



Agricultural Biomass Waste and Livestock Waste

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Agriculture Biomass Waste – Introduction

- ❖ Ha Noi 3R Declaration had set a dedicated goal (Goal 11) for Agriculture Biomass Waste management from 2013 to 2023
- ❖ Aimed at maximum utilization of agricultural biomass and livestock waste in Asia and Pacific
- ❖ Other targeted implicit benefits included;
 - ❖ Energy security
 - ❖ Reduction in greenhouse gases (GHG)
 - ❖ Reduction in poverty
 - ❖ Sustainable livelihoods in rural areas
 - ❖ Reutilization of organic resources
- ❖ Following indicators may inform about the progress made through Ha Noi 3R Declaration
 - ❖ Annual generation
 - ❖ Annual utilization of agricultural biomass
 - ❖ Annual electricity production from agricultural biomass
 - ❖ Annual bioenergy capacity installed

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2 Sources of Agriculture Biomass Waste

- ❖ Agriculture Biomass Waste is the organic material (except fossil resources)
- ❖ Waste from Agriculture may include;
 - ❖ Straw, husk, bagasse, bran, leaves, stems, shell and others
- ❖ Waste from Fishery & Livestock may include;
 - ❖ Manure





Rice Straw (Image Source: Google)



Sugarcane Bagasse (Image Source: Google)

Annual Generation of Agriculture Biomass Waste in Asia Pacific

Countries	Quantity of Biomass Type (Million Tonnes)					References
	Agriculture	Livestock	MSW	Forest	Total	
Bangladesh	94.10	88.89	13.38	17.44	213.81	Hil Baky et al., 2017
Hong Kong SAR	N.A.	0.061	1.33	N.A.	1.391	EDP, 2020
India	500	1,095	21.67	59.68	1,676.35	Agamuthu et al., 2020; Bisht & Thakur, 2018
Japan	4.38	4.86	11.55	4.2	34	MAFF, 2021
Malaysia	131.4	21.7	7	N.A.	160.1	Agamuthu et al., 2020
Myanmar	19	N.A.	5.62	N.A.	24.62	Agamuthu et al., 2020
Pakistan	113.896	417.3	12.36	N.A.	543.556	World Bank, 2016; Khan et al., 2021
Singapore	0.313	N.A.	0.665	N.A.	0.978	NEA, 2021
Sri Lanka	6.86	N.A.	1.58	N.A.	8.44	Agamuthu et al., 2020
Thailand	174.1	N.A.	N.A.	N.A.	174.1	Jusakulvijit et al., 2021
The People's Republic of China	900	3,900	127,183	406.76	132,389.7	Guo et al., 2017; CICC, n.d
The Republic of Korea	1.584	2.05	1.625	N.A.	5.259	Statistics Korea, 2015
Viet Nam	94.71	86.92	13.23	N.A.	194.86	Son et al., 2021

Legislations on Agriculture Biomass Waste

- ❖ Majority of national legislations, policies, plans and strategies are related to energy
- ❖ The common theme between policies, plans and regulations of Asia and Pacific countries are summarized below:
 - i. A certain share of renewable energy sources (including biomass) in national electricity generation by a certain year
 - ii. Special focus on use of renewable energy sources for electricity and power in rural areas to make rural areas self-sustaining and also improve the socio-economic situation of villages
 - iii. Incorporating and implementation of feed-in-tariff scheme. Similarly, other initiatives such as government subsidies and loans (although at lower percentage) are also offered through national legislations
 - iv. Blending of biofuel and biodiesel by a certain year. Most of the countries with specific regulations, plans and strategies on biofuel and biodiesel blending clearly state the use of agricultural waste as the feedstock
 - v. Inclusion and implementation of bio-gasification for power and energy

Legislations on Agriculture Biomass Waste Since Ha Noi 3R Declaration

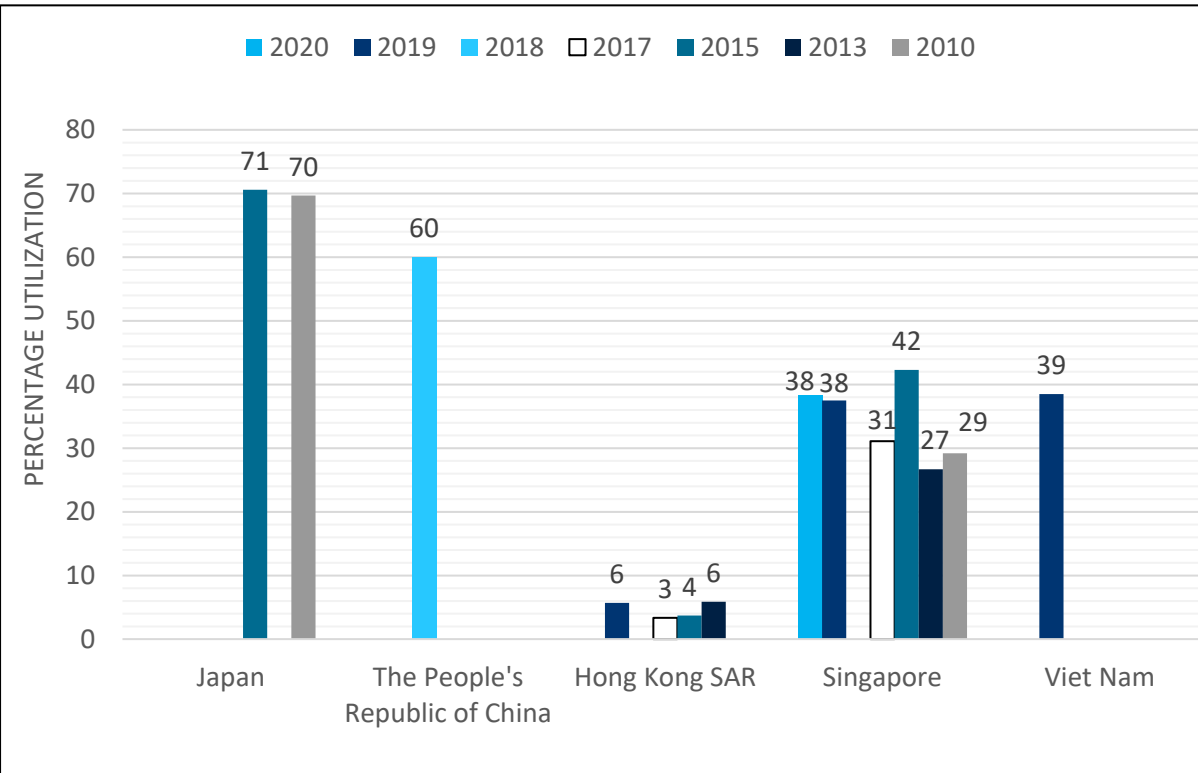
Asia Pacific Countries	Legislations, National Policies, Plans and Strategies					
	2013	2014	2015	2017	2018	2019
Cambodia	National Strategic Plan on Green Growth 2013 – 2030					Cambodia Basic Energy Plan
India	Biogas Power (off-grid) Programme	National Biogas and Manure Management Programme	India 175 GW Renewable Energy Target for 2022		National Policy on Biofuels	Draft National Energy Policy
Indonesia	Biofuel Blending (Ministry Regulation No. 25/2013)	Feed-in-Tariffs for Biomass and Municipal Waste (Ministerial Regulation No. 27/2014 and No. 44/2015)		Government Regulation No. 50 of 2017 on Utilization of Renewable Energy Sources for Power Supply		
Japan	Act No. 81 – Act on Promoting the Generation of Electricity from Renewable Energy Sources Harmonized with Sound Development of Agriculture, Forestry and Fisheries	Basic Energy Plan				
Lao PDR				Law on Electricity		
Malaysia					Green Technology Master Plan Malaysia 2017 – 2030	National Renewable Energy Policy

