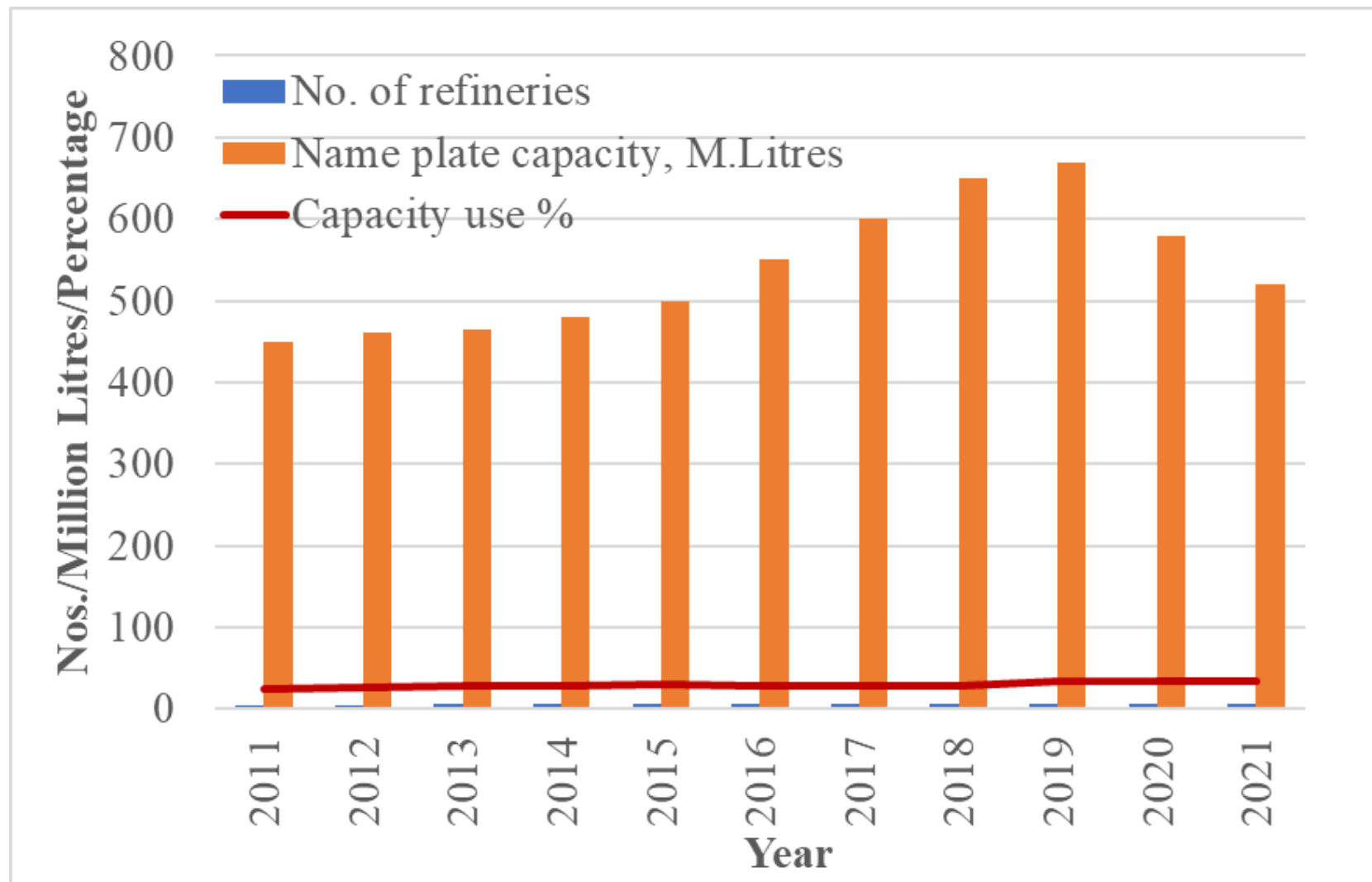
Biodiesel-Production/Consumption



Biodiesel-Market Penetration



Biodiesel-Refineries Production and Capacity use



Data for 2020 and 2021: Projected/Estimated

Biodiesel-Feedstock Use

in 1000 MT

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021*
Non-edible Industrial	58	65	70	75	85	90	100	110	140	145	90
Used Cooking Oil	42	48	49	50	55	55	55	60	65	50	55
Animal Fats/Tallows	6	7	7	6	5	6	6	8	10	9	9
Total	106	120	126	131	145	151	161	178	215	204	154

*projected figure

Biofuel Research and Development - India

Fuel	Substitute	Technologies Deployed
Diesel	*Biodiesel, **Green Diesel, Bio-based oxygenates (alcohols and ethers)	Esterification, Hydroprocessing, Fermentation, Syngas conversion
Aviation Turbine Fuel (ATF)	**Sustainable Aviation Fuel, or Bio Aviation Turbine Fuel	Hydroprocessing, Sugar conversion, alcohol-to-jet, Fischer–Tropsch process
Gasoline (Petrol/Motor Spirit)	*Ethanol (1G), **Ethanol (2G), **Methanol, Green (drop-in) gasoline	Fischer–Tropsch process, Gas Fermentation, Alcohol-to-gasoline, Hydroprocessing, Pyrolysis/Catalytic Cracking
Compressed natural gas (CNG)/piped natural gas (PNG)	*Bio-CNG/Bio-PNG, HCNG, Bio-H2	Waste Fermentation
Marine Fuel/Industrial Fuel Oil	**Green heavy distillate, biomass derived oils	Hydroprocessing, Pyrolysis/Fluid catalytic cracking, Hydrothermal Liquefaction, MSW-thermochemical processing

*Indicates technologies are available | **Indicates emerging technologies (in development)

Biodiesel - Remarks

- ❑ India's biodiesel industry remains in its nascent stage
- ❑ Biodiesel market remains informal, dispersed with minimal domestic production
- ❑ India's annual biodiesel consumption grew by six percent for the 2011-2019 period
- ❑ India's biodiesel market has tremendous growth potential - long way to reach B5 and B10
- ❑ Strategy for a financially sustainable domestic industry with sufficient feedstock availability is needed
- ❑ Limited number of domestic players - most of their production capacities are under-utilized - with few viable feedstock sources and limited government support mechanisms
- ❑ Non-edible oil, genetically engineered plants and microalgae feedstocks can be proper solutions for this problem and can ensure the sustainability of biodiesel production in the future