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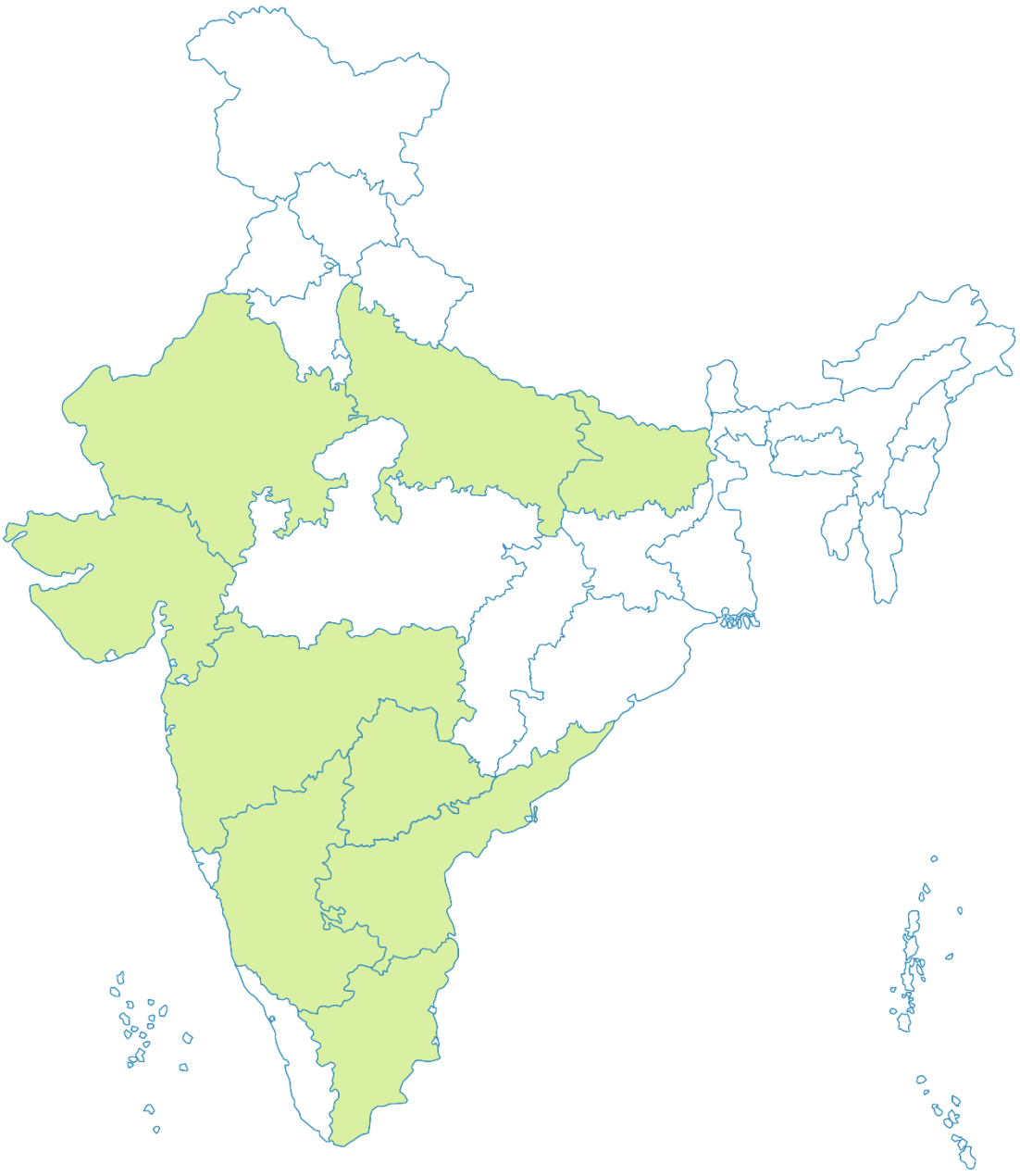
UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION



MNRE-GEF-UNIDO

Identification of Potential States for Energy Generation using Organic Waste from Sugar, Poultry, Cattle farm and Fruit, Food and Vegetable Processing Industries

Part-2

INCLUSIVE AND SUSTAINABLE INDUSTRIAL DEVELOPMENT

PREFACE

United Nations Industrial Development Organisation (UNIDO) is implementing a GEF supported project "Organic Waste Streams for Industrial Energy Applications in India" jointly with the Ministry of New and Renewable Energy (MNRE), Government of India. The project aims to contribute to its climate change strategic objective namely, promoting investment in renewable energy technologies by transforming the market for using organic waste for SME industrial energy applications in India; and focuses on supporting different technological and commercial innovations in the application of bio-methanation technology (Biogas or Anaerobic Digestion).

An analysis of waste generation in industrial sector and review of existing scenario of commercial waste to energy technologies carried out by UNIDO in project preparation phase reviewed the 14 sectors identified under the National Master Plan to select priority SME sectors and clusters with the most promising potential for the use of organic waste streams. This resulted in the identification of four targeted industrial sectors namely, (i) Sugar, (ii) Poultry, (iii) Cattle farming and (iv) Fruit, vegetable and food processing where large potential exists but the resources remain unexploited for energy conversion.

A study for mapping the urban and industrial organic waste availability across India is being carried out by UNIDO, also to determine energy generation potential from different organic wastes. A comprehensive and integrated "Bio-Resource Map" of the organic waste from four targeted sectors will be developed using GIS applications. A complete study will have following outcome reports.

Part – I	Identification of Organic Waste Streams in India
Part – II	Identification of Potential States for Energy Generation Using Organic Waste from the Targeted Industries
Part – III	Availability, Utilisation Pattern and Price of Organic Waste from Targeted Industries in Potential States
Part – IV	Characterisation of Organic Waste from Targeted Industries in Potential States.
Part – V	A Comprehensive Map (GIS) of the Organic Waste from Targeted Industries in Potential States.
Part – VI	National and Regional Level Conferences on Energy Generation from Waste from Targeted Industries in Potential States.

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Abbreviations

AIDA	:	All India Distillers' Association
AIFPA	:	All India Food Processors' Association
AIWPA	:	All India Wine Processing Association
APEDA	:	The Agricultural and Processed Food Products Export Development Authority
ASI	:	Annual Survey of Industries
BOD	:	Biological Oxygen Demand
CBG	:	Compressed Biogas
CFTRI	:	Central Food Technological Research Institute
CLRI	:	Center Leather Research Institute
CNG	:	Compresseds Natural Gas
COD	:	Chemical Oxygen Demand
CPCB	:	Central Pollution Control Board
DADF	:	Department of Animal Husbandry Dairying & Fisheries
DPR	:	The Directorate of Poultry Research
ETP	:	Effluent Treatment Plant
F&V	:	Fruits and Vegetable
FGD	:	Focus group discussion
FOASTAT	:	Foundation for Open Access Statistics
GCMMF	:	Gujarat Cooperative Milk Marketing Federation Ltd.
GEDA	:	Gujarat Energy Development Agency
GEF	:	Global Environment Facility
HPMC	:	Himachal Pradesh Horticulture Produce Marketing and Processing Corporation Ltd
IARPMA	:	Indian Agro & Recycled Paper Mills Association
IBA	:	Indian Biogas Association
ICAR	:	Indian Council of Agriculture Research
IISR	:	The Indian Institute of Sugarcane Research
ISMA	:	Indian Sugar Mill Association
IWA	:	Indian Wine Academy
LPG	:	Liquefied Petroleum Gas
MAIDC	:	Maharashtra Agro Industries Development Corporation Ltd
MEDA	:	Maharashtra Energy Development Agency
MNRE	:	Ministry of New & Renewable Energy
MOAFW	:	Ministry of Agriculture & Farmers Welfare
MOSPI	:	Ministry of Statistics and Program Implementation
MPEDA	:	Marine Products Export Development Authority
MSME	:	Micro, Small and Medium Enterprises
MSW	:	Municipal Solid Waste
MT	:	Metric Ton
MW	:	Mega Watt
NAPCC	:	National Action Plan on Climate Change
NEDA	:	Non-conventional Energy Development Agency
NHB	:	National Horticulture Board
ORS	:	Organic Recycling System
PCDF	:	Pradeshik Cooperative Dairy Federation
PESO	:	Petroleum Explosive Safety Organization

PPG	:	Project Preparation Grant
SEA	:	Solvent Extractors Association
SNA	:	State Nodal Agency
TEDA	:	Tamil Nadu Energy Development Agency
TPD	:	Ton Per Day
TS	:	Total Solids
UNDP	:	United Nations Development Program
UNIDO	:	United Nations Industrial Development Organization
UP	:	Uttar Pradesh
VS	:	Volatile Solid
VSI	:	Vasantdada Sugar Institute
WTE	:	Waste to Energy

1.0 ORGANIC WASTE STREAMS IN INDIA

1.1 Background

The project "Organic waste streams for industrial renewable energy applications in India" reflects the Government's priorities to promote sustainable development as set out in the National Action Plan on Climate Change (NAPCC). To further access the potential of energy generation from industrial and urban organic wastes, a study entitled "Organic waste streams for industrial renewable energy application in India" was undertaken by GEF under the project preparation grant (PPG) in consultation with Ministry of New and Renewable Energy (MNRE). During the study bio methanation (Anaerobic Digestion) was identified as most feasible technology for organic waste to energy generation.

The platform for accelerating the implementation of bio methanation technologies in India to maximise potential of available organic industrial waste for energy generation was built upon four important areas, which included:

- Identification of SMEs sector with highest untapped potential
- Identification of most suitable business models based on level of innovation, technology, integration capability, end applications and acceptance by technical and financial due diligence.
- Mapping of actual availability of selected categories of industrial organic wastes across various locations in India.

With the above background, this assignment aims to develop comprehensive and integrated "**Bio Resource Map**" of organic industrial waste using GIS application for mapping actual availability of organic wastes in identified sectors across various locations in India. It also includes organization of "**National/ State Level Conferences**" to introduce the project to relevant stakeholders and share Bio-resource Map which will facilitate them in exploring installation of potential organic waste to energy projects.

The first progress report for the project included state wise assessment of the urban and industrial organic wastes in India, which included identification of waste sources, estimation of waste generation quantities and estimation of energy potential for urban and industrial organic waste streams in India. The current report is an extension of first progress report; summarises content of first progress report and provides detail matrix on estimated waste generation and energy potential of urban and industrial organic waste. This report also provides detail assessment of four key sectors such as poultry industry, sugar industry, fruit & vegetable processing industry and cattle farming, priorities and shortlisting of states and districts / regions based on the waste generation/ availability and other parameters. This report further provides a detail strategy for field investigations, visits and stakeholder consultation for each identified sector and the states.

1.2 Organic Waste Streams

This chapter summarises findings of the first progress report of project which is primarily focused on identification of organic waste stream, waste estimation and calculation of energy generation potential. Potential sectors generating organic industrial waste were identified based on series of discussion between UNIDO and Arcadis team, earlier studies conducted by UNIDO / MNRE, data collected from Annual Survey of Industries, from industrial sectors already explored across country to set up WTE plants and industries listed in and Ministry of Food Processing Industries.

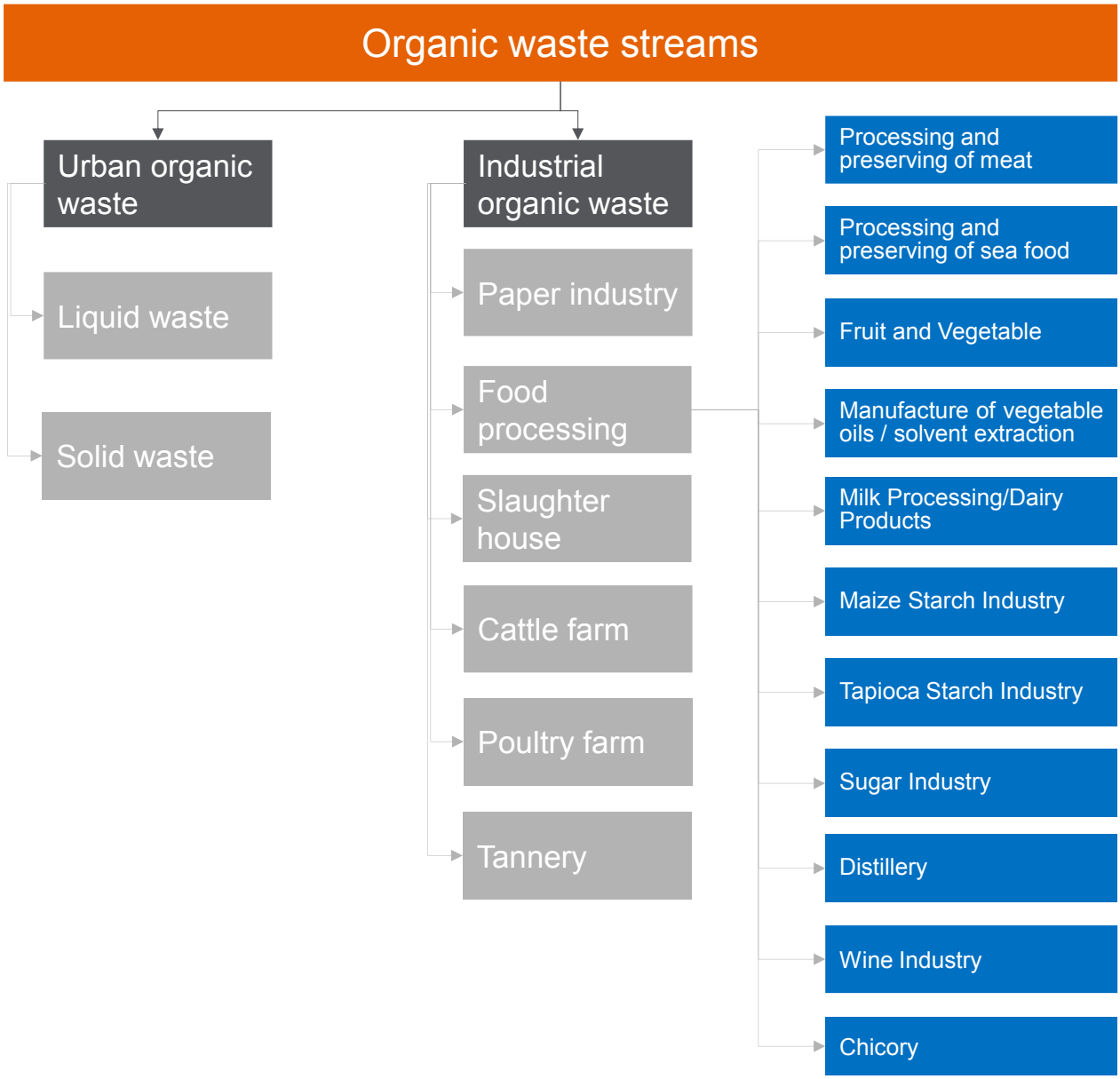
Identification of potential sectors followed with identification of waste streams in solid and liquid form and their quantification. Waste estimation for various sectors was done in reference to various research articles, government guidelines and published reports. In the absence of any published document, direct consultation was undertaken with the players working in the respective sector such as industries and technology providers.

1.2.1 Identification of Potential Sectors

There are more than 175 classification of industry groups in India as per Annual Survey of Industries (2013-14), which includes more than thousand categories of industries. However, the current study is limited to the sectors generating organic waste and having potential to supply it to energy plants based on bio-methanation technology. Selected industry category for assessment as part of this project were identified based on the earlier studies conducted by Ministry of New and Renewable Energy (MNRE) and UNIDO; few other industrial categories generating organic waste and having potential for energy generation were also included. National master plan for development of waste to energy in India was prepared by MNRE focusing on 14 key urban and industrial sectors which generate organic waste. In addition to

these 14 sectors[1], current study also evaluated the energy generation potential from cattle farm, food processing industry (18 category of industries) solvent extraction, meat processing, seafood processing and wine industry. The details of sectors considered for the study is presented in Figure 1-1.

Figure 1-1: Organic waste streams



Several secondary sources were considered for getting data on urban and industrial waste generation for assessment. Key secondary data sources and type of data available have been detailed in the following table.