Legislations on Agriculture Biomass Waste Since Ha Noi 3R Declaration (Cont'd)

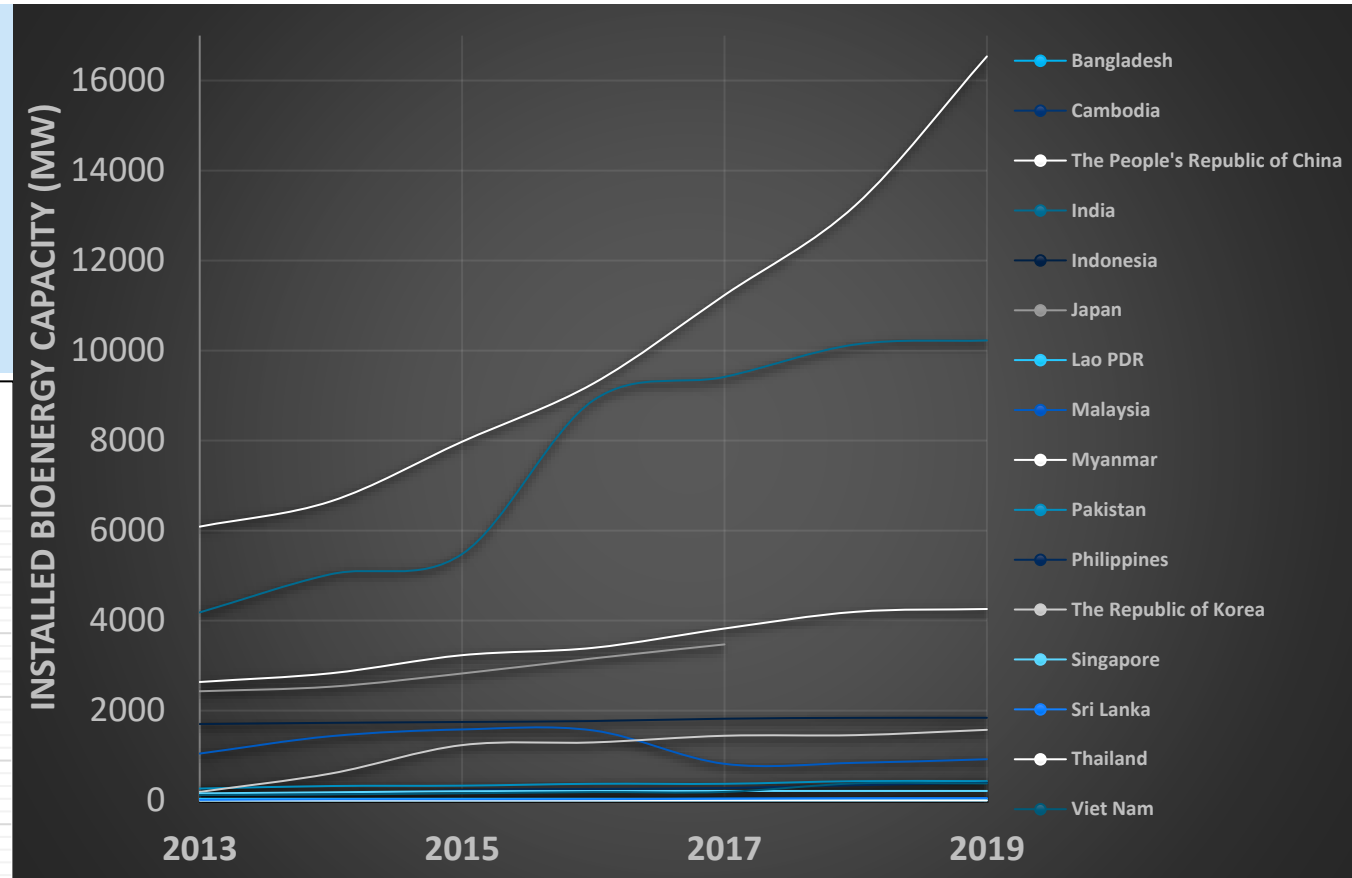
Asia Pacific Countries	Legislations, National Policies, Plans and Strategies					
	2013	2014	2015	2016	2017	2018
Myanmar		National Energy Policy			Myanmar Climate Change Strategy and Action Plan 2016–2030	Myanmar Sustainable Development Plan 2018 – 2030
Pakistan	Framework for Power Cogeneration 2013 Bagasse and Biomass					
Republic of Korea			Framework Act on Agriculture, Rural Community and Food Industry			
Thailand		Alternative Energy Development Plan: AEDP2015				
Viet Nam		Decision on support mechanisms for the development of biomass power project in Vietnam (biomass feed-in tariff)	Vietnam Renewable Energy Development Strategy 2016-2030 with outlook until 2050 (REDS)	National Power Development Plan 7 (PDPD7 – revised)		

Management of Agriculture Biomass Waste

- ❖ Goal 11-1 of Ha Noi 3R Declaration promotes 'full scale' utilization of agricultural biomass waste
- ❖ Which has not been achieved throughout Asia and Pacific
- ❖ Utilization includes reuse, composting, energy recovery, bio-methanation and others



Percentage of utilization of agricultural biomass waste in Asia and Pacific (MAFF, 2021; CICC, n.d.; EPD, 2020; NEA, 2021; NEA, 2016; Son et al., 2021)



The trend of installed bioenergy capacity in Asia and Pacific since Ha Noi 3R Declaration (Adapted from Asia Pacific Energy Portal, n.d.; MOEJ, 2021 (Personal Communications); Aikawa,

- ❖ Goal 11-2 of Ha Noi 3R Declaration promotes implementation of new projects for agricultural biomass waste management
- ❖ PR China, India, Thailand & Japan are leading in bioenergy capacity installation
- ❖ Overall upward trend of bioenergy capacity installation is observed in Asia and Pacific since Ha Noi 3R Declaration

Common Technologies Used for Agriculture Biomass Waste Management

❖ Reuse

- ❖ Reuse of agriculture biomass waste as fodder, biofertilizer, cooking fuel and others

❖ Composting

- ❖ Composting is the most commonly deployed technology for organic waste globally
- ❖ India has about 279 composting plants and 138 vermicomposting facilities
- ❖ Hong Kong composts horse stable waste, pig waste (92 tpd) and yard waste
- ❖ In China about 700 million tonnes of agricultural biomass waste was composted in 2018
- ❖ Organic fraction of MSW is composted in other Asia and Pacific countries

❖ Gasification

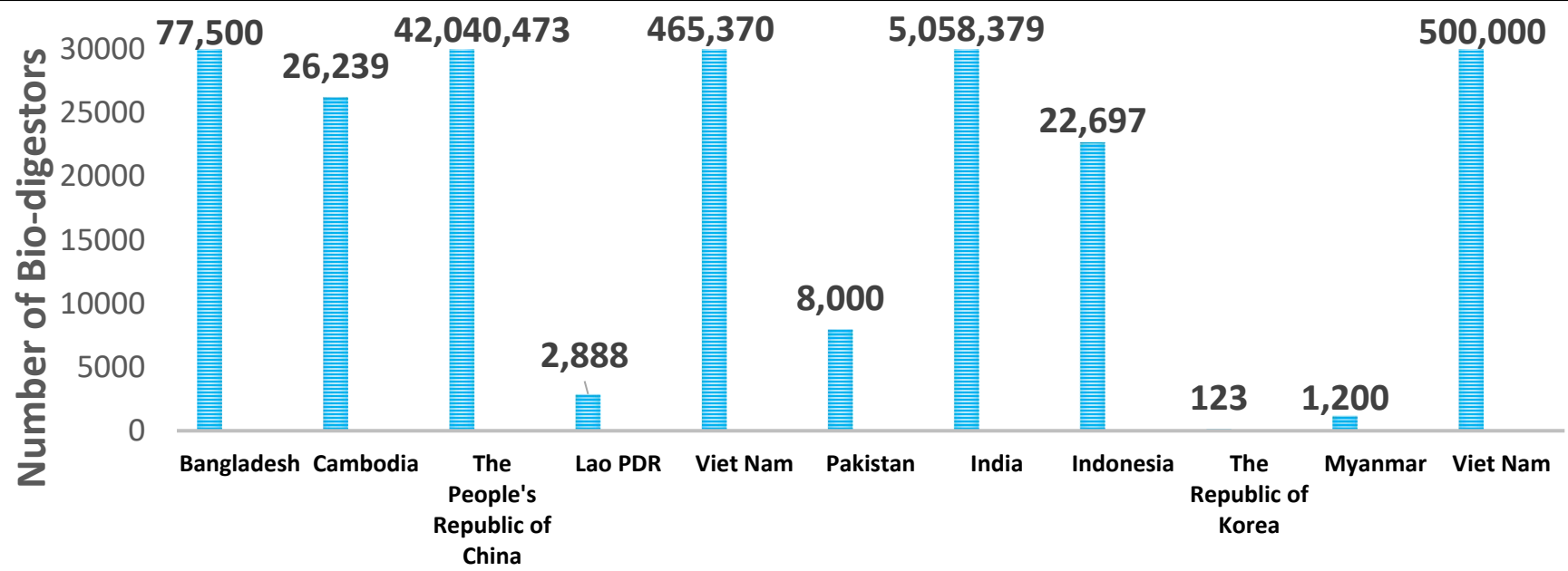
- ❖ Out of 270 operational gasification plants, only a few use agriculture biomass waste as feedstock (Lee et al., 2020)
- ❖ Small scale biomass gasifier has been used for generating electricity in South and Southeast Asia (REN21, 2018)
- ❖ 2 plants in Bangladesh process rice husks (Hil Baky et al., 2017)
- ❖ Myanmar has about 1,105 gasification plants which produce electricity from rice husk and wood chip (Tun & Juchelkova, 2019)



Compost (Image Source: Google)



Fodder for Animals (Image Source: Google)



Anaerobic digestion is one of the most commonly employed technology for agriculture biomass waste