Table 1-1: Sector wise key sources and scale of data availability

Sl. No.	Sector	Key Source	Scale of data available
1	Urban solid waste and urban liquid waste	Central Pollution Control Board (CPCB) Ministry of Urban Development (MOUD)	State level
2	Meat processing	Annual Survey of Industries, Ministry of Statistics and Program Implementation (ASI, MOSPI)	State level
3	Seafood processing	Annual Survey of Industries, Ministry of Statistics and Program Implementation (ASI, MOSPI)	State level

[1] http://www.seas.columbia.edu/earth/wtert/sofos/Natl_%20Master_%20Plan_of_India.pdf

Sl. No.	Sector	Key Source	Scale of data available
		Marine Products Export Development Authority (MPEDA)	
4	Fruit and vegetable processing	Annual Survey of Industries, Ministry of Statistics and Program Implementation (ASI, MOSPI) Indian Horticulture Database 2014	State level
5	Milk processing (dairy)	Annual Survey of Industries, Ministry of Statistics and Program Implementation (ASI, MOSPI) Department of Animal Husbandry Dairying & Fisheries (DAHDF)	State level
6	Solvent extraction	Annual Survey of Industries, Ministry of Statistics and Program Implementation (ASI, MOSPI) Solvent Extractors Association of India, SEA Handbook 2014	State / district level
7	Slaughter house, cattle farm, poultry farm	Department of Animal Husbandry Dairying & Fisheries (DAHDF) Basic Animal Husbandry & Fisheries Statistics 2015, Ministry of Agriculture & Farmers Welfare (MOAFW) 19th Livestock census 2012	State / district level
8	Maize starch	Annual Survey of Industries, Ministry of Statistics and Program Implementation (ASI, MOSPI) Directorate of Economics and Statistics, Department of Agriculture and Cooperation	State level
9	Sugar industry	Indian Sugar Mills Association (ISMA) Directorate of Sugarcane Development Government of India, Ministry of Agriculture & Farmers Welfare Department of Agriculture, Cooperation & Farmers Welfare	State / district level
10	Tapioca starch	Central Tuber Crops Research Institute (CTCRI) Indian Horticulture Database 2014	State level
11	Tannery industry	Central Leather Research Institute (CLRI)	State level
12	Distillery industry	All India Distillers' Association (AIDA) Directory of Indian Distilleries, 2015 -16	State / district level
13	Paper industry	Indian Agro & Recycled Paper Mills Association's "In paper Directory on Indian Paper Manufactures and Allied Industry, 2016	State / district level
14	Wine industry	Indian wine academy (IWA)	State level
15	Chicory processing	Farmers and Industries (chicory manufacturers)	State level

1.2.2 Waste Quantification

Assessment of waste generation for each identified sector has been done based on data available from secondary source which include published data from various organisations on quantity of the raw material processed by industries, quantity of the final product manufactured, number of animals/birds (for poultry, cattle waste, slaughter house), waste generation data (if available e.g. urban solid and liquid waste). For the cases where waste generation estimates were not available from reliable sources, the same were quantified based on applying suitable waste generation factors on production, processing or final output, whichever applicable. Waste generation factors were referred from various secondary sources such as research papers, published reports and government guidelines, discussions with the industry and plant operators.

Both solid and liquid waste streams generated from all identified sectors has been estimated for assessment. Table 1-2 presents a brief of the type of raw material and waste generated for the identified sectors.

Table 1-2: Sector wise type of data used to assess the waste, raw material and waste streams

Sl. No.	Sector	Data base to estimate the waste quantity	Raw material	Waste stream – solid	Waste stream – liquid
1	Meat processing	State wise raw material processed by the industries	Raw meat	Flesh, bone, fat, hair	Blood, water
2	Milk processing (dairy)		Milk	NA	Milk, water mixed with other dairy products
3	Fruit and vegetable processing		Fruits and vegetables	Peel, pulp, leaves, seeds, juice	NA
4	Maize starch		Maize	NA	Steep liquor
5	Solvent extraction		Oilseed	Oilseed cake	NA
6	Cattle farm, poultry farm	State wise number of cattle/poultry in the farms/sector	Cattle, Poultry	Cattle dung Poultry litter	NA
7	Slaughter house	State wise number of animals slaughtered	Animals (cattle, buffalo, pig)	Flesh, bone, fat, hair, head, skin	Blood, waste water having organic matter
8	Urban solid waste	State wise quantity of waste generated	Solid waste	Solid waste	
9	Sewage (liquid waste)	State wise sewage generation in class I and II cities.	Sewage	NA	Sewage
10	Sugar industry	State wise cane crushed in sugar industry	Sugarcane	Press mud	Stillage
11	Seafood processing	State wise seafood exported from India**	Fish, crustaceans and molluscs	Skin, head, bones,	Blood, waste water having organic matter
12	Tapioca starch	State wise quantity of tapioca starch manufactured	Tapioca	Peel, pulp	Starchy water
13	Tannery industry	Quantity of leather manufactured	Animal skin	Skin, salt, hair	Effluent
14	Distillery industry	State wise number of industries and plant capacity 65% of the capacity utilisation is considered	Molasses, grains	NA	Spent wash
15	Paper industry	State wise number of industries and plant capacity 65% of the capacity utilisation is considered*	Wood, bagasse, grass, waste paper	NA	Black liquor
16	Wine industry	State wise quantity of wine production	Grapes	Stalk and marc	NA
17	Chicory	State wise chicory processing data	Chicory	Chicory pieces	NA

**Capacity utilisation factor for the operating plants is approximately 80% (http://shaktifoundation.in/wp-content/uploads/2014/02/pulp_paper.pdf). However, currently approximately 100 units are closed. Hence capacity utilisation factor of 65% of the installed capacity has been considered*

*** For waste estimation from the processing industry, data on export of seafood have been referred. Most of the pre-processing plants and processing plants currently operate with only 50% of their capacity or even less, hence waste estimation based on processing plants would not give the correct picture of the actual quantity processed.*

Table 1-3 presents the matrix on waste estimation for all the sector in different states.

Table 1-3: Matrix showing sector wise urban and industrial waste generation for different states (solid waste in million ton and liquid waste in million m^3)

S. No	States/ UTs	MSW	Sewage	Sugar		Poultry	Distillery	Cattle farm	Maize	Tapioca		Milk Processing	Vegetable Raw	Vegetable Processing	Fruit Raw	Fruit Processing	Palm Oil	Slaughter		Tannery	Tannery	Meat	Meat	Fish	Paper	Chicory
		Solid	Liquid	Press mud	Effluent	Solid	Liquid	Solid	Liquid	Solid	Liquid	Liquid	Solid	Solid	Solid	Solid	Solid	Solid	Liquid	Liquid	Solid	Solid	Liquid	Liquid	Liquid	Solid
1	Andhra Pradesh	4	4	*0.3*	1	4	3	12	7	*0.1*	12	4	*0.9*	*0.02*	1	*0.1*	*0.01*	*0.2*	2			*0.001*	*0.04*	9	22	
2	Arunachal Pradesh	*0.04*				*0.002*		*0.0*							*0.02*			*0.01*	*0.1*							
3	Assam	*0.2*	141			*0.1*		*1.0*				*0.2*	*0.1*		*0.3*			*0.01*	*0.3*						6	
4	Bihar	*0.6*	408	*0.2*	*0.9*	*0.3*	*0.7*	*15.7*				*0.7*	2	*0.002*	*0.6*	*0.0002*		*0.2*	2						1	
5	Chhattisgarh	*0.7*	143	*0.03*	*0.2*	*0.9*	*0.1*	*1.2*	*0.9*			*0.05*	*0.2*		*0.1*			*0.004*	*0.2*						1	
6	Goa	*0.1*	9			*0.01*	*0.05*	*0.1*										*0.002*	*0.03*					2		
7	Gujarat	3	696	*0.3*	2	*0.6*	2	*18.5*	11			5	1	*0.01*	*1.3*	*0.03*	*0.01*	*0.005*	*0.3*					18	34	*0.003*
8	Haryana	1	245	*0.2*	*0.9*	3	1	*9.8*	1			1	*0.3*					*0.03*	3						3	
9	Himachal Pradesh	*0.1*	11			*0.05*	*0.11*	*2.4*	*0.8*			*0.02*	*0.1*		*0.1*	*0.01*		*0.0004*	*0.01*						3	
10	Jammu and Kashmir	*0.7*	88			*0.3*	*0.8*	*2.9*				*0.1*			*0.3*	*0.0003*		*0.005*	*0.1*						0	
11	Jharkhand	1	332			*0.2*		*1.3*				*0.2*	*0.1*		*0.1*			*0.01*	*0.3*						*0.01*	
12	Karnataka	3	739	*1.3*	7	3	7	*9.6*	6			6	*0.9*		1	*0.01*	*0.002*	*0.03*	*0.8*			*0.003*	*0.1*	7	8	
13	Kerala	*0.6*	294			*0.8*	*0.3*	*1.9*				1			*0.1*		*0.0001*	*0.2*	*0.9*					12	4	
14	Madhya Pradesh	2	504	*0.1*	*0.6*	*0.4*	2	*12.5*	2			2	1	*0.002*	*0.6*			*0.02*	*0.3*						4	
15	Maharashtra	10	3723	*2.8*	14	4	33	*13.5*	1			9	1	*0.02*	1	*0.1*	*0.0003*	*0.1*	2			*0.05*	2	11	23	
16	Manipur	*0.1*	10			*0.01*		*0.1*							*0.04*			*0.01*	*0.1*							
17	Meghalaya	*0.1*	12			*0.01*		*0.1*							*0.03*			*0.02*	*0.2*							
18	Mizoram	*0.2*	2			*0.0004*		*0.0*										*0.003*	*0.04*							
19	Nagaland	*0.1*	5			*0.003*	*0.0*	*0.2*							*0.0*			*0.01*	*0.2*						1	
20	Odisha	*0.9*	270			*0.5*	*0.2*	*2.3*				*0.6*	*0.4*		*0.2*			*0.02*	*0.4*						7	
21	Punjab	1	1686	*0.2*	*0.9*	1	2	*10.6*				2	*0.4*		*0.2*	*0.0001*		*0.1*	*1.2*			*0.01*	*0.2*		20	
22	Rajasthan	2	1530	*0.002*	*0.01*	*0.3*	*0.8*	*21.2*				3	*0.1*		*0.05*			*0.1*	*0.6*						1	
23	Sikkim	*0.02*				*0.001*	*0.0*	*0.1*				*0.03*						*0.002*	*0.01*							
24	Tamil Nadu	5	461	*0.4*	*2.2*	7	4	*10.1*	*0.8*	*0.2*	48	8	*0.1*		1	*0.1*		*0.1*	2			*0.3*	10	7	18	
	Telangana												*0.4*		*0.4*											
25	Tripura	*0.1*	9			*0.1*		*0.2*				*0.002*			*0.04*			*0.003*	*0.2*							
26	Uttar Pradesh	7	1406	*2.2*	*11.5*	*0.7*	56	*47.1*				6	3	*0.0003*	*0.9*			*0.5*	3			*0.5*	18		34	*0.005*
27	Uttarakhand	*0.4*	68	*0.1*	*0.5*	*0.3*	*0.8*	*2.1*				*0.2*			*0.02*			*0.01*	*0.1*						9	
28	West Bengal	3	922			2	*0.4*	*4.1*	1			*0.2*	2	*0.02*	*0.4*	*0.01*		*0.1*	3			*0.0004*	*0.01*	5	10	
29	Uts & Others	3		*0.03*	*0.2*	*0.04*	*0.5*	*0.5*	*0.2*			*0.1*	1	*0.003*	1	*0.01*		*0.03*	*0.3*	35	*0.4*			*0.02*	*0.0*	
		52	**13716**	**8**	**42**	**28**	**114**	**201**	**32**	**0**	**60**	**49**	**16**	***0.08***	**12**	**0.3**	***0.02***	**2**	**22**	**35**	**0**	**1**	**30**	**70**	**208**	***0.01***

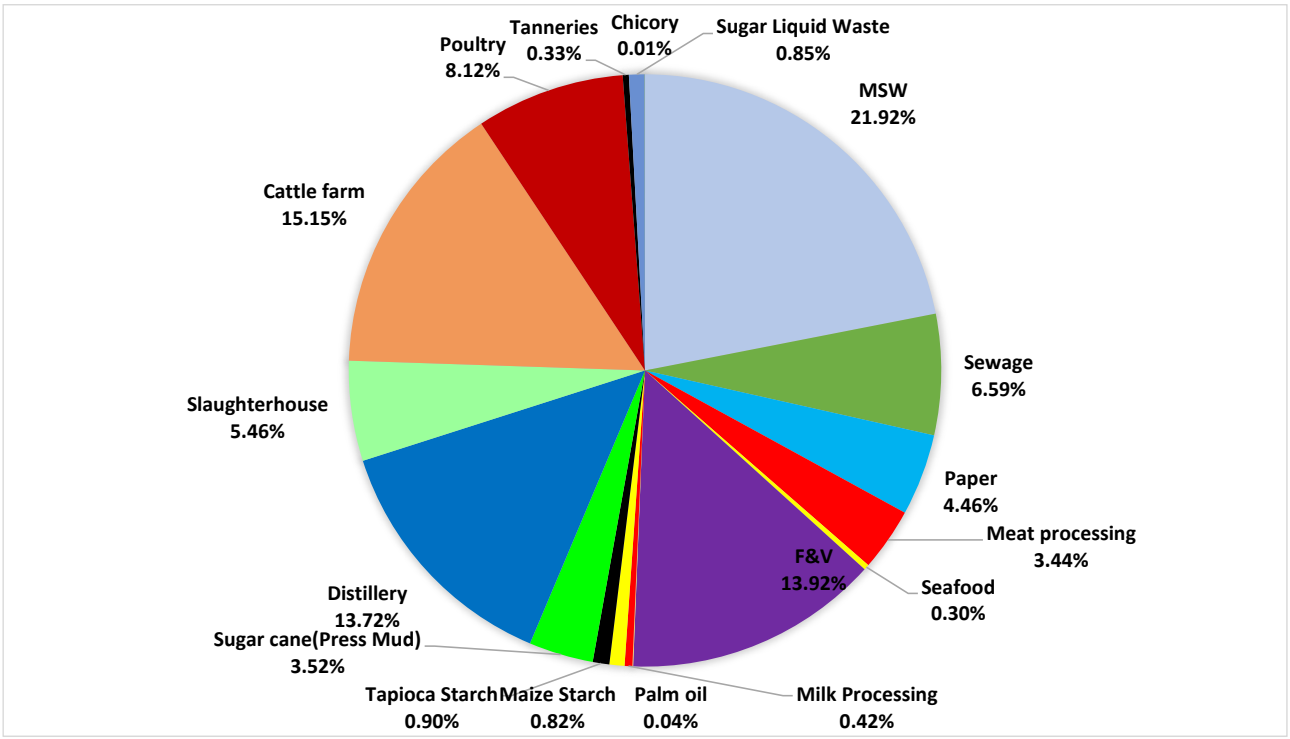
Source: Arcadis Estimation

1.2.3 Energy Potential

Energy potential for identified sectors in different states have been estimated based on various factors such as biogas yield, methane yield, total solids, volatile solids, calorific value etc. referred from various secondary and primary sources. Total energy potential for the selected sectors is 5690 MW.

Sector wise share in energy potential including potential from solid and liquid waste is shown in Figure 1-2. MSW has maximum energy potential with 22% of the total followed by cattle 15%, F&V and distillery 14% each and poultry 8%.

Figure 1-2: Sectoral share in energy potential



Matrix on energy potential for identified sectors for different states is presented in Table 1-4.

Table 1-4: Matrix on state and sector wise energy potential – in MW

S. No	States/ UTs	MSW	Sewage	Sugar		Poultry	Distillery	Cattle farm	Maize	Tapioca		Milk Processing	Vegetable Raw	Vegetable Processing	Fruit Raw	Fruit Processing	Palm Oil	Slaughter		Tanner		Meat		Fish	Chicory	Paper	Total
		Solid	Liquid	Press mud	Effluent	Solid	Liquid	Solid	Liquid	Solid	Liquid	Liquid	Solid	Solid	Solid	Solid	Solid	Solid	Liquid	Liquid	Solid	Solid	Liquid	Liquid	Solid	Liquid	
1	Andhra Pradesh	101	19	7	2	60	19	50	10	3	7	2	28	0.28	27	3	1	5	23			0.02	0.2	2		27	396
2	Arunachal Pradesh	1				0.03		0.1							0.3			0.3	y								2
3	Assam	6	4			1		4				0.10	5	0.01	4			0.4	3							8	35
4	Bihar	15	11	4	1	5	5	65				0.33	66	0.06	10	0.003		5	20							1	209
5	Chhattisgarh	17	4	1	0.2	12	0.4	5	1			0.02	5		1			0.1	2							1	50
6	Goa	2	0.2			0.15	0.3	0.3				0.02						0.05	0.4					1			4
7	Gujarat	81	19	8	2	8	11	77	15			2	39	0.56	20	1	1	0.1	4					4	0.3	41	335
8	Haryana	31	7	4	1	39	8	41	1			1	10					1	33							4	181
9	Himachal Pradesh	3	0.3			1	1	10	1			0.01	4		3	0.3		0.01	0.1							3	26
10	Jammu and Kashmir	16	2			5	6	12				0.03			7	0.01		0.1	1							0	49
11	Jharkhand	31	9			2		6				0.09	5		2			0.4	3							0.0	59
12	Karnataka	77	20	33	8	40	51	40	9			3	32	0.01	17	0.2	0	1	9			0.04	1	2		10	353
13	Kerala	14	8			12	2	8				1			3		0.01	5	11					3		4	70
14	Madhya Pradesh	44	14	3	1	5	13	52	2			1	51	0.06	7			0.5	3							4	200
15	Maharashtra	235	100	68	17	55	224	56	2			4	52	0.93	21	1	0	3	19			1	9	3		28	898
16	Manipur	2	0.3			0.07		0.5							0	0.001		0.4	2								5
17	Meghalaya	2	0.3			0.13		0.2							0			1	2								6
18	Mizoram	5	0.1			0.01		0.1							0			0.1	0.5								6
19	Nagaland	2	0.1			0.05	0.1	1							1			0.2	3							1	8
20	Odisha	22	7			7	1	9				0.29	12		5			1	5							9	77
21	Punjab	34	17	4	1	14	15	44	0.01			1	17		2	0.001		2	15			0.1	1			24	191
22	Rajasthan	44	15	0.1	0.01	5	5	88				2	5		0.4			2	8							1	175
23	Sikkim	0.4				0.02	0.2	1				0.01						0.05	0.1								1
24	Tamil Nadu	127	12	10	2	93	24	42	1	12	29	4	4	0.14	18	3		2	22			4	60	2		22	493
25	Telangana					63		27					12	0.23	9												111
26	Tripura	4	0.2			1		1				0.001			1			0.1	3								9
27	Uttar Pradesh	168	38	55	13	10	384	195				3	109	0.01	20			13	31			8	106		1	42	1195
28	Uttarakhand	9	2	3	1	4	5	9				0.07			0.3			0.2	1							11	44
29	West Bengal	76	25			22	3	17	2			0.08	76	0.58	7	0.1		3	34			0.01	0.1	1		12	279
30	Uts & Others	82	42	1	0.2	1	3	2	0.4			0.06	47	0.11	16	0.2		1	4	9	10	0.4	5	0.004			225
		1247	**375**	**200**	**49**	**462**	**781**	**862**	**47**	**15**	**37**	**24**	**579**	**3**	**203**	**8**	**2.4**	**48**	**263**	**9**	**10**	**13**	**182**	**17**	**1**	254	5690