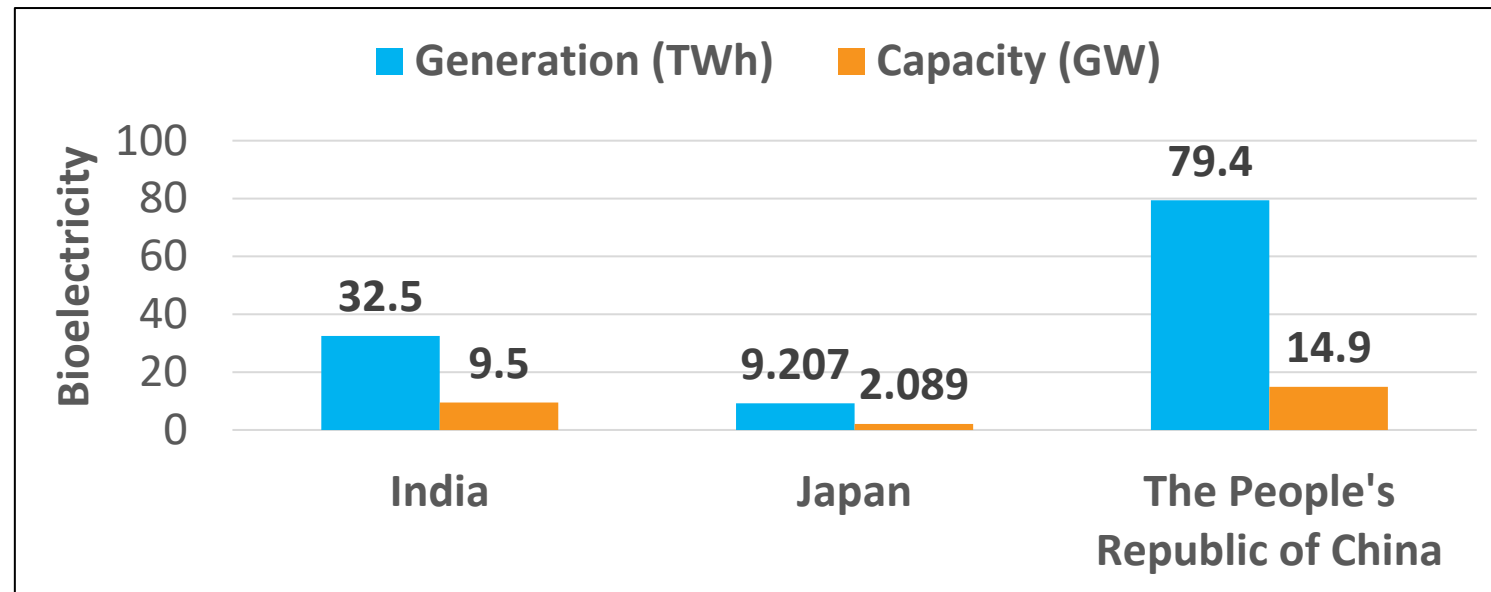
Treatment capacity & methane generation capacity of bio-digestors may vary in each country

Hence, number of bio-digestor may not directly be comparable in terms of capacity or scale

Number of bio-digestors present in selected Asia and Pacific countries

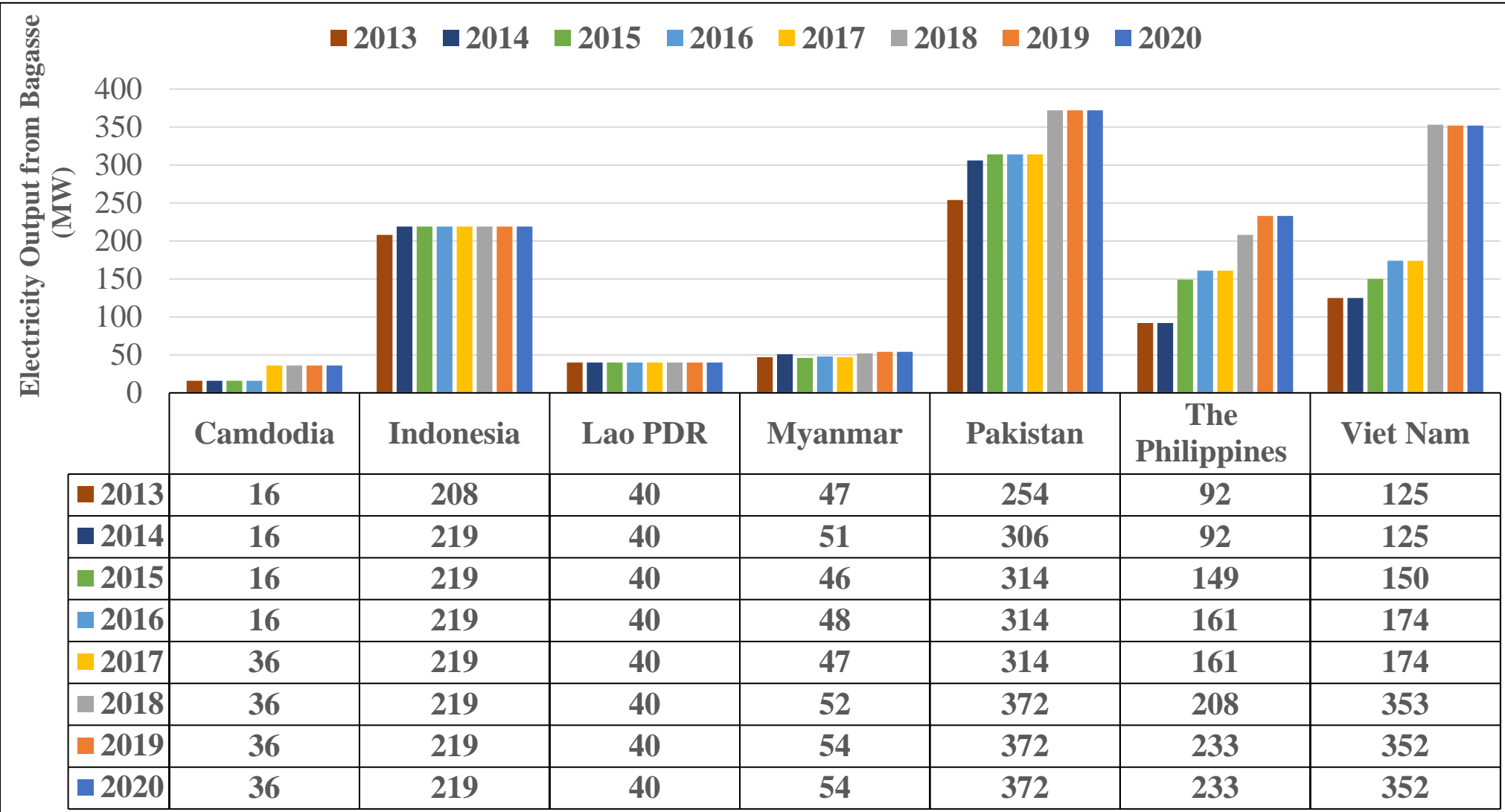
(MNRE, 2021; Khan et al., 2021; Giwa et al., 2020; Zheng et al., 2020; Tun & Juchelkova, 2019; GDE, 2019; Pirelli & Rossi, 2018; Kang, 2013)

- ❖ Agriculture biomass waste with low moisture content is incinerated
- ❖ In People's Republic of China, bio-power generation & capacity has increased by 23%
- ❖ 14% increase in generation capacity & 16% increase in generation of bioelectricity in Japan
- ❖ Bioelectricity capacity increased by 10% & generation increased by 8% in India



The generation and capacity of bioelectricity in 2017 (REN21, 2018; MOEJ, 2021)

Common Technologies Used for Agriculture Biomass Waste Management (Cont'd)

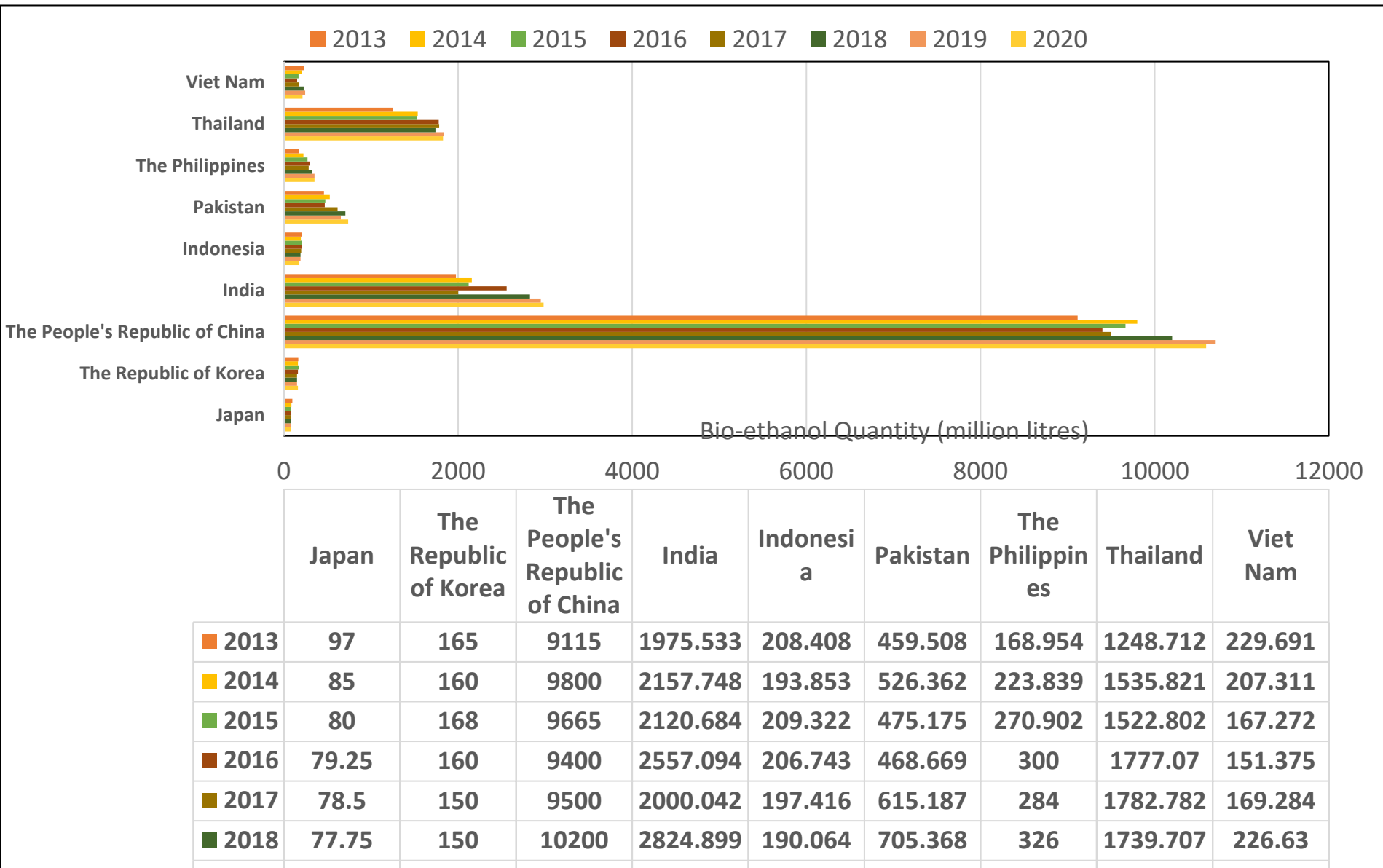


- ❖ Cogeneration of agricultural biomass waste can provide heat & electricity as by-product
- ❖ Mainly bagasse is utilized for cogeneration
- ❖ Pakistan has total capacity of cogeneration of 830 MW
- ❖ India has total capacity of cogeneration of 9,373 MW