Source: Arcadis Estimation

1.3 Energy Potential for Selected Four Sectors

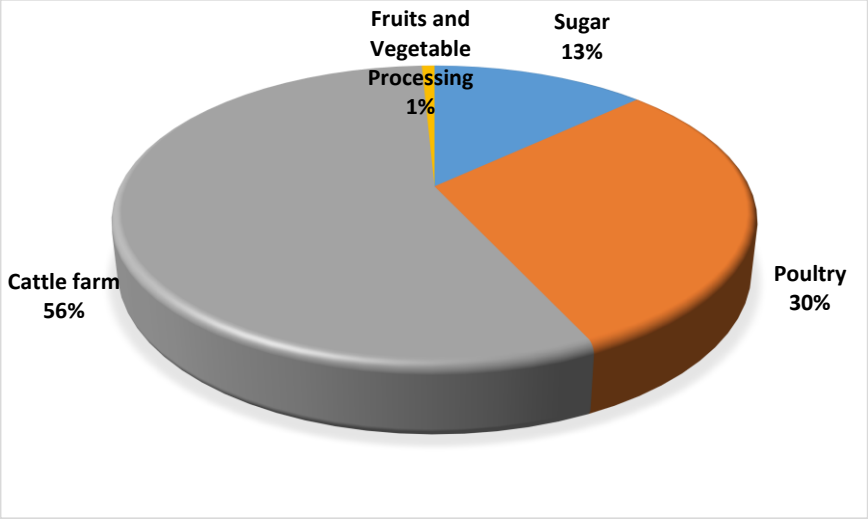
For the current project UNIDO has already identified four priority SME sector, where despite large waste generation and energy potential, the existing resource remain unexploited for energy conversion. Four key identified sector are **poultry industry (poultry litter), sugar industry (press mud), fruit and vegetable processing industry and cattle farm (cattle dung)**. The current reports on the project will assess these four identified sectors in detail.

Table 1-5 presents state wise energy potential for the selected four sectors. Total energy potential from these four sectors is 1535 MW. Among the four sectors, maximum share is contributed by cattle sector 56% followed by poultry 30%, sugar industry 13% and fruits & vegetable industry 1%.

Table 1-5: Matrix on state and sector wise energy potential for four selected sectors– in MW

S. No	States/ UTs	Sugar – press mud	Poultry	Cattle farm	Fruits & Vegetable Processing	Total	State share in total
1	Andhra Pradesh	7	60	50	3.28	120	8%
2	Arunachal Pradesh		*0.03*	*0.1*		0	0.01%
3	Assam		1	4	0.01	5	0.33%
4	Bihar	4	5	65	*0.063*	74	5%
5	Chhattisgarh	1	12	5		18	1%
6	Goa		*0.15*	*0.3*		0.	0.03%
7	Gujarat	8	8	77	1.56	*0.45*	6%
8	Haryana	4	39	41		84	5%
9	Himachal Pradesh		1	10	0.3	11	1%
10	Jammu and Kashmir		5	12	*0.01*	17	1%
11	Jharkhand		2	6		8	1%
12	Karnataka	33	40	40	*0.21*	113	7%
13	Kerala		12	8		20	1%
14	Madhya Pradesh	3	5	52	*0.06*	60	4%
15	Maharashtra	68	55	56	1.93	181	12%
16	Manipur		*0.07*	*0.5*	*0.001*	1	0.04%
17	Meghalaya		*0.13*	*0.2*		*0.33*	0.02%
18	Mizoram		*0.01*	*0.1*		*0.11*	0.01%
19	Nagaland		*0.05*	1		1	0.07%
20	Odisha		7	9		16	1%
21	Punjab	4	14	44	*0.001*	62	4%
22	Rajasthan	0.1	5	88		93	6%
23	Sikkim		*0.02*	1		1	0.07%
24	Tamil Nadu	10	93	42	*3.14*	148	10%
25	Telangana		63	27	*0.23*	90	6%
26	Tripura		1	1		2	0.13%
27	Uttar Pradesh	55	10	195	*0.01*	260	17%
28	Uttarakhand	3	4	9		16	1%
29	West Bengal		22	17	*0.68*	40	3%
30	Uts & Others	1	1	2	*0.31*	4	0.28%
Total		**200**	**462**	**862**	**10.79**	**1535**	**100%**

Figure 1-3: Sectoral share in energy potential for four sectors



These four sectors will be further evaluated based on various factors such as district level data assessment, seasonal variation, waste characterises, waste availability, pricing, distance for transportation and feasibility of co-digestion. Shortlisting of the states and districts for each of the sector is also detailed out in the next section.

Basis for shortlisting of states and districts

Level 1 screening -

Factor for state level shortlisting:

- Top five / four states having maximum energy potential for all the four sectors

Factors for district level shortlisting (district number can vary from 5-10 district in each of the state):

- Districts having maximum potential – top districts identification
- Districts having more potential than the state's average number
- Clusterisation of the districts in one region / avoid scattered energy potential
- Districts with at least 50% of the state energy potential concentration

Level 2 screening -

- Mapping of the four sector in each of the state to shortlist the state having multi sector availability.
- Mapping of the four sector in each of the district to shortlist the districts having multi sector availability.
- Second level of screening for the states – shortlisting based combination of two factors i.e. maximum potential and multi waste availability at district level.
- Finalisation of the region / districts in each of the state having multi waste presence.

1.4 Organic Waste to Energy Plants in India

About 160 plants of 251 MW installed capacity for generation of energy from urban and industrial waste have been established in India. Maximum number of plants installed are in distillery industry sector (46 plants), followed by maize starch industry (39 plants) and tapioca starch industry (25 plants); three together contributing almost 70% of the total number of plants and installed capacity of 110 MW.

Table 1-6 presents sector wise number of existing plants based on urban and industrial wastes in India along with installed capacity. The table also shows sector wise estimated energy potential for urban and industrial waste.

Table 1-6: Matrix on sector wise WTE projects installed and estimated

Sl. No.	Sectors	Number of plants – existing [1]	Installed capacity – MW [1]	Potential capacity – MW [2]
1	Agro waste/residue	1	1	NA
2	Cattle dung	4	4	862
3	Dairy industry	2	2	24
4	Distillery	46	96	781
5	Food processing industry waste	4	1	NA
6	Maize starch industry	39	42	47
7	Solvent oil extraction plants (Palm oil)	6	15	2
8	Paper industry	6	4	254
9	Poultry litter (Combustion)	6	31	462
10	Poultry litter (Bio-methanation)	3	6	
11	Sewage	3	4	375
12	Slaughter house	2	1	311
13	Tannery	4	0.3	19
14	Sugar cane(Press Mud)	2	3	200
15	Tapioca starch	25	10	26
16	Urban waste	7	31	1,247
Additional sectors				
17	Meat processing			196
18	Seafood			17
19	Fruits and Vegetables			792
20	Sugar Liquid Waste			49
Total		**160**	**251**	**5,690**

Source: [1] MNRE

[2]Estimated by Arcadis

2.0 ASSESSMENT OF IDENTIFIED SECTORS

2.1 Poultry Sector

Indian poultry industry has registered a very high growth rate in last few years. While the production of agricultural crops has been rising at a rate of 1.5 to 2 percent per annum, egg and broiler production has shown growth rate of 8 to 10 percent per annum. As a result, India is now the world's fifth largest egg producer and eighteenth largest producer of broilers (The Agricultural and Processed Food Products Export Development Authority (APEDA), Ministry of Commerce and Industry, Government of India). Poultry industry in India has undergone a transformation in the last four years. From backyard activity, it has taken a shape of commercial activity. Poultry activities involve breeding, hatching, rearing and processing.

Poultry farming involves breeding and raising chickens for various purposes. Breeding farms hatch and raise poultry for sale to other farms. Broiler farms rear chickens for their meat, procuring day-old chicks and keeping them for around six weeks. Layer farms keep hens to produce eggs at 19 to 23 weeks of age. Another category of operators, which can loosely be termed “integrators” (also known as contract farming), keep breeding stock and also operate hatcheries and commercial broiler farms.

Table 2-1 presents the data regarding the state wise number of poultry farms of layers and broilers.

Table 2-1: State wise number of birds in poultry farms

S. No	States/ UTs	Number of birds in poultry farms / hatcheries - layer	%	Number of birds in poultry farms / hatcheries - broiler	%
1	Andhra Pradesh	4,36,77,531	20.39%	2,05,50,898	7.28%
2	Arunachal Pradesh	523	0.00%	26,870	0.01%
3	Assam	16,082	0.01%	9,99,207	0.35%
4	Bihar	3,89,386	0.18%	46,22,283	1.64%
5	Chhattisgarh	54,78,250	2.56%	75,33,455	2.67%
6	Goa	83,797	0.04%	76,868	0.03%
7	Gujarat	45,44,604	2.12%	41,88,608	1.48%
8	Haryana	2,04,99,007	9.57%	2,12,79,002	7.54%
9	Himachal Pradesh	2,20,068	0.10%	4,94,790	0.18%
10	Jammu and Kashmir	1,32,627	0.06%	48,13,215	1.71%
11	Jharkhand	1,09,277	0.05%	24,15,204	0.86%
12	Karnataka	1,56,70,171	7.31%	2,75,58,116	9.77%
13	Kerala	8,52,775	0.40%	1,18,37,612	4.20%
14	Madhya Pradesh	36,58,942	1.71%	17,83,413	0.63%
15	Maharashtra	80,29,893	3.75%	5,08,66,466	18.03%
16	Manipur	503	0.00%	76,443	0.03%
17	Meghalaya	26,016	0.01%	1,11,066	0.04%
18	Mizoram	4,668	0.00%	1,412	0.00%
19	Nagaland	16,302	0.01%	33,533	0.01%
20	Odisha	19,40,544	0.91%	55,64,494	1.97%
21	Punjab	96,51,176	4.50%	56,80,262	2.01%
22	Rajasthan	26,14,572	1.22%	22,69,227	0.80%
23	Sikkim	2,102	0.00%	17,600	0.01%

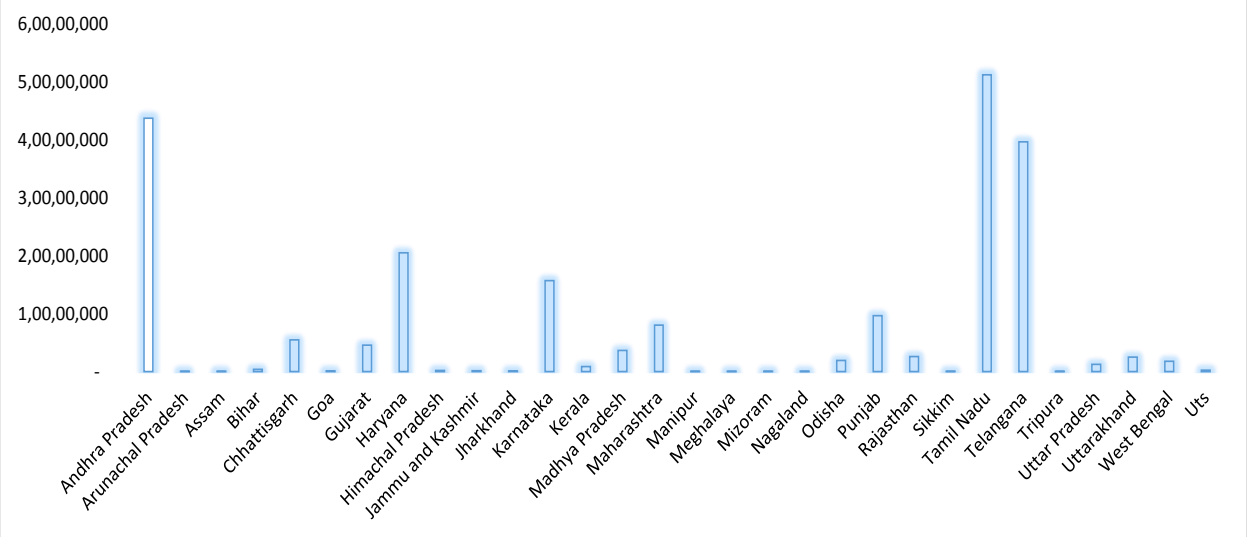
S. No	States/ UTs	Number of birds in poultry farms / hatcheries - layer	%	Number of birds in poultry farms / hatcheries - broiler	%
24	Tamil Nadu	5,11,94,235	23.90%	4,83,11,658	17.12%
25	Telangana	3,96,26,387	18.50	2,76,89,177	9.81%
26	Tripura	30,288	0.01%	9,61,683	0.34%
27	Uttar Pradesh	12,64,459	0.59%	90,60,332	3.21%
28	Uttarakhand	24,98,684	1.17%	13,37,531	0.47%
29	West Bengal	17,63,547	0.82%	2,16,26,678	7.66%
30	UTs	2,48,000	0.12%	3,76,328	0.13%
Total		**214,244,416**	**100.00%**	**282,163,431**	**100.00%**
Number in million		**214**		**282**	

Source: 19th Livestock census 2012

The poultry industry chain – layers

As per the data available from 19th Livestock census 2012, total number of 214 million poultry birds – layers are in India. Layers poultry industry is mostly concentrated in southern part of the country. Top states having layer poultry industry are Tamil Nadu with 24% of the share, Andhra Pradesh 20% of share, Telangana 19% of share and Haryana 10% of share in the industry. Figure 2-1 shows the state wise share of poultry -layers.

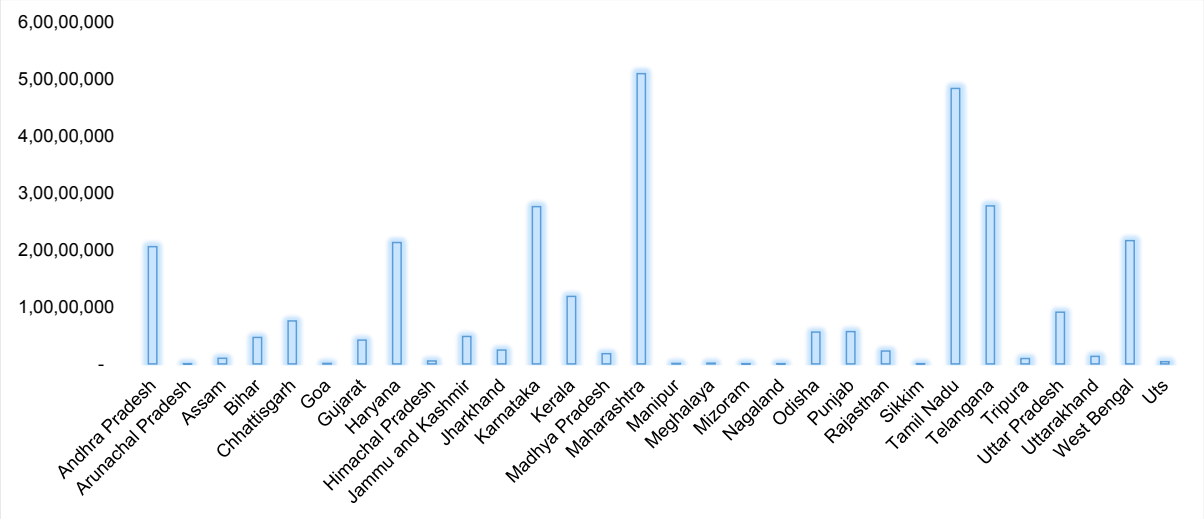
Figure 2-1: State wise poultry farm– layer



The poultry industry chain – broilers

Data available from 19th Livestock census 2012 for broilers is shown in Table 2-1 and Figure 2-2 . There are total 282 million poultry birds in the country under broilers category. Top states having maximum share in total production are Maharashtra, Tamil Nadu, Telangana and Karnataka with 18%, 17%, 10% and 10% of the share respectively.

Figure 2-2: State wise poultry farm – Broiler



Poultry litter

Poultry rearing results in various types of waste which include hatchery wastes, manure (bird excrement), litter (bedding materials such as sawdust, wood shavings, straw and peanut or rice hulls), and on-farm mortalities. Poultry manure is the organic waste material from poultry consisting of animal faeces and urine. Poultry litter refers to the manure mixed with some of the bedding material or litter (wood shavings or sawdust) and feathers. Poultry houses are regularly cleaned out by removing a thin layer of the bedding along with the manure.