The trend of utilization of bagasse for electricity output in Asia and Pacific since Ha Noi 3R Declaration

(Adapted from IRENA, 2021)

Innovative Technologies for Agriculture Biomass Waste Management

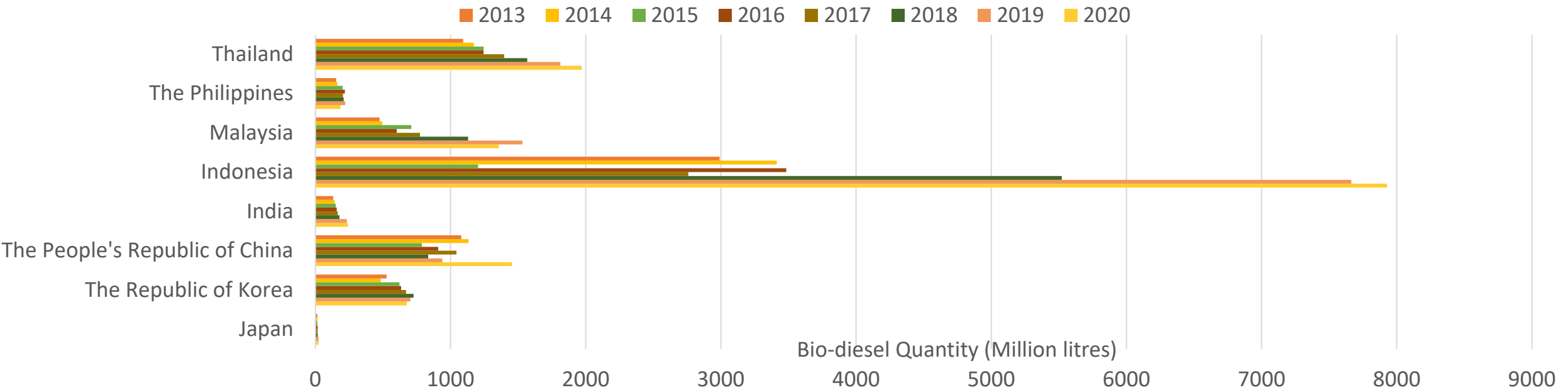


- ❖ Fermentation can be used to produce bio-ethanol and bio-diesel
- ❖ Wood residue, straw waste and crop residues can be used to produce bioethanol
- ❖ About 98.4 billion litres of bioethanol were produced globally in 2018 and Asia produced 6.87 billion litres
- ❖ Starch-based or sugary feedstock is used for bioethanol production, thus use of agriculture biomass waste for bioethanol production is not as common

The trend of production of bio-ethanol in Selected Asian and Pacific countries since Ha Noi 3R Declaration

(Adapted from OECD-FAO, n.d.)

Innovative Technologies for Agriculture Biomass Waste Management (Cont'd)



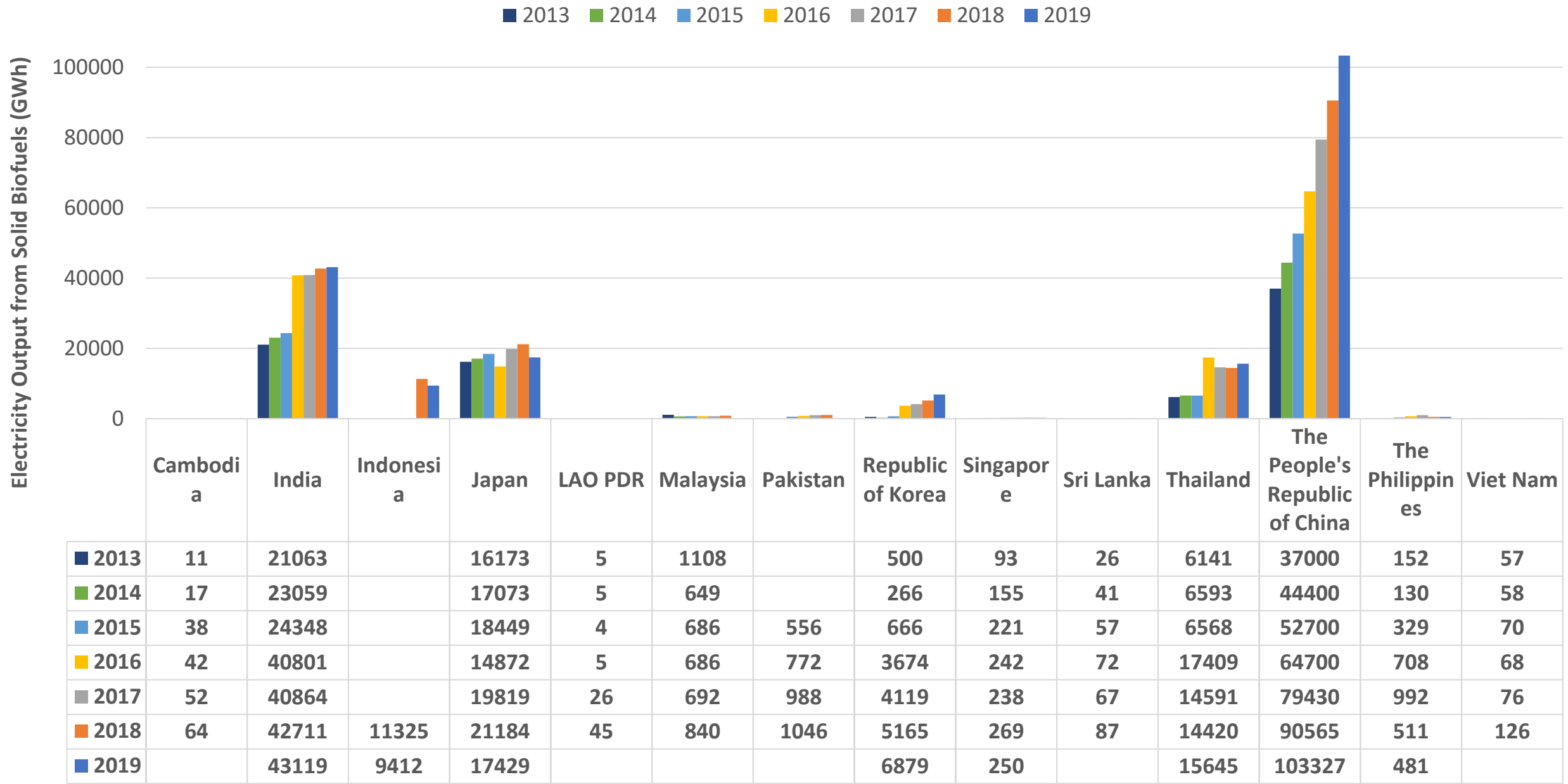
	Japan	The Republic of Korea	The People's Republic of China	India	Indonesia	Malaysia	The Philippines	Thailand
2013	14	526.465	1079	131.6	2989.999	474.999	153	1093
2014	15	484.007	1133	141.8	3413.999	494.999	163	1172
2015	15	621.989	787	150.3	1202.999	708.999	201	1244
2016	16	633.706	909	158	3483.999	600.999	218	1244
2017	16	670.515	1043	165.5	2758.999	773.999	204	1397
2018	17	726.466	834	177.9	5521.999	1129.999	208.999	1567
2019	23	702.528	939	232	7663.999	1531.999	219.999	1812

The trend of production of bio-diesel in Selected Asian and Pacific countries since Ha Noi 3R Declaration

(Adapted from OECD-FAO, n.d.)

Conclusion

- ❖ Agricultural biomass waste is seen more as a commodity for energy extraction than a resource to be reused and recycled
- ❖ Technologies such as bio-gasification, cogeneration, co-firing and fermentation for biofuels are mainly employed in Asia and Pacific
- ❖ An overall increasing trend of electricity output from agricultural biomass waste highlights the progress made as per Goal 11 of Ha Noi 3R declaration
- ❖ However, Asia and Pacific developing countries i.e. Cambodia, Viet Nam, India, Pakistan and others openly burnt or openly disposed of agriculture biomass waste
- ❖ Some form of utilization of agricultural biomass waste occurs in Asia and Pacific such as anerobic digestion, mulching, use as fodder etc. but is not as extensive
- ❖ Cambodia, Myanmar, Malaysia, Viet Nam, Thailand, Indonesia, India, Japan, and The Republic of Korea have formulated plans and policies for utilization of agriculture biomass waste for energy recovery after the Ha Noi 3R Declaration

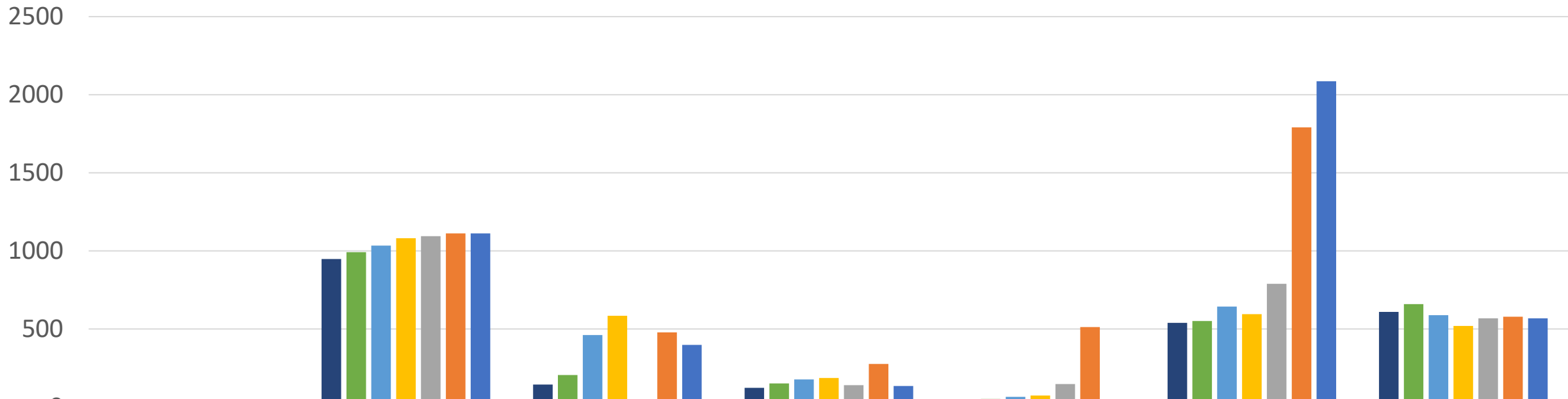


The trend of electricity generation from solid agricultural biomass in Asian Pacific countries since Ha Noi 3R Declaration

(Adapted from IEA, 2021)

■ 2013 ■ 2014 ■ 2015 ■ 2016 ■ 2017 ■ 2018 ■ 2019

Electricity Output from Biogases (GWh)