Current usage of poultry litter - Historically poultry litter has been used as fertilizer in crop production and cattle feed. However, recently poultry litter has been banned as cattle feed due to concerns over Mad Cow Disease, along with increased restrictions on use as fertilizer and land applications. Land applications of poultry litter in the agricultural fields leads to ground water pollution because of its high phosphorous content. Fertilizing value of the poultry litter is comparable to the chemical fertilizer however, if not consumed within 4-5 days, its nitrogen value decreases very quickly. Therefore, it is generally used in the nearby agriculture farms. Currently most of the poultry litter is being dumped near poultry farms, gets degraded along with release of methane into the atmosphere, along with other environmental problems as odor, pest generation etc. The concerns on safe disposal of poultry litter and high potential of energy generation from poultry litter is making poultry litter based waste to energy plants as one of the most preferred alternative for poultry litter management.

Poultry litter characteristics - Based on the secondary sources, waste characteristics of poultry litter has been briefed out in below table. Key parameters considered for the waste are PH, total solid (TS), volatile solid (VS), C:N ratio, bio-methane potential etc. Verification of the waste characteristics will be done in the further stages of work after collecting the waste samples from the poultry farms.

Table 2-2: Poultry litter characteristics

Parameters	Units	Poultry Litter - value
TS	% (wet based)	24 - 30 [4]
VS	% (dry based)	76 - 86 [4]
BOD	mg/kg	31,395 – 63745 [4]
COD	mg/kg	1,391,91 – 2,500,00 [4]
NH_3N	%	20 – 31 [4]
pH	NA	7.25[1]
Moisture content	%	60 - 70 [2]
C-N ratio	NA	5.8 – 11.5 [2]
Total nitrogen	%	1.7 – 5.3 [2]

Source: [1] *http://www.ijcsr.in/Documents/Volumes/Vol4%20issue%203/ijcsr%20v4i3%20mj%20(1).pdf*

[2] http://scialert.net/fulltext/?doi=ajps.2010.172.182&org=11

[4] *https://www.bae.ncsu.edu/bae//topic/animal-waste-mgmt/program/land-ap/barker/a&pmp&c/brfm.htm*

Poultry litter generation - For estimating total amount of waste produced from poultry farms, data on average bird dropping was referred from various secondary sources. The bird dropping estimate taken from various sources ranges between 50gms to 180gms per day. Waste estimation from poultry has been done considering one bird generating 180 gm of litter per day[2]. Table 2-3 shows number of poultry birds, poultry waste generation and estimated power potential for different states.

Table 2-3: State wise poultry litter generation and estimated energy potential

S. No	States/ UTs	Number of poultry birds in farms / hatcheries – layer and broiler	180 gm /day/bird (quantity in ton) – per day	Energy Potential (MW) *
1	Andhra Pradesh	6,42,28,429	11,561	60
2	Arunachal Pradesh	27,393	5	*0.03*
3	Assam	1,015,289	183	*0.95*
4	Bihar	50,11,669	902	5
5	Chhattisgarh	13,011,705	2,342	12
6	Goa	160,665	29	*0.15*
7	Gujarat	8733,212	1,572	8
8	Haryana	41,778,009	7,520	39
9	Himachal Pradesh	714,858	129	*0.67*
10	Jammu and Kashmir	4,945,842	890	5
11	Jharkhand	2,524,481	454	2
12	Karnataka	43,228,287	7,781	40
13	Kerala	12,690,387	2,284	12
14	Madhya Pradesh	5,442,355	980	5
15	Maharashtra	58,896,359	10,601	55
16	Manipur	76,946	14	*0.07*
17	Meghalaya	137,082	25	*0.13*
18	Mizoram	6,080	1	*0.01*
19	Nagaland	49,835	9	*0.05*
20	Odisha	7,505,038	1,351	7
21	Punjab	15,331,438	2,760	14
22	Rajasthan	4,883,799	879	6
23	Sikkim	19,702	4	*0.02*
24	Tamil Nadu	99,505,893	17,911	93
25	Telangana	6,73,15,564	12,117	63
26	Tripura	991,971	179	*0.92*
27	Uttar Pradesh	10,324,791	1,858	91
28	Uttarakhand	3,836,215	691	4
29	West Bengal	23,390,225	4,210	22
30	UTs	624,328	112	*0.58*

[2] http://web.iitd.ac.in/~vkvijay/Biogas%20Technology.pdf

S. No	States/ UTs	Number of poultry birds in farms / hatcheries – layer and broiler	180 gm /day/bird (quantity in ton) – per day	Energy Potential (MW) *
Total		**496,407,847**	**89,353**	**462**

Source: 19th Livestock census 2012

*Biogas potential has been assumed considering 0.058m^3 of biogas from 1 kg of waste. *(Source: http://urpjournals.com/tocjnls/38_13v3i1_3.pdf)*

Poultry litter availability: Poultry litter is easily available from the poultry farms at the rate of approximately Rs.1000 per ton[3]. Existing plants are set up near the poultry farm to get access of the litter for power generation. In addition to power generation from poultry litter, organic fertilizer is also manufactured in the unit. There is no seasonality in the availability of poultry litter, hence available throughout the year.

Energy potential

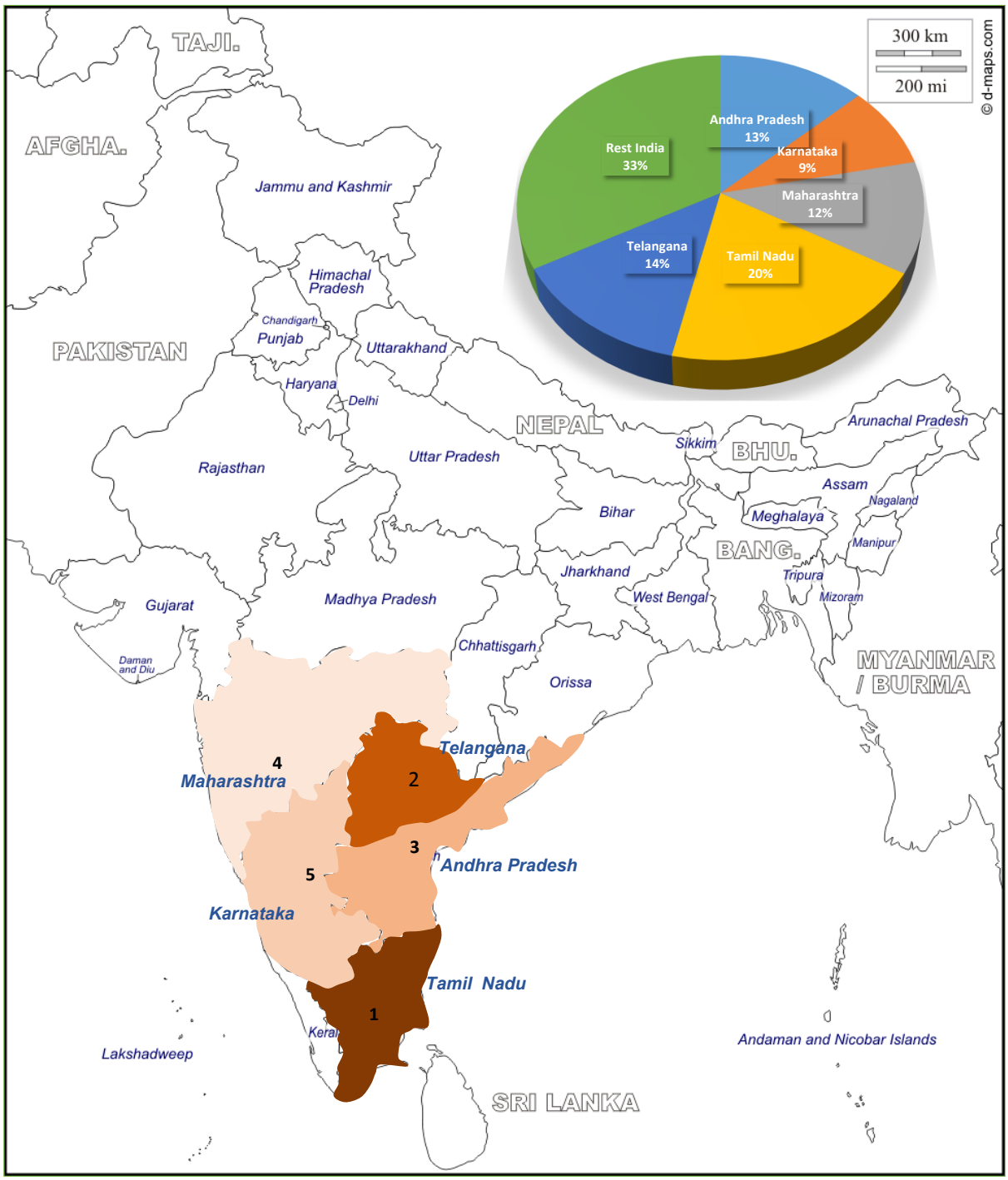
Poultry manure and litter contain organic matter that can be converted in to bioenergy both through anaerobic route and through thermochemical process through pyrolysis/ gasification /combustion route. There are number of plants based on both anaerobic decomposition as well as combustion based technologies in India from poultry waste.

This report reviews biogas and energy generated through anaerobic route for further evaluation. It has been estimated that approximately 0.058m^3 of biogas[4] is generated from 1 kg of waste. With a total litter production of approximately 89,353 tonnes per day, the estimated energy potential from poultry waste in India is approximately 462 MW. Cow dung is normally used as co-substrate with poultry litter to generate biogas. Other waste material having potential to mix with poultry litter are silage (agriculture/horticulture waste/forage corps etc.), grain waste, de-oiled cake and recycled waste.

Total energy potential from poultry waste in India is approximately 462 MW. Figure 2-3 shows top five states generating maximum poultry litter and having maximum energy potential. Tamil Nadu followed by Telangana, Andhra Pradesh, Maharashtra and Karnataka together generate more than 67% of total poultry litter and have energy potential of 93 MW, 63 MW, 60 MW, 55 MW and 40 MW respectively.

[3] http://www.theweekendleader.com/Innovation/1848/power-of-waste.html
[4] http://urpjournals.com/tocjnls/38_13v3i1_3.pdf

Figure 2-3: Location of major states generating poultry litter and energy potential



State wise major districts / regions

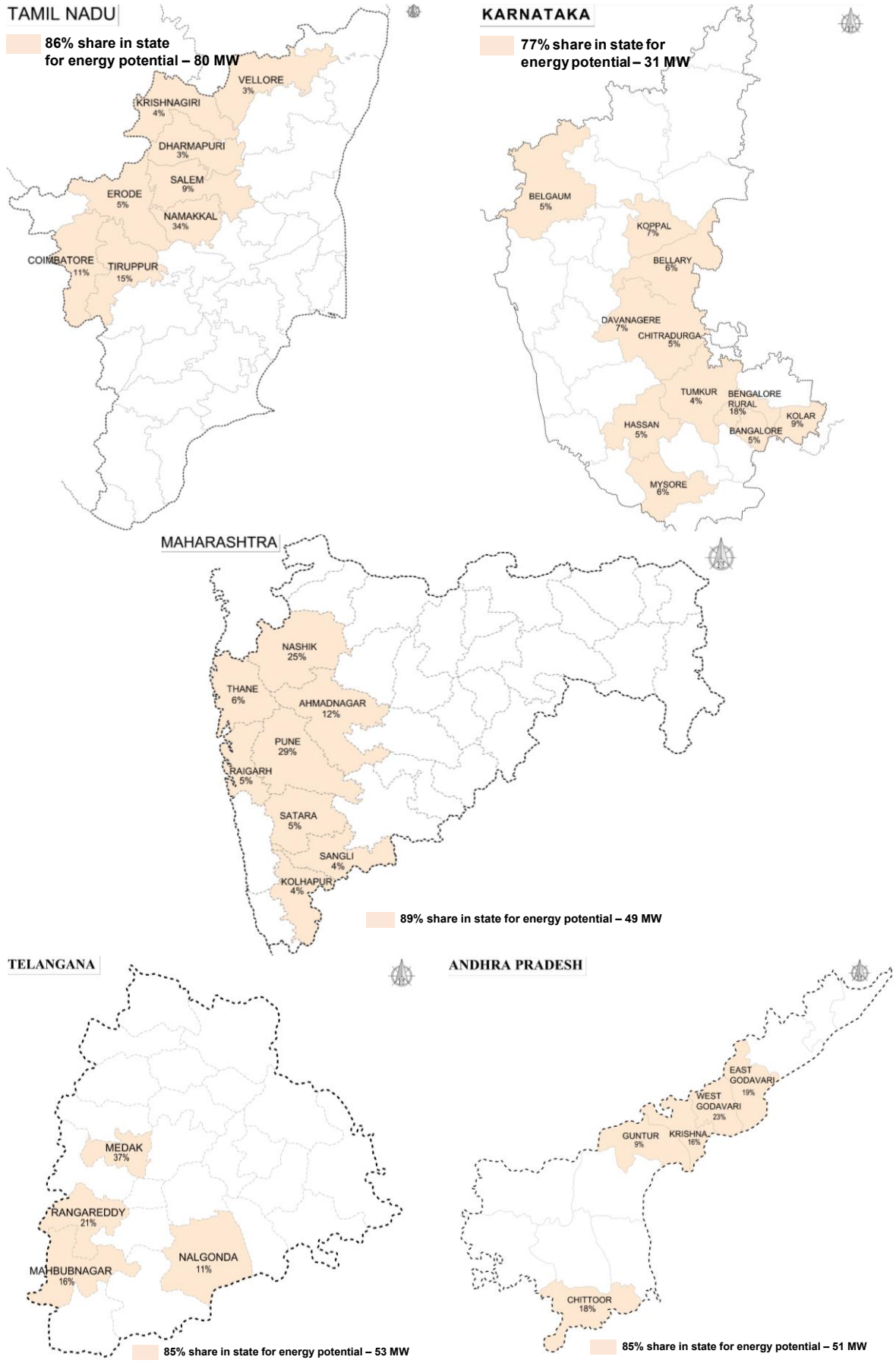
The key regions contributing maximum poultry litter and maximum energy potential in top poultry producing states have been shortlisted. District level data has been compiled from 19th Livestock census 2012 published by Department of Animal Husbandry and Dairying (AH&D), Ministry of Agriculture and Farmer Welfare to identify the key regions contributing to poultry litter and having maximum energy potential from poultry waste. Figure 2-4 presents the location of the shortlisted regions in the top 5 states.

Table 2-4: Districts having maximum potential in the selected states

State	District	Share in state	State	District	Share in state
1. Tamil Nadu - 86% concentrated in these eight districts	Coimbatore	11%	4. Maharashtra - 89% concentrated in these eight districts	Ahmadnagar	12%
	Dharmapuri	3%		Nashik	25%
	Erode	5%		Pune	29%
	Krishnagiri	4%		Thane	6%
	Namakkal	34%		Kolhapur	4%
	Salem	9%		Raigarh	5%
	Tiruppur	15%		Sangli	4%
	Vellore	3%		Satara	5%
2. Telangana-85% concentrated in these four districts	Mahbubnagar	16%	5. Karnataka -77% concentrated in these eleven districts	Bangalore	5%
	Medak	37%		Bangalore Rural	18%
	Nalgonda	11%		Belgaum	5%
	Rangareddy	21%		Bellary	6%
3. Andhra Pradesh - 85% concentrated in these five districts	Chittoor	18%		Chitradurga	5%
	East Godavari	19%		Davanagere	7%
	Guntur	9%		Hassan	5%
	Krishna	16%		Kolar	9%
	West Godavari	23%		Koppal	7%
Poultry litter Energy potential in India – 462 MW Energy potential in 5 selected states – 310 MW Energy potential in selected districts of selected 5 states – 264 MW				Mysore	6%
				Tumkur	4%

Energy potential of the selected top five states in the sector is 310 MW which is 67% of the total estimated energy potential in the country. Above table presents details on share of the energy potential for top districts in all the states. Districts having energy potential more than the state's average energy potential has been selected for further evaluation in all five shortlisted states. Identified districts in five states together have an energy potential of 264 MW contributing to almost 85% of the total energy potential estimated from these five state.

Figure 2-4: Identification of districts in the top 5 states for energy potential – poultry litter



Existing waste to energy plants in India based on poultry litter

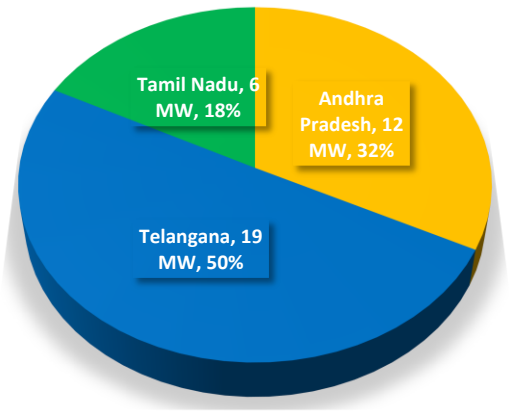
In India, there are total 9 waste to energy plants based on poultry litter. Three plants are being run through bio-methanation technology with total capacity of 6 MW and another six plants are generating energy through combustion process with total plant capacity of 31 MW. Telangana state has maximum installed capacity of poultry litter based energy plants i.e. 19 MW followed by Andhra Pradesh 12 MW and Tamil Nadu 6 MW. Location of the plant, associated industry, plant capacity and year of establishment is provided in Table 2-5.

Table 2-5: Details of existing poultry litter based energy plants

Sl. No.	WTE plant location	Plant installed capacity	Year if installation	State
Poultry Litter based Plants (Combustion)				
1	M/s Redan Infrastructure Pvt. Ltd., , Hyderabad at Village & Mandal Gangavaram , Chittoor Dist., A. P.	7.50 MW	2014-15	Andhra Pradesh
2	M/s PSR Green Power Projects Pvt. Ltd., Marikal Village, Danwada Mandal, Mahabubnagar Dist., Telangana.	7.50 MW	2013-14	Telangana
3	M/s Shravana Power Projects Pvt. Ltd. Takkalapalli Vill. Yacharam Mandal, Ranga Reddy District, Telangana.	7.5 MW	2010-11	Telangana
4	Poultry litter based power generation project by M/s Raus Power Ltd., Dupalapudi, East Godavari Distt., A.P.	3.66 MW	2008-09	Andhra Pradesh
5	Poultry litter based power generation project by M/s SLT Power & Infrastructure Projects Pvt. Ltd., Pocham Pally Village & Mandal, Nalgonda Dist., A.P.	3.50 MW	2007-08	Telangana
6	Power generation from poultry droppings by M/s G.K. Bio-energy Pvt. Ltd., Namakkal, T.N.	1.50 MW	2005-06	Tamil Nadu
Poultry Litter (Bio-methanation)				
7	M/s. Synergy Biorefineries Private Limited, at Samalkot, East Godavari Dist., A.P.	0.75 MWeq.	2014-15	Andhra Pradesh
8	M/s IOT Mabagas Ltd., at Puduchatram, Namakkal, T. N.	2.40MW	2012-13	Tamil Nadu
9	Poultry litter based power generation project by M/s Subhashri Bio-energies Pvt. Ltd. Namakkal, T.N.	2.50 MW	2006-07	Tamil Nadu

Source: MNRE

Figure 2-5: Share of states in existing WTE plants - poultry



***Case study - Biogas Power Plant & Organic Fertilizer Unit in Namakkal District, Tamil Nadu* (Combustion)**

The Biogas Power Plant & Organic Fertilizer Unit located in Namakkal district of Tamil Nadu was established in February 2005 to manage the issue of poultry litter. Before implementing the plant, poultry litter used to be cleaned every six month and dumped in open area resulting in generation of methane and nitrous oxide due to uncontrolled anaerobic digestion. The objective of the project was to generate energy from poultry litter and stop prevailing unhygienic practices. The silent features of the plant are provided below:

- *Capacity: 1.5 MW / 40 t of manure/day*
- *Location: Namakkal, Tamil Nadu*
- *Commissioned: Jan-Feb 2005*
- *Quantum of litter collected: 200 tons/day (from 12 farms housing 1.5 Mn birds)*
- *Technology: Combustion*
- *Promoters: G. K. Bioenergy Pvt. Ltd.*

***Case study - M/s IOT Mabagas Ltd., at Puduchatram, Namakkal District, Tamil Nadu* (Biogas)**

2.4 MWel biogas waste plant in Tamil Nadu commissioned in December 2012. Annually, the plant produces power, heat and manure from up to 110,000 tons of poultry manure and other organic residues and waste materials from that region. Input material - Up to 110,000 tn/a of organic waste materials and residues, mainly dry chicken dung and residues from the local starch and sugar industry. Special features - Digestate utilization: use of fertilizers in the surrounding agricultural areas after separation and sun-drying.

The plant is a single-tier wet fermentation plant, consisting of four fermenters with a total volume of 16,000 m³. During operation, this capacity allows a production of about 8 million m³ or 40 million kWh of biogas every year and its subsequent conversion to power using two combined heat and power plants of 1.2 MWel each.

- *Capacity: 2.5 MW / 110,000 t of manure/annum*
- *Location: Namakkal, Tamil Nadu*
- *Commissioned: 2012*
- *Technology: Bio-methanation*
- *Promoters: IOT Mabagas Ltd.,*

Source: http://www.qfree.in/namakkal/list/agriculture/iot-mabagas-private-ltd

2.2 Cattle Farm

India ranks first among the world's milk producing nations since 1998 and has the largest bovine population in the world. The total cattle population in India contributes to around 37.8% of the total livestock population as per census 2012. Total number of cattle in the country are 190.90 million in number (including male and female). Most of these cattle are under individual ownership and may not form part of cattle farm. For the current assessment, we have assumed that 50 % of the milk producing female cattle would form part of cattle farm. This number would be further revalidated during discussions with various stakeholders and farm owners during the site visits. Key milk producing animals in India are buffalo, cow exotic/crossbred, cow indigenous/non-descript and goats with percentage share of 51%, 25%, 20% and 4% respectively (Basic Animal Husbandry & Fisheries Statistics 2015).

Cattle farm / breeding farm - No separate data on the number of cattle farms or number of cattle's in the cattle farm is available with Department of Animal Husbandry Dairying & Fisheries, Veterinary Council of India, National Dairy Development Board, All India Dairy – private publisher and Dairy in India – private publisher. Cattle breeding farm data has been procured from All India Dairy (private publisher). There are 7 central cattle breeding farms in India located in Rajasthan, Gujarat, Odisha, Karnataka, Uttar Pradesh and Tamil Nadu. In addition, there are 178 state breeding farms and semen farm located in various states. State wise number of farms is provided in Table 2-6.

Table 2-6: State wise number of cattle breeding farm / semen bank / livestock farm / dairy farm*

State	Cattle breeding farm / Semen bank / livestock farm / dairy farm	State share in total
Andhra Pradesh	26	14.05%
Arunachal Pradesh	10	5.41%

State	Cattle breeding farm / Semen bank / livestock farm / dairy farm	State share in total
Assam	7	3.78%
Bihar	8	4.32%
Chhattisgarh	1	0.54%
Goa	1	0.54%
Gujarat	20	10.81%
Haryana	8	4.32%
Himachal Pradesh	11	5.95%
Jammu & Kashmir	4	2.16%
Jharkhand	3	1.62%
Karnataka	13	7.03%
Kerala	1	0.54%
Madhya Pradesh	10	5.41%
Maharashtra	6	3.24%
Manipur	2	1.08%
Meghalaya	4	2.16%
Nagaland	1	0.54%
Odisha	4	2.16%
Punjab	8	4.32%
Rajasthan	4	2.16%
Tamil Nadu	17	9.19%
Tripura	2	1.08%
Uttar Pradesh	6	3.24%
West Bengal	8	4.32%
Total	**185**	100.00%

Source: All India Dairy Business Directory 2016-17
** This list is preliminary level of compilation and does not cover 100% of the farms / gaushala present in the country. Detail list of the farms and dairies can be obtained from the state animal husbandry department from shortlisted states.*

Table 2-7 present the data obtained from 19th livestock census 2012 on state wise availability of milk producing cattle population which include buffalo female and cattle - exotic/ crossbred – female.

Table 2-7: State wise number of buffalo and cattle – female[5]

S. No	States/ UTs	Buffalo population female[1]	%	Cattle - exotic/ crossbred female[2]	%	Total	%
1	Andhra Pradesh	56,83,259	6.14%	16,27,462	4.82%	73,10,721	5.79%
2	Arunachal Pradesh	3,373	0.004%	15,881	0.05%	19,254	0.02%
3	Assam	2,63,845	0.28%	3,19,570	0.95%	5,83,415	0.46%
4	Bihar	65,90,797	7.12%	29,95,818	8.87%	95,86,615	7.59%
5	Chhattisgarh	6,00,463	0.65%	1,28,572	0.38%	7,29,035	0.58%
6	Goa	25,094	0.03%	15,670	0.05%	40,764	0.03%
7	Gujarat	95,49,799	10.31%	17,34,161	5.14%	1,12,83,960	8.93%
8	Haryana	51,47,429	5.56%	8,36,224	2.48%	59,83,653	4.74%
9	Himachal Pradesh	6,55,841	0.71%	8,25,266	2.44%	14,81,107	1.17%
10	Jammu and Kashmir	6,59,638	0.71%	11,26,066	3.34%	17,85,704	1.41%
11	Jharkhand	6,14,368	0.66%	2,05,363	0.61%	8,19,731	0.65%

[5] *The data is provided only for the female population, male cattle population is not considered for the estimation as they are not involved in dairy activity.*

S. No	States/ UTs	Buffalo population female[1]	%	Cattle - exotic/ crossbred female[2]	%	Total	%
12	Karnataka	31,10,131	3.36%	27,07,335	8.02%	58,17,466	4.60%
13	Kerala	31,085	0.03%	11,15,375	3.30%	11,46,460	0.91%
14	Madhya Pradesh	69,04,369	7.46%	6,81,093	2.02%	75,85,462	6.00%
15	Maharashtra	49,97,703	5.40%	32,07,011	9.50%	82,04,714	6.49%
16	Manipur	38,367	0.04%	32,920	0.10%	71,287	0.06%
17	Meghalaya	7,599	0.01%	26,537	0.08%	34,136	0.03%
18	Mizoram	3,386	0.004%	8,970	0.03%	12,356	0.01%
19	Nagaland	17,015	0.02%	82,846	0.25%	99,861	0.08%
20	Odisha	3,91,051	0.42%	9,86,054	2.92%	13,77,105	1.09%
21	Punjab	46,26,033	5.00%	18,23,801	5.40%	64,49,834	5.10%
22	Rajasthan	1,14,00,819	12.31%	14,96,504	4.43%	1,28,97,323	10.21%
23	Sikkim	559	0.001%	88,266	0.26%	88,825	0.07%
24	Tamil Nadu	6,80,151	0.73%	54,67,646	16.20%	61,47,797	4.87%
25	Telangana	35,88,998	3.88%	3,65,234	1.08%	39,54,232	3.13%
26	Tripura	6,518	0.01%	99,812	0.30%	1,06,330	0.08%
27	Uttar Pradesh	2,57,10,629	27.77%	29,47,459	8.73%	2,86,58,088	22.68%
28	Uttarakhand	8,73,626	0.94%	4,16,977	1.24%	12,90,603	1.02%
29	West Bengal	2,54,320	0.27%	22,56,228	6.68%	25,10,548	1.99%
30	UTs	1,62,810	0.18%	1,20,339	0.36%	2,83,149	0.22%
Total		**9,25,99,075**	**100.00%**	**3,37,60,460**	**100.00%**	**12,63,59,537**	**100.00%**
Total in million		**93**		**34**		**126**	

Source: 19th Livestock census 2012

[1] Table 20 (R+U) [2]Table 12 (R+U)

Approximately 73% of the milk producing cattle population in India constitutes buffalo and rest 27% constitutes exotic/crossbreed cattle. Following figures shows the top four states having maximum numbers of buffalo, exotic / crossbreed cattle and total of both the categories. Uttar Pradesh has maximum number of total cattle population with 23% of the share followed by Rajasthan, Gujarat, Bihar and Maharashtra with respective share of 10%, 9%, 8% and 6%.

Figure 2-6: Share of buffalo and exotic cattle

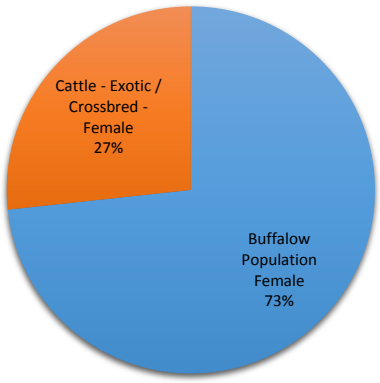


Figure 2-7: Top 5 states – buffalo population

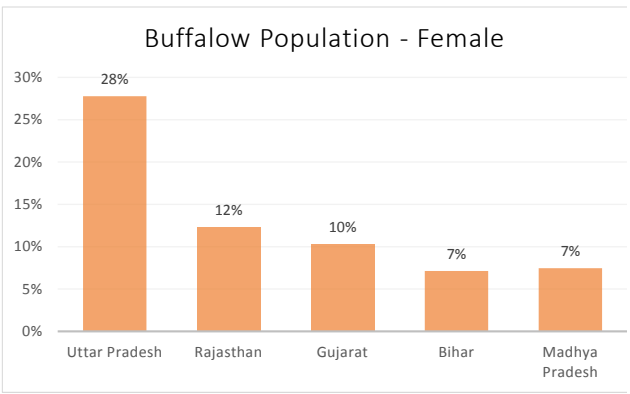


Figure 2-8: Top 5 states – exotic / crossbreed population

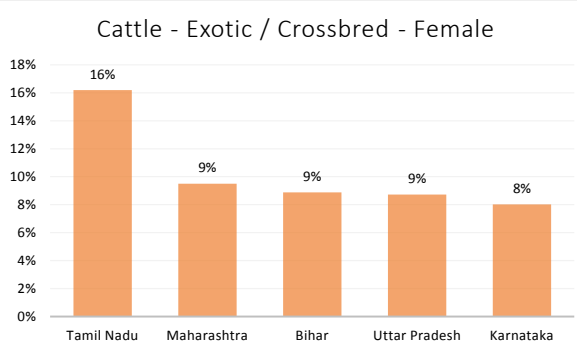
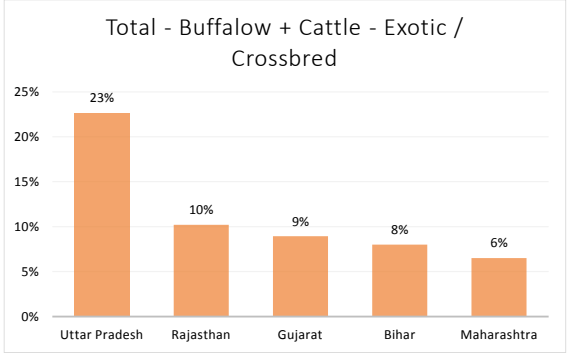


Figure 2-9: Top 5 states – total of buffalo and exotic /crossbreed population



Cattle dung

A cattle farm generates two types of waste i.e. solid waste (dung) and liquid waste (slurry). Slurry contains cattle urine and waste water which is normally drained out in the municipal drain.

Current usage of cattle dung - Cattle dung is used in various ways such as manure for agriculture fields, fuel, and direct application on the floor and biogas generation. Biogas generated from cattle dung is used as domestic cooking fuel in various part of rural India.

Cattle dung characteristics - Based on the secondary sources, waste characteristics of cattle dung has been briefed out in below table. Details on key parameters for waste characteristics are pH, total solid (TS), volatile solid (VS), COD, BOD, ammonia (NH_3) and moisture content have been presented in Table 2-7. Further validations of the waste characteristics will be done based on laboratory primary investigations to be conducted for the project in next stage.

Table 2-8: Cattle dung characteristics

Parameters	Units	Cattle dung - value
TS	% (wet based)	7.4 - 22[1]
VS	% (dry based)	61 - 91[1]
COD	mg/kg	83,000 – 2,01,434[1]
BOD	mg/kg	13,831 – 29,223[1]
NH3-N	%	1.8 - 62[1]
pH	NA	7.1 - 7.4[2]
Moisture content	%	41.2[2]
C-N ratio	NA	19 - 25 [3]
Total nitrogen	%	1.2 – 3.5 [4]

Source:

[1] https://www.bae.ncsu.edu/bae//topic/animal-waste-mgmt/program/land-ap/barker/a&pmp&c/1dfm.htm

[2] http://www.arpnjournals.com/jeas/research_papers/rp_2012/jeas_0212_635.pdf

[3] https://www.researchgate.net/post/What_is_the_C_N_ratio_of_fresh_cattle_dung

[4] http://manuremanagement.ucdavis.edu/files/134369.pdf

Waste generation from cattle farm and subsequent energy potential from the waste has been estimated in Table 2-9.