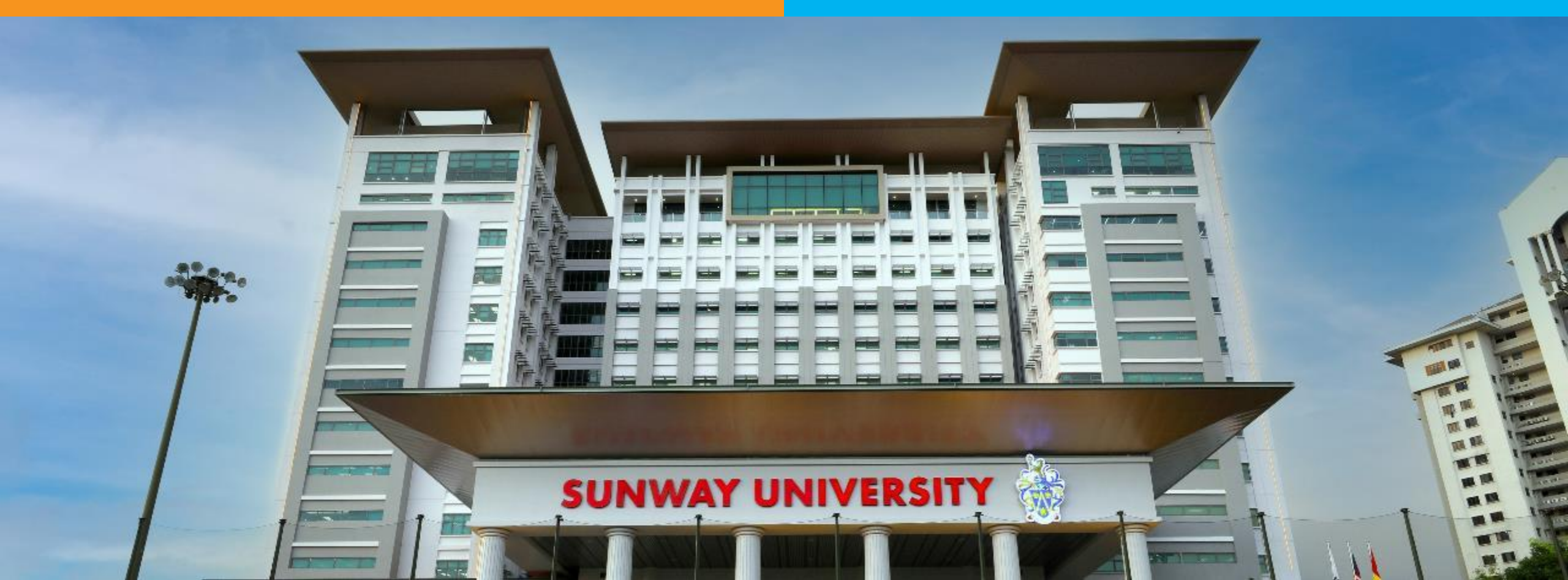
	Hong Kong SAR	India	Indonesia	Japan	Malaysia	Thailand	The Republic of Korea
2013	36	948	144	123	23	539	609
2014	43	992	205	151	52	551	659
2015	43	1034	461	177	65	643	588
2016	40	1081	584	186	74	595	519
2017	41	1094		140	147	789	568
2018	43	1112	478	276	512	1791	578
2019		1112	398	135		2086	568

The trend of electricity generation from biogases in Asian Pacific countries since Ha Noi Declaration

(Adapted from IEA, 2021)

Way Forward

- ❖ **A holistic approach is required by renewable energy sector to achieve the common goal**
 - ❖ Hydro or solar energy capacity and projects are greater in number than agricultural biomass waste related capacity and projects
- ❖ **Efforts from all stakeholders are required to realize the maturation of technologies for maximum extraction of resources from agricultural biomass waste. Similar attempts must be made to scale up the new technologies to increase their capacity, advancing from laboratory scale to pilot scale to commercialisation**
- ❖ **There is an urgent requirement for dedicated legislations for the management of agricultural biomass waste. Only developed countries of Asia and Pacific have specific waste laws for agricultural biomass waste**
- ❖ **Post Ha Noi 3R Declaration, several clear goals or targets could be set for agriculture biomass waste, such as**
 - ❖ Data collection
 - ❖ Quantitative targets of utilization
 - ❖ Quantitative targets of increase in installed capacity for bioenergy
 - ❖ Quantitative targets of reducing GHG emissions
 - ❖ Encouraging technology sharing and capacity building between developed and developing countries of Asia and Pacific



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Some of My Books

Senior Editor in
Chief of Journal



Innovative Technologies for Agriculture Biomass Waste Management

❖ Hydrothermal Liquefaction

- ❖ Depolymerises, degrades and repolymerises organic waste
- ❖ By-products include biogas, bio-oil and bio-char
- ❖ Technology is still in infancy stage and requires further research

❖ Industrial Insect Farming (Ragossnig & Ragossnig, 2021)

- ❖ Hundreds of tonnes of organic waste can be processed in a day
- ❖ By-products may include insect oil, frass product and high-quality organic fertilizer
- ❖ It may create competition among several technologies for agriculture biomass waste as feedstock

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LCA of Technologies for Agriculture Biomass Waste Management

❖ Life-Cycle Analysis (LCA) can be used to assess the performance of technologies for agriculture biomass waste management

❖ LCA can provide quantitative and qualitative analysis of technologies i.e.:

- ❖ GHG reductions
- ❖ Energy savings
- ❖ Heat / Power savings

Agricultural Biomass Waste	Technology	Benefits	References
Sewage Sludge, Woody biomass	Proposed: Gasification Current: Incineration	Annual GHG emission savings 138.9 – 165.9 million kg CO ₂ -eq, better electricity recovery & by-product biochar	Ramachandran et al., 2017
Food waste, pig slurry, cattle slurry, maize	Anaerobic digestion with different combination of biomass	Reductions of 128.6 – 634.2 kg CO ₂ -eq/MWh heat	Welfle et al., 2017
Pig/cow manure	Anaerobic digestion for bioelectricity	-128 – -395 g CO ₂ -eq	Tonini et al., 2016
Manure	Anaerobic digestion for biogas (bio-methanation)	44 – 104 g CO ₂ -eq MJ ⁻¹	
Straw/stover		20 – 50 g CO ₂ -eq MJ ⁻¹	

Ha Noi 3R Declaration and Sustainable Development Goals

- ❖ Target 2 of SDG 7 (Affordable and Clean Energy) requires significant increment of renewable energy in the share of energy mix worldwide by 2030
- ❖ The target 4 of SDG 12 (Responsible Consumption and Production) encourages environmentally sound management of waste throughout their life-span, which would also cover agriculture biomass waste and target 5 sets the goal of waste reduction through resource circulation
- ❖ Indirectly, SDG 11 (Sustainable Cities and Communities) has target 11.6 which aims towards reducing per capita negative environment impacts through air quality and waste management which could include agriculture biomass waste