Table 2-9: State wise estimation of waste and energy potential from cattle farm

S. No	States/ UTs	Total of buffalo and Cattle - Exotic / crossbred – female (number in million)[1]	50% of buffalo and Cattle - Exotic / crossbred – female (number in million) **	Waste generation @ 4.5 kg per cattle** (number in ton)/day[6]	Energy Potential (MW) [2]
1	Andhra Pradesh	7	4	16,449	50
2	Arunachal Pradesh	*0.02*	*0.01*	43	0.13
3	Assam	1	*0.3*	1,313	4
4	Bihar	10	5	21,570	65
5	Chhattisgarh	1	*0.4*	1,640	5
6	Goa	*0.04*	*0.02*	92	0.28
7	Gujarat	11	6	25,389	77
8	Haryana	6	3	13,463	41
9	Himachal Pradesh	1	1	3,332	10
10	Jammu and Kashmir	2	1	4,018	12
11	Jharkhand	1	*0.4*	1,844	6
12	Karnataka	6	3	13,089	40
13	Kerala	1	1	2,580	8
14	Madhya Pradesh	8	4	17,067	52
15	Maharashtra	8	4	18,461	56
16	Manipur	*0.07*	*0.04*	160	0.49
17	Meghalaya	*0.03*	*0.02*	77	0.23
18	Mizoram	*0.01*	*0.01*	28	0.08
19	Nagaland	*0.10*	*0.05*	225	1
20	Odisha	1	1	3,098	9
21	Punjab	6	3	14,512	44
22	Rajasthan	13	6	29,019	88
23	Sikkim	*0.09*	*0.04*	200	1
24	Tamil Nadu	6	3	13,833	42
25	Telangana	4	2	8,897	27
26	Tripura	*0.11*	*0.1*	239	1
27	Uttar Pradesh	29	14	64,481	195
28	Uttarakhand	1	1	2,904	9
29	West Bengal	3	1	5,649	17
30	UTs	*0.28*	*0.1*	637	2
Total		**126**	**63**	**284,309**	**862**

Source: [1] 19th Livestock census 2012

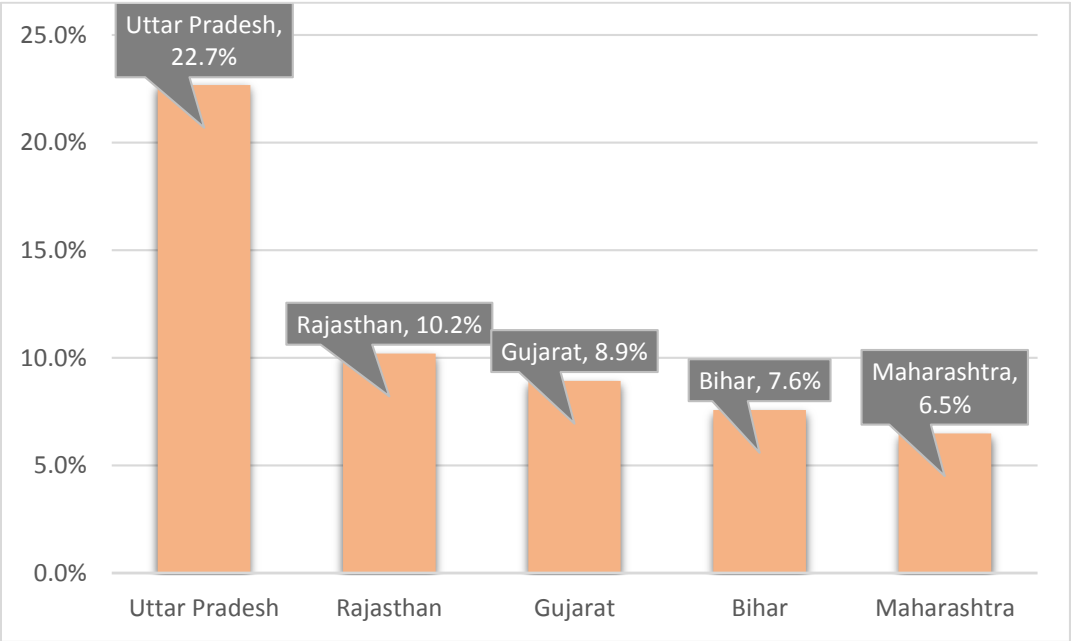
[2] 0.034m³ of biogas can be generated from 1 kg of cattle waste as referred from secondary source - http://urpjournals.com/tocjnls/38_13v3i1_3.pdf

[6] http://large.stanford.edu/courses/2010/ph240/pydipati2/

*** For the waste calculation, we have assumed that 50 % of the milk producing cattle would form part of cattle farm, therefore 50% of the cattle dung generated has been considered to estimate the energy potential.*

Cow dung availability: Cow dung is easily available across the country at the rate of approximately Rs250 per ton[7]. Only constraint with cow dung is transportation. Cow dung is a heavy material in semi liquid form, therefore it cannot be transported to long distance. Waste to energy plants based on cow dung needs to be set up near the cattle farm. There is no seasonality in the availability of cow dung, hence available throughout the year.

Figure 2-10: States producing maximum cattle dung



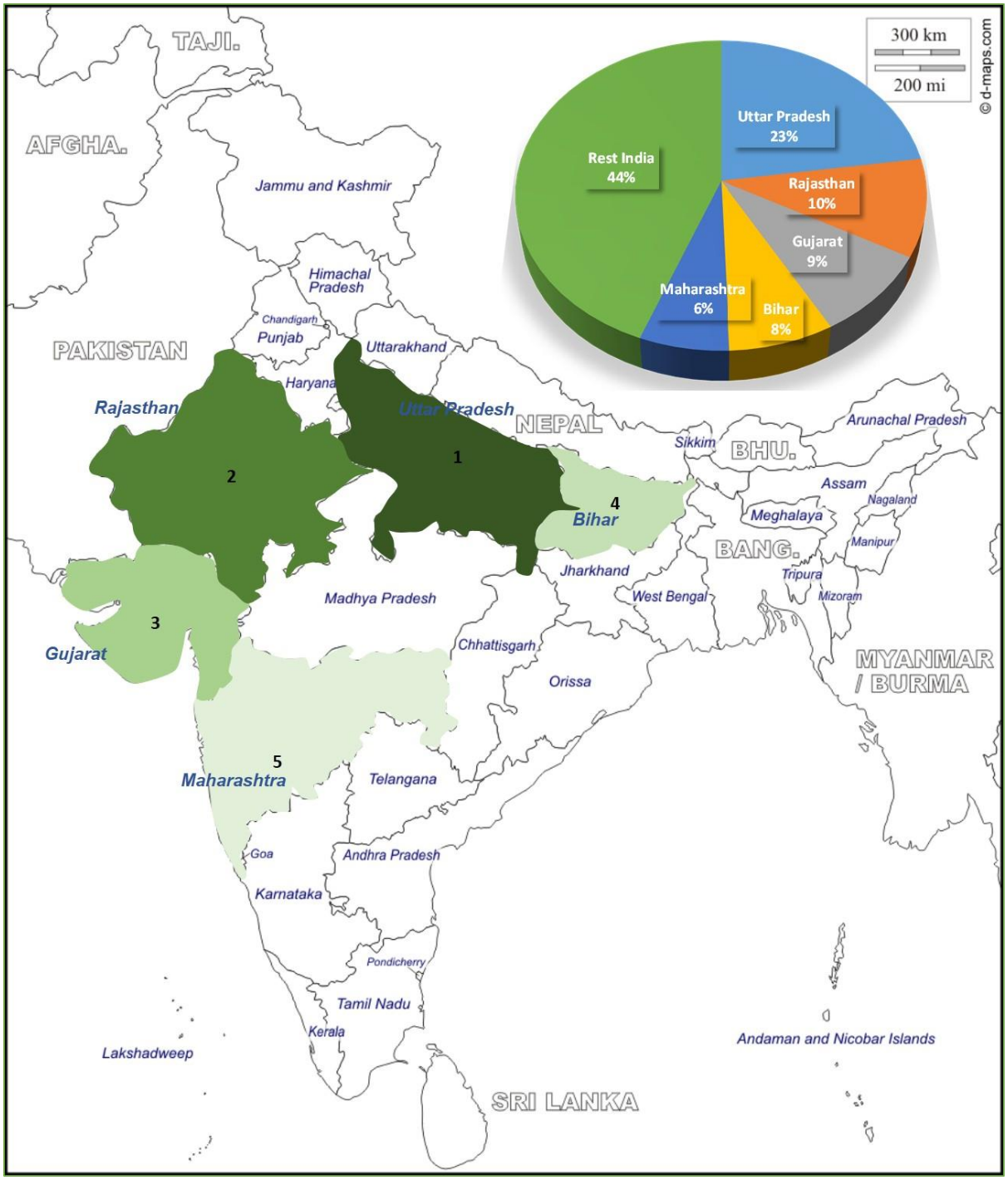
Energy potential

Cow dung is composed of 1.8-2.4% nitrogen (N2), 1.0-1.2% phosphorus (P2O5), 0.6-0.8% potassium (K2O) and 50-75% organic humus and has high potential of biogas generation under anaerobic condition. This gas is used as cooking fuel in various rural households of India and as fuel in power generators to generate electricity.

The total estimated energy potential from waste generated in cattle farm is 862 MW with maximum potential being for the state of Uttar Pradesh (23%) followed by Rajasthan (10%), Gujarat (9%), Bihar (8%) and Maharashtra (6%).

7 http://web.iitd.ac.in/~vkvijay/Entrepreneurship%20Models%20on%20Biogas%20for%20Rural%20Areas_2.pdf

Figure 2-11: Location of major states generating cattle dung and energy potential



State wise major regions

After shortlisting of major states having maximum energy potential from cattle dung, districts contributing to maximum resource availability have been identified. Based on the district level data available from 19th Livestock census 2012 published by Department of Animal Husbandry and Dairying (AH&D), Ministry of Agriculture and Farmer Welfare, key districts within 5 major states have been earmarked (Refer Figure 2-12 and Table 2-9).

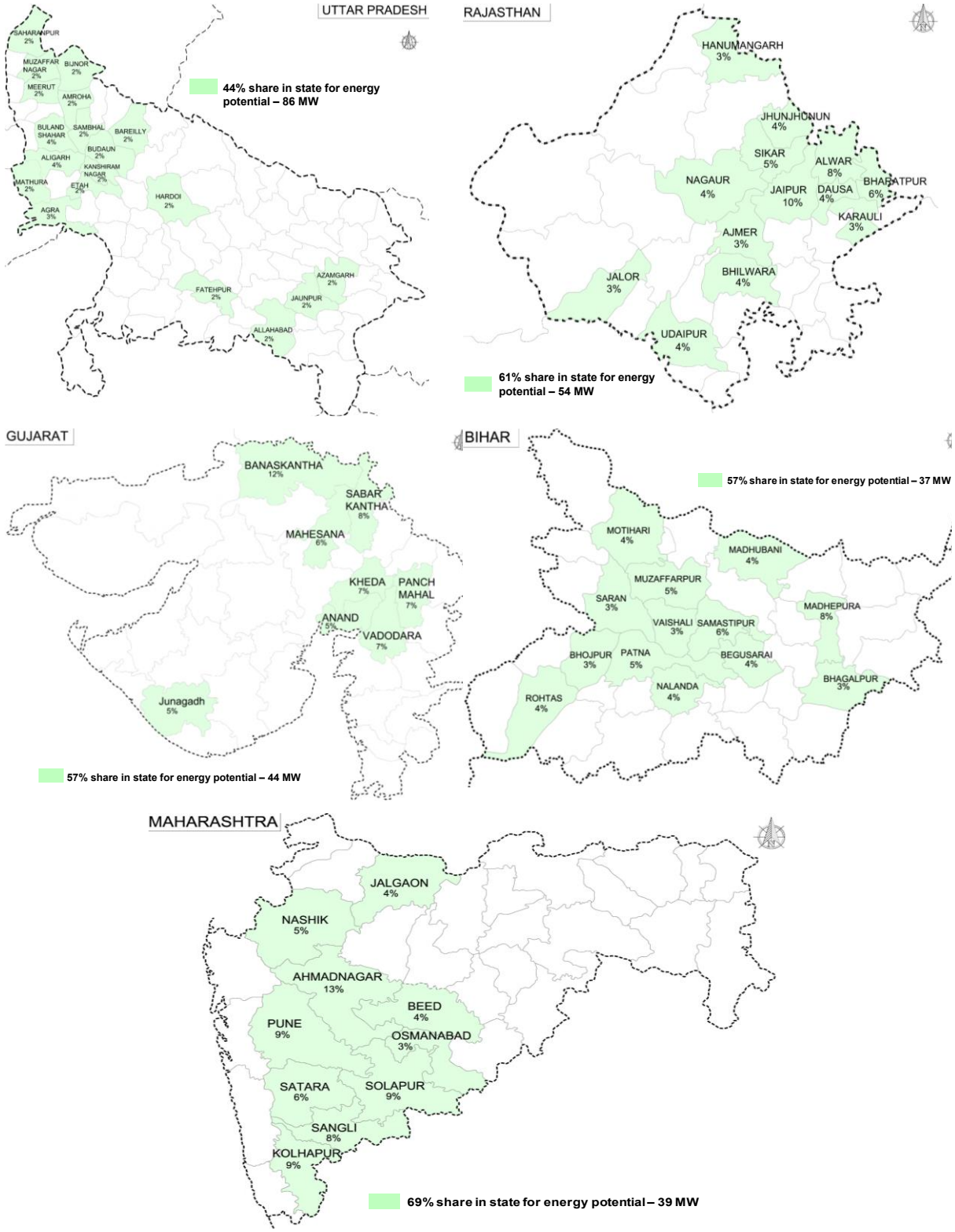
Table 2-10: Districts having maximum potential in the selected states

State	District	Share in state	State	District	Share in state
1. Uttar Pradesh - 44% concentrated in these nineteen districts	Agra	3%	3. Gujarat -57% concentrated in these eight districts	Anand	5%
	Aligarh	4%		Banas Kantha	12%
	Allahabad	2%		Junagadh	5%
	Azamgarh	2%		Kheda	7%
	Bareilly	2%		Mahesana	6%
	Bijnor	2%		Panch Mahals	7%
	Budaun	2%		Sabar Kantha	8%
	Bulandshahr	4%		Vadodara	7%
	Etah	2%	4. Bihar - 57% concentrated in these eleven districts	Begusarai	4%
	Fatehpur	2%		Bhagalpur	3%
	Hardoi	2%		Bhojpur	3%
	Jaunpur	2%		Madhepura	8%
	Jyotiba Phule Nagar	2%		Madhubani	4%
	Kanshiram Nagar	2%		Motihari	4%
	Mathura	2%		Muzaffarpur	5%
	Meerut	2%		Nalanda	4%
	Muzaffarnagar	2%		Patna	5%
	Saharanpur	2%		Rohtas	4%
	Sambhal	2%		Samastipur	6%
				Saran	3%
				Vaishali	3%
2. Rajasthan - 61% concentrated in these thirteen districts	Ajmer	3%	5. Maharashtra -- 69% concentrated in these eleven districts	Ahmadnagar	13%
	Alwar	8%		Bid	4%
	Bharatpur	6%		Jalgaon	4%
	Bhilwara	4%		Kolhapur	9%
	Dausa	4%		Nashik	5%
	Hanumangarh	3%		Osmanabad	3%
	Jaipur	10%		Pune	9%
	Jalor	3%		Sangli	8%
	Jhunjhunun	4%		Satara	6%
	Karauli	3%		Solapur	9%
	Nagaur	4%			
	Sikar	5%	**Cattle dung** Energy potential in India – 862 MW Energy potential in 5 selected states – 482 MW Energy potential in selected districts of selected 5 states – 259 MW		
	Udaipur	4%			

Energy potential of the selected top five states in the sector is 482 MW which is 56% of the estimated energy potential for the entire country. Above table presents details on the key districts having maximum resource availability and energy potential in each of the selected state. Districts having energy potential more than the state's average energy potential has been selected for further evaluation in each state. For the states having

large number of districts and scattered energy potential throughout the state (Uttar Pradesh 75 districts, Bihar 38 districts, Tamil Nadu 32 districts), districts with less than 1% of the share are excluded in the process. After excluding the districts with less than 1% of share, average energy potential for remaining districts has been derived and districts above the state average number are selected as potential areas. Identified districts have 259 MW of energy potential contributing to 54% of the respective 5 states. Following figures shows location of the identified districts and share in the state. As apparent from the figures, in all the state major portion of the energy potential is concentrated in one region.

Figure 2-12: Identification of districts in the top 5 states for energy potential – cattle dung



Existing cattle dung based WTE plants

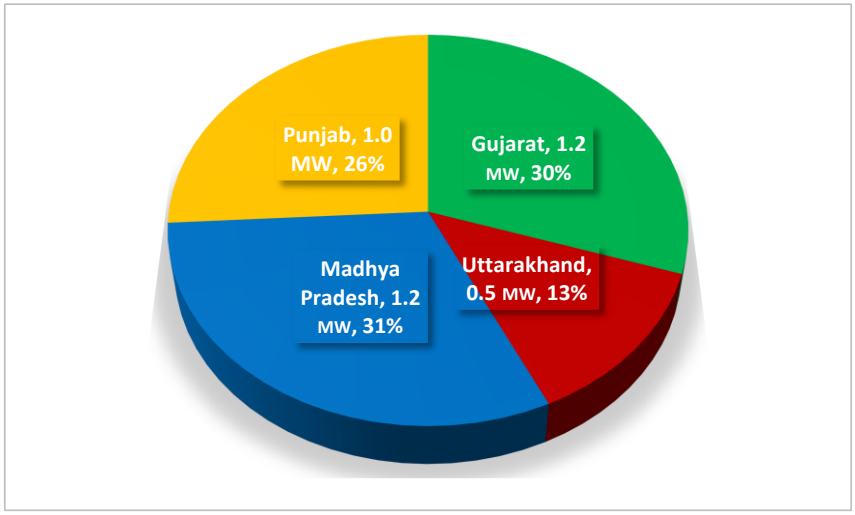
As per the information available on cattle dung based waste to energy plants from MNRE, there are four plants located one each in Gujarat, Uttarakhand, Madhya Pradesh and Punjab state. In addition to that, there are many small-scale biogas plants running at household level or institutional/community level in India.

Table 2-11: Details of existing cattle dung based WTE plants

Sl. No.	WTE plant location	Plant installed capacity	Year if installation	State
2	M/s. Bharat Bio Gas Energy Limited, Navarangpura, Ahmedabad, Gujarat. (Bio-CNG)	1.16 MWeq	2014-15	Gujarat
3	M/s. Patanjali Bio Research Institute, Vill. Padartha, Laksar Road, Haridwar (U.K)	0.50 MWeq.	2014-15	Uttarakhand
4	M/s. RDM Care Pvt. Ltd. at Pariyat, Jabalpur, M.P.	1.2 MW	2011-12	Madhya Pradesh
5	Power generation from Cattle dung through bio-methanation at Haebowal, Ludhiana, Punjab by PEDA	1 MW	2004-05	Punjab

Source: MNRE

Figure 2-13: State wise share in WTE plants – cattle dung based



CATTLE DUNG - CASE STUDY

One-Megawatt, High-Rate Bio-methanation Plant Ludhiana, Punjab, India Haebowal Dairy Complex

This project at Haebowal was set up as the first project to demonstrate large - scale power generation from cattle manure. The project has proven the technical feasibility of developing such projects for energy recovery as well as producing large quantities of enriched organic fertilizer and reducing GHG emissions.

- Site Name: 1-MW high-rate bio-methanation plant based on cattle manure
- Site Type: Dairy complex
- Site Size: 80,000 cattle
- Baseline Waste Management System: Collected manually, used for making cow dung cakes for use as fuel or disposed of into city sewerage system
- Digester Type: Intermittently stirred tank reactors based on biogas-induced mixing arrangement
- Digester Volume: 2 x 5,000 CUM
- Type/Volume of Gas Storage: 1,000 CUM (bell-and shell-type storage made of neoprene-coated nylon fabric
- Year Built/Operational: Constructed and commissioned in Sept 2004
- Feedstock(s): Cattle manure, 200 tons/day
- System Designer: Ministry of New and Renewable Energy and Punjab Energy Development Agency developed and executed the project with technology obtained from ENTEC (Austria)

Biogas and Energy Highlights

- Generating capacity & biogas generation: 10,000 CUM/day of biogas generation for use in 1000 kW GE gas genset
- Total annual generation capacity: 6 million kWh
- Biogas used for generating electricity for feeding into the national grid. The waste heat recovered from the engine provides heat to the digesters for maintaining them at a constant temperature of 37 C (+/-2 C)
- Energy generation cost: Operating cost is about Rs 3.14/kWh (Capital cost was provided as a grant by the Government of India and the State Government of Punjab)
- Price of energy sold to the grid: Rs 3.49/kWh
- Final digestate use: Separated solids with less than 70% moisture are sold as farm manure at Rs 1000 per metric ton

Incentives/Benefits

- Reason for Installing Digester: It was set up as a demonstration project to recover energy and reduce GHG emissions, as well as improve the environment by scientific management of cattle manure
- Incentives Used to Install Digester: Grants provided by the Ministry of New and Renewable Energy, Government of India, and the Government of Punjab
- Benefits Gained from Digester System: GHG reduction, power generation, and proper management of manure through reduced risk of run - off and leaching of nutrients; conversion of nutrients from organic to inorganic form, allowing use as a natural fertilizer; potential revenue from sale of excess energy and digested manure.

Source:https://www.globalmethane.org/expo-docs/posters/Agriculture/Ag_IN_Success_Haebowal-Dairy.pdf

2.3 Fruit and Vegetable Processing Industry

India is the second largest producer of the Fruits (79.10 Million ton) and vegetables (130.30 Million ton) in the world, contributing 12.6% and 14.0% of the total world production of fruits and vegetables respectively. (Source: Indian Horticulture Database 2014).

Banana, mango, citrus, papaya, guava and grape account for major share in total fruit production across India. The major fruit producing states are Andhra Pradesh, Maharashtra, Karnataka, Bihar, Uttar Pradesh, Tamil Nadu, Kerala and Gujarat. These eight states account for 70 per cent of the area under fruit cultivation. Potato, tomato, onion, brinjals, cabbage, cauliflower and tapioca account for maximum share in vegetable production in the country.

Figure 2-14: Fruit production

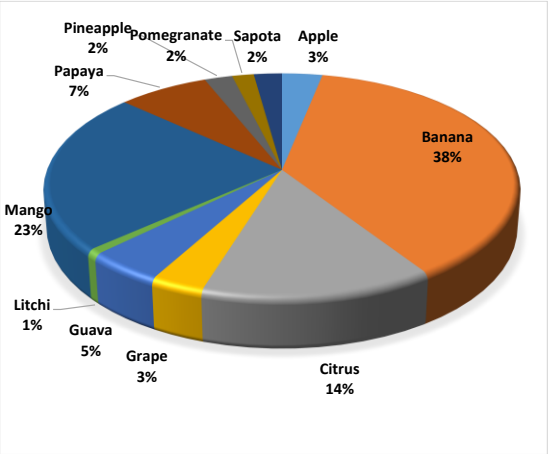
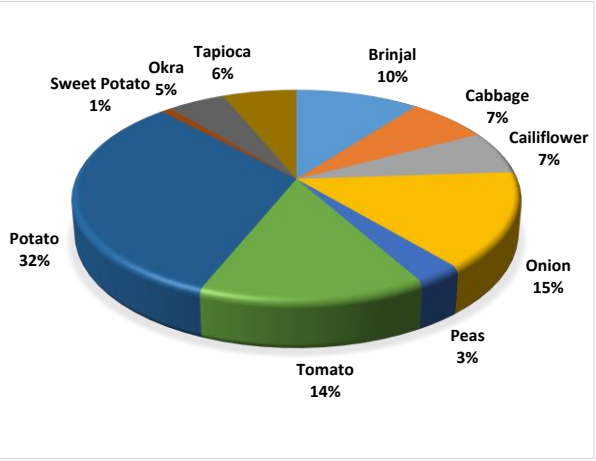


Figure 2-15: Vegetable production



Raw fruit and vegetable–Out of the total production of fruits and vegetables (210 million ton), nearly 76 per cent is consumed in fresh form, while wastage, and losses account for 20 to 22 per cent. 40 to 45 million ton per annum of wastage is there due to limitation of storage facilities (warehouse & cold storage) after production. Only 2 per cent of vegetable production and 4 per cent of fruit production is being processed. Food waste has great potential for biogas production via anaerobic digestion. State wise fruit and vegetable production and estimated wastage numbers have been provided in respective fruit and vegetable sections.

Fruit and vegetable processing industry in India is highly decentralized. A large number of units are in the small-scale sector, having small capacities upto 250 ton/annum; in comparison, big Indian and multinational companies have capacities in the range of 30 ton per hour or similar range. The prominent processed items are fruit pulps and juices, fruit based ready-to-serve beverages, canned fruits and vegetables, jams, squashes, pickles, chutneys and dehydrated vegetables. More recently, products like frozen pulps and vegetables, frozen dried fruits and vegetables, fruit juice concentrates and vegetable curries in restorable pouches, canned mushroom and mushroom products have been taken up for manufacturing by the industry.[8] Of the total processed fruit production in the country, about 45% is contributed by mango-based products and 15% by pineapple-based products[9]. All the above numbers are confirmed by All India Food Processors' Association (AIFPA).

Presently there are approximately over 5200 units registered under the Fruit Product Order of 1955 distributed all over the country with installed capacity of 2.1 million ton. Out of the total units, 2002 (38%) were home-scale (household) units, 1083 (21%) cottage, 834 (16%) small-scale, 598 (12%) large-scale and the remaining 681 (13%) were only re-labellers. Most of the units fall in the cottage and /or small-scale sector. A few modern processing plants have also developed in the recent years.

Seasonal variation in fruit and vegetable processing industry

Seasonal variation for fruit and vegetable processing has been assessed in context to the production season during the year. All the fruits and vegetables are perishable in nature and need immediate processing to preserve. Therefore, harvesting season provide by National Horticulture Board for fruits and vegetables has been referred to identify the processing months. Seasonal variation for each of the sector is provided in the respective sections.

Fruits

Production details, processing quantity, processing regions and estimated wastage details for major fruits in India is provided in Table 2-12.

[8] *http://foodprocessingindia.co.in/fruits-and-vegetables.html*

[9] *http://www.dsir.gov.in/reports/ittp_tedo/agro/AF_Farm_Fruits_Vegetables_Intro.pdf*

Table 2-12: Fruit production, processing share and wastage generation

Fruit	Total quantity in '000 ton[1]	Production wastage – 20% ('000 ton/annum)	Total processing quantity in '000 ton[2]	Processing wastage in '000 ton – per annum	Type of processing waste	% of waste from processing	Remark	Processing Region
Apple	2,498	500	26	8	Pomace	30%	Potential for bioenergy	Himachal Pradesh Jammu & Kashmir
Banana	29,725	5,945	54	11	Peel	20%	Potential for bioenergy	Gujarat Maharashtra
Orange	3,431	686	23	7	Peel and Pulp	30-50%	Potential for bioenergy	Tamil Nadu Karnataka
Mosambi	3,886	777	NA	NA	Peel and Pulp	30-50%	Minimal processing and wastage	NA
Lime	2,835	567	NA	NA	Peel and Pulp	30-50%	Minimal processing and wastage	NA
Grape	2,585	517	NA	NA	NA	20%	Minimal processing and wastage	NA
Guava	3,668	734	NA	NA	NA	10%	Minimal processing and wastage	NA
Litchi	586	117	NA	NA	NA	NA	Minimal processing and wastage	NA
Mango	18,431	3,686	705	282	Pulp, Peel and kernel	30-50%	Potential for bioenergy	Krishnagiri, Andhra Pradesh Chittor, Tamil Nadu Ratnagiri, Maharashtra
Papaya	5,639	1,128	57	29	Peel, Pulp and Seeds	40-50%	Potential for bioenergy	Maharashtra Tamil Nadu Andhra Pradesh
Pineapple	1,737	347	6	3	Peel, Leaf, Pulp	40-50%	Potential for bioenergy	Karnataka Uttar Pradesh Imphal, Manipur Dimapur, Nagaland Agartala, Tripura Meghalaya
Pomegranate	1,346	269	NA	NA	NA	NA	Minimal processing and wastage	NA
Sapota	1,744	349	NA	NA	NA	NA	Minimal processing and wastage	NA

Source: [1] Indian Horticulture Database, National Horticulture Board, 2014

[2] Annual Survey of Industry, 2013-14

Apple

Apple production in India is concentrated in two states only i.e. Jammu and Kashmir with 65% of total production and Himachal Pradesh with 31%, accounting to total of 95% from these states. Himachal Pradesh Horticulture Produce Marketing and Processing Corporation Ltd (HPMC) has established two Fruit Processing Plants with a combined capacity to process about 20,000 MT of fruits every year. These plants are located at Jarol (Sundernagar) in Mandi District and Parwanu in Solan District. Jammu & Kashmir and Uttarakhand states also have some processing units. The details of apple production, wastage, processing capacity and estimated energy

potential from raw fruit waste and energy potential from wastage from processing industry have been estimated in Table 2-13.

Table 2-13: Apple production, processing share, waste generation and energy potential

State	Apple production[1] ('000 ton) – per annum	Raw material wastage – 20% – per annum	Processing quantity[2] – per annum ('000 ton)	Wastage in processing – per annum ('000 ton)	Energy Potential (MW) – raw material wastage*	Energy Potential (MW) – processing wastage**
Arunachal Pradesh	32	6	NA	NA	*0.14*	NA
Himachal Pradesh	739	148	24	7	3	*0.26*
Jammu and Kashmir	1648	330	1	*0.26*	7	*0.01*
Uttarakhand	78	16	NA	NA	*0.33*	NA
Others	2	0.4	1	*0.38*	*0.01*	*0.01*
Total	**2498**	**500**	**26**	**8**	**11**	***0.3***

Source: [1] Indian Horticulture Database, National Horticulture Board, 2014

[2] Annual Survey of Industry, 2013-14

**Biogas potential from raw apple waste has been considered as 87.35m³/ ton considering methane yield of 0.332m³ CH4 /kg VS with methane percentage of 97.87% (https://repository.ugm.ac.id/125397/); TS -27.8% and VS- 92.57% (http://fulltext.study/download/683685.pdf). The formula used for calculation is given in the box below.*

** Biogas potential from apple processing waste has been considered as 148m³/ton *(http://www.balticbiogasbus.eu/web/Upload/Supply_of_biogas/Act_4_8/4_8_1_Biogas_potential_ENG_Endfassung_webb.pdf)*

Formula for biogas yield calculation

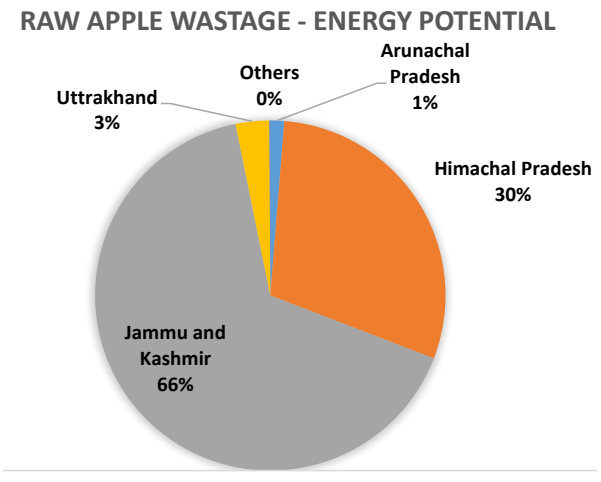
1. Biogas yield (m³/kg of waste) = $\frac{\text{methane yield (m}^3\text{/kg of VS) x TS\% x VS\%}}{\text{Percent of methane in biogas}}$

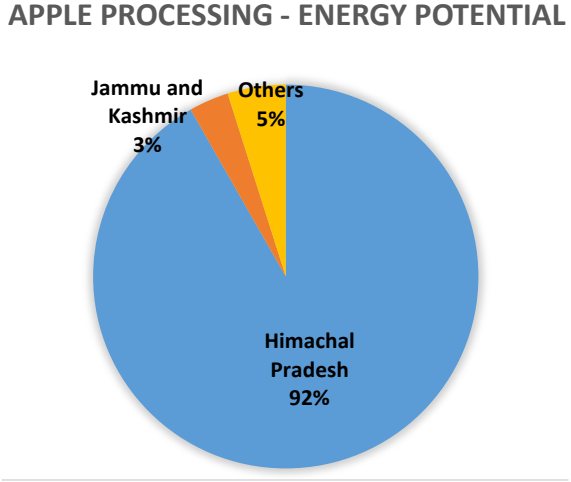
Note: Above formula has been considered to calculate biogas yield for Apple, Orange, Papaya and Onion

2. Biogas yield (m³/kg of waste) = biogas yield (m³/kg of VS) x TS% x VS%*

*Source: *Biogas calculation tool user´s guide, Alternative Energy Promotion Center - NRREP Government of Nepal, June 2014*

Note: Above formula has been considered to calculate biogas yield for Mango, Pineapple, Banana, Potato and Tomato





Raw material waste – Jammu & Kashmir followed by Himachal Pradesh generates maximum apple wastage with 66% and 30% share respectively. Estimated energy potential from apple wastage is approximately 11 MW.

Processing waste - As per the records available from MOSPI, ASI, 26,200 ton of apple is processed majorly in Himachal Pradesh and Jammu and Kashmir. Apple processing units generate almost 30% wastage of total raw material in the form of apple pomace. Himachal Pradesh alone generate 92% of the apple processing waste i.e. 7,200 ton. The estimated energy potential from processing of apple waste is 0.3 MW

As a current practice the waste is used for cattle feed or thrown in the open. The waste is rich sources of carbohydrate, pectin, crude fibre, and minerals. Dried apple pomace has potential to generate energy which can be utilised for the industry[10]. Write about energy potential here in detail.

Seasonal variation

Peak season for apple production and processing is August and September in Himachal Pradesh, the largest apple processing centre. June – July and October – November are the lean season, whereas for the rest of the year i.e. from December to May processing plants are almost closed.

State	January	February	March	April	May	June	July	August	September	October	November	December
Arunachal Pradesh												
Himachal Pradesh												
Jammu and Kashmir												
Uttarakhand												

Legend

Peak Season	
Lean Season	
No Production	
Major States	

Mango

Among the fruits, mango production in India is second highest, next only to Banana. The major mango producing states in India include Uttar Pradesh, Andhra Pradesh and Karnataka. Mango processing industries in India are limited, with only 1.5% of the total production being diverted for processing. Mango processing include processing of raw mangoes to chutney, pickles, curries & dehydrated products and ripe mangoes to canned and frozen slices, purée, juices, nectar and various dried products. Major products of mango processing industry include mango pulp/puree and mango concentrates. Mango Pulp/Concentrate are further converted to juices, nectars, drinks, jams, fruit cheese and various other kinds of beverages.

There are two main clusters of Mango pulp processing in the country, which has around 65 processing units (90% of the total mango pulp processing capacity) with a good backward linkage of Alphonso and Totapuri variety of mangoes. These clusters are Chittoor in the state of Andhra Pradesh and Krishnagiri in the state of Tamil Nadu. Some of the Processing units are also in the state of Maharashtra (Ratnagiri – 37 functional units) and Gujarat. Table 2-14 provides details of mango production in various states, wastage, processing capacity and estimated energy potential from raw fruit waste and energy potential from wastage from processing industry.

[10] *https://www.researchgate.net/publication/236189241_Utilization_of_pomace_from_apple_processing_industries_A_review*

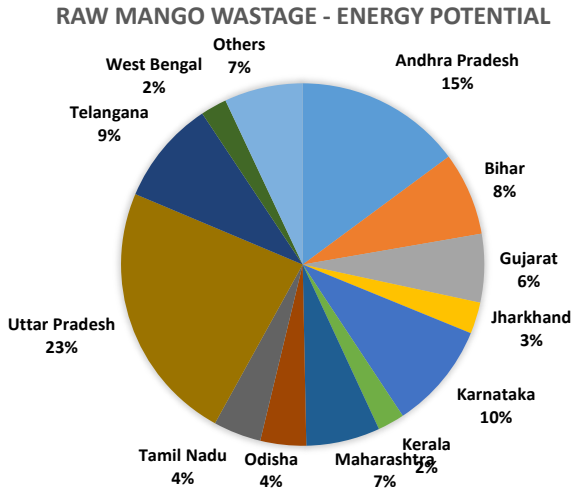
Table 2-14: Mango production, processing share, waste generation and energy potential

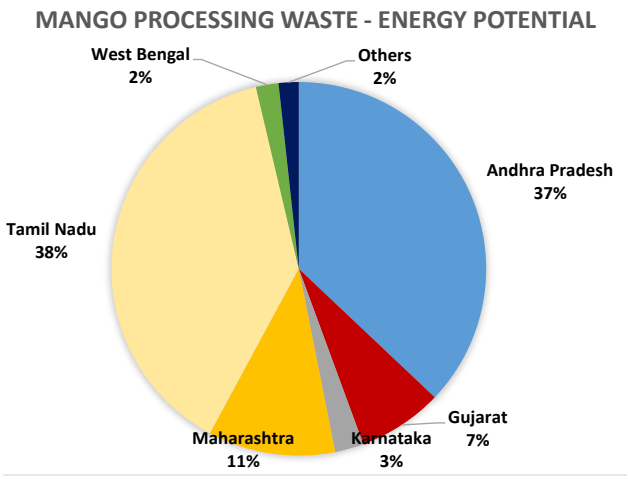
State	Mango production[1] ('000 ton/annum)	Raw material wastage – 20% – per annum	Processing quantity[2] ('000 ton/annum)	Wastage in processing– per annum ('000 ton/annum)	Energy Potential (MW) – raw material wastage**	Energy Potential (MW) – processing industry wastage**
Andhra Pradesh	2,737	547	261	105	13	2
Bihar	1,368	274	NA	NA	6	NA
Gujarat	1,126	225	52	21	5	0.5
Jharkhand	518	104	NA	NA	2	NA
Karnataka	1,756	351	17	7	8	0.2
Kerala	441	88	NA	NA	2	NA
Maharashtra	1,213	243	77	31	6	1
Odisha	751	150	NA	NA	4	NA
Tamil Nadu	786	157	271	108	4	3
Uttar Pradesh	4,301	860	NA	NA	20	NA
Telangana	1,718	344	NA	NA	8	NA
West Bengal	431	86	14	6	2	*0.1*
Others	1,288	258	12	5	6	*0.1*
Total	**18,431**	**3,686**	**705**	**282**	**87**	**7**

Source: [1] Indian Horticulture Database, National Horticulture Board, 2014

[2] Annual Survey of Industry, 2013-14

*** Biogas potential from mango raw and processing waste has been considered as 96.61m³/ ton considering biogas yield of 0.43m³ /kg VS (Ranges from 0.22 to 0.63, average value taken 0.43), TS -26.3% and VS- 95.2% (http://journal.gnest.org/sites/default/files/Submissions/639/639_published.pdf);*





Raw material waste – Uttar Pradesh being the largest producer of mangoes is also the largest contributor towards raw mango wastage with 23% of the total, followed by Andhra Pradesh 15%, Karnataka 10% and Telangana 9%. Total estimated energy potential from raw mango wastage is 87 MW.

Processing waste - Mango fruit processing industries generate two types of waste, including solid waste (peel and stones) and liquid waste (juice and wash water). Based on the discussion with ALFPA and information gathered from secondary sources, 30% to 50%[11] of the total quantum of raw material (mango) is wastage in the processing industry. Tamil Nadu and Maharashtra are the major contributors in mango processing waste with more than 75% of the total, followed by Maharashtra with 11% share. The total estimated energy potential from mango processing waste is 7 MW.

Currently, this waste is either used as cattle feed or dumped in open areas. Potential of mango wastage for biogas production has also been assessed in various studies. The presence of high amount of reducing sugars in dried and fresh mango peel makes it a suitable as a raw material for ethanol production[12].

Seasonal variation

Peak months for mango production and processing are April – May for Andhra Pradesh (largest mango processing state) and Maharashtra. For the state of Tamil Nadu, the peak season is May – June. From August to March there is hardly any production except for Andhra Pradesh, where January to March is lean season.

State	January	February	March	April	May	June	July	August	September	October	November	December
Andhra Pradesh												
Gujarat												
Karnataka												
Maharashtra												
Tamil Nadu												
West Bengal												

Legend

Peak Season

Lean Season

No Production

Major States

Banana

India is the largest producer of banana in the world with a production of approximately 30 million tons (National Horticulture Board). Out of this amount only 1-2% of banana is processed. Tamil Nadu, Maharashtra, Gujarat and Andhra Pradesh are major contributing states in total banana production i.e. 65%. The most popular processed product is Nendran chips, which is still in cottage scale while some bigger manufactures are processing banana puree for export. Key products from banana processing are chips, candy/stem candy, fig, flour, wine, powder, juice, fruit bar, biscuit, jam & jelly, health drinks and baby food. The details of banana production in different states, wastage, processing capacity and estimated energy potential from raw fruit waste and energy potential from wastage from processing industry have been estimated in Table 2-15.

Table 2-15: Banana production, processing share, waste generation and energy potential

State	Banana production[1] ('000 ton per annum)	Raw material wastage – 20% – per annum	Processing quantity[2] ('000 ton per annum)	Wastage in processing ('000 ton per annum)	Energy Potential (MW) – raw material wastage**	Energy Potential (MW) – processing wastage**
Andhra Pradesh	3,167	633	*0.31*	*0.06*	8	*0.001*

[11] *http://www.appropedia.org/Fruit_waste_utilisation_(Practical_Action_Brief)*

[12] *http://www.academicjournals.org/journal/AJB/article-full-text-pdf/777095D30789*

State	Banana production[1] ('000 ton per annum)	Raw material wastage – 20% – per annum	Processing quantity[2] ('000 ton per annum)	Wastage in processing ('000 ton per annum)	Energy Potential (MW) – raw material wastage**	Energy Potential (MW) – processing wastage**
Assam	858	172	NA	NA	2	NA
Bihar	1,436	287	NA	NA	3	NA
Gujarat	4,225	845	39	8	10	*0.09*
Karnataka	2,676	535	NA	NA	6	NA
Madhya Pradesh	1,735	347	NA	NA	4	NA
Maharashtra	4,831	966	14	3	12	*0.03*
Odisha	477	95	NA	NA	1	NA
Tamil Nadu	5,650	1,130	NA	NA	14	NA
West Bengal	1,098	220	NA	NA	3	NA
Others	3,573	715	*0.74*	*0.15*	9	*0.002*
Total	**29,725**	**5,945**	**54**	**11**	**72**	***0.13***

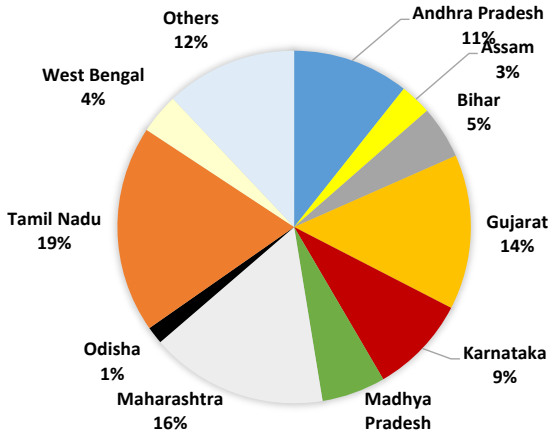
Source: [1] Indian Horticulture Database, National Horticulture Board, 2014

[2] Annual Survey of Industry, 2013-14

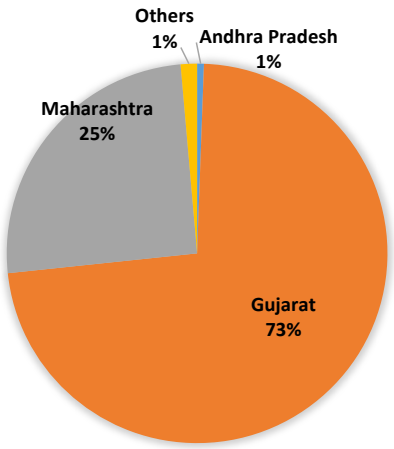
*** Biogas potential from banana raw and processing waste has been considered as 49.26m³/ ton considering biogas yield of 0.28m³ /kg VS (http://journal.library.iisc.ernet.in/index.php/iisc/article/view/25/25),*

TS - 19% and VS - 92.6% *(Production of Biogas from Fruit and Vegetable Wastes Mixed with Different Wastes, Environment and Ecology Research 3(3): 65-71, 2015)*

RAW BANANA WASTAGE - ENERGY POTENTIAL



BANANA PROCESSING WASTE - ENERGY POTENTIAL



Raw material wastage - Tamil Nadu being the largest producer of banana also contributes maximum to banana wastage including banana leaves and peel (19% of the total), followed by states like Maharashtra, Gujarat and Andhra Pradesh together contributing to approximately 40% of the total. Total estimated energy potential from banana wastage is 72 MW as presented in Table 2-15.

Processing waste - Banana processing industry generates approximately 20% wastage of the total raw material input. Banana peel is the key waste derived from processing activity. 73% of the banana processing in India is being done by Gujarat state followed by Maharashtra with 25% contribution. The total estimated energy potential from waste obtained from banana processing is 0.13 MW.

The waste contains carbohydrates, proteins, and fibre in significant amounts. Various studies conducted to assess the potential of banana peel for energy generation have established the fact that banana peel is rich source of ethanol or biogas generation.

Seasonal variation

Gujarat is the major state for banana processing industries. Peak season in Gujarat is September to October, lean season from December to March and August. Between April and July there is no production of banana in the state.

State	January	February	March	April	May	June	July	August	September	October	November	December
Andhra Pradesh												
Gujarat												
Maharashtra												

Legend

Round the year	
Peak Season	
Lean Season	
No Production	
Major States	

Pineapple

Pineapple production in the country is concentrated in north eastern states, south India and West Bengal contributing 68% of the total production. 20% is contributed by Karnataka and Kerala and remaining by rest of the India. Major pineapple processing states are Karnataka and Uttar Pradesh with total share of 87%. Rest of the pineapple processing units are located in Manipur, Meghalaya, Nagaland and Tripura with total plant capacity of 4500 MT. Major products from processing are canned pineapple, juice concentrate and pulp[13]. Table 2-16 provides details of pineapple production in various states, wastage details, processing capacity and estimated energy potential from raw fruit waste and energy potential from wastage from processing industry.

Table 2-16: Pineapple production, processing share, waste generation and energy potential

State	Pineapple production[1] ('000 ton per annum)	Raw material wastage – 20% – per annum	Processing quantity[2] ('000 ton per annum)	Wastage in processing ('000 ton per annum)	Energy Potential (MW) – raw material wastage**	Energy Potential (MW) – processing wastage**
Arunachal Pradesh	70	14	NA	NA	*0.21*	NA
Assam	289	58	NA	NA	*0.86*	NA
Bihar	114	23	*0.43*	*0.19*	*0.34*	*0.003*
Karnataka	160	32	5	2	*0.48*	*0.03*
Kerala	73	15	NA	NA	*0.22*	NA
Manipur	136	27	*0.11*	*0.05*	*0.41*	*0.001*
Meghalaya	118	24	NA	NA	*0.35*	NA
Nagaland	143	29	NA	NA	*0.42*	NA
Tripura	162	32	NA	NA	*0.48*	NA

[13] *http://www.pineappleindia.com/Production-units.html*

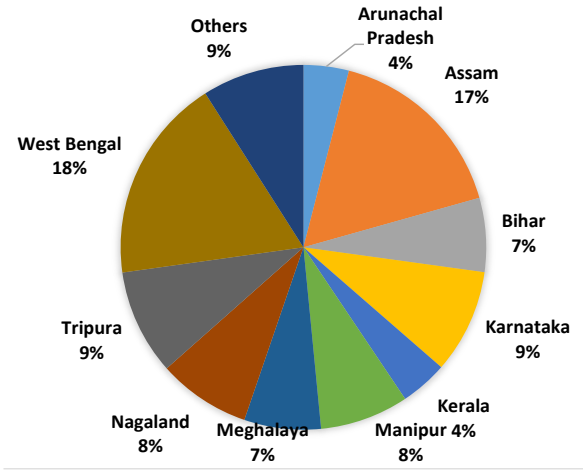
West Bengal	316	63	NA	NA	*0.94*	NA
Uttar Pradesh	NA	NA	*0.76*	*0.34*	*0.00*	*0.01*
Others	157	31	*0.25*	*0.11*	*0.47*	*0.002*
Total	**1,737**	**347**	**7**	**3**	**5**	***0.04***

Source:[1] Indian Horticulture Database, National Horticulture Board, 2014

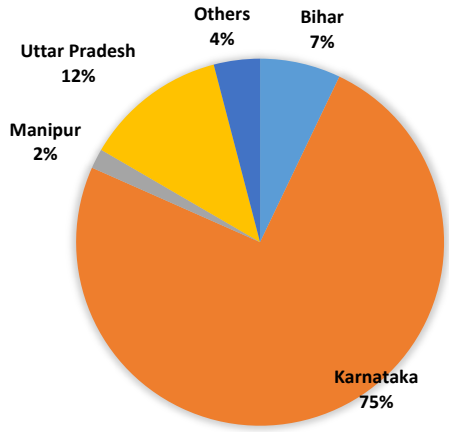
[2] Annual Survey of Industry, 2013-14

*** Biogas potential from pineapple raw and processing waste has been considered as 61m³/ ton considering biogas yield of 0.55m³ /kg VS (http://www.resjournal.kku.ac.th/abstract/17_5_734.pdf),*
TS – 11.7% and VS - 94.8% (http://www.ijaser.com/articles/vol4issue52015/vol4issue4/JASER4077.pdf);

RAW PINEAPPLE WASTAGE - ENERGY POTENTIAL



PINEAPPLE PROCESSING WASTE - ENERGY POTENTIAL



Raw material waste – West Bengal is generating maximum raw pineapple waste with 18% contribution followed by Assam with 17%, Karnataka and Tripura 9% each. Energy potential from pineapple waste is estimated to be 5 MW.

Processing waste - Waste in pineapple processing are in huge quantity, almost 40% to 50% of the raw material. Karnataka and Uttar Pradesh are main states generating pineapple processing waste. The total energy potential estimated from pineapples processing waste is 0.04 MW.

The bio-wastes like crown, leaves, cores, peels, stem, effluents etc. from pineapple production and processing can be used for production of value added products. Pineapple peel wastes are seasonal and comprise of peels and rags. Since pineapple peel is rich in cellulose, hemicellulose and other carbohydrates it was found to be a potential substrate for methane generation by anaerobic digestion[14].

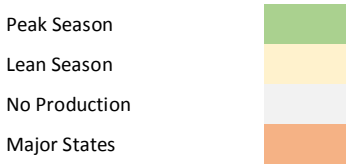
Seasonal variation

75% of the pineapple processing is done in Karnataka. June to August are the peak season and March to May are the lean season. Between the month of September and February no pineapple production is almost nil.

State	January	February	March	April	May	June	July	August	September	October	November	December
Karnataka												
Manipur												

Legend

[14] http://www.ncbi.nlm.nih.gov/pubmed/15120436



Orange

Orange contribute 34% of the total citrus production in the country. Citrus industry in India is the third largest fruit industry of the country after mango and banana[15]. Orange is major citrus fruit which gets processed at large scale in India. Tamil Nadu, Karnataka, Punjab and Maharashtra are the major orange processing states. Table 2-17 provides details of orange production in various states, wastage details, processing capacity and estimated energy potential from raw fruit waste and energy potential from wastage from processing industry.

Table 2-17: Orange production, processing share, waste generation and energy potential

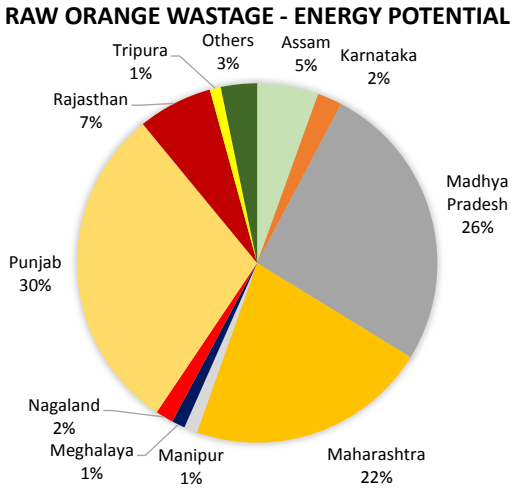
State	Orange production[1] ('000 ton per annum)	Raw material wastage – 20% – per annum	Processing quantity[2] ('000 ton per annum)	Wastage in processing– per annum ('000 ton per annum)	Energy Potential (MW) – raw material wastage**	Energy Potential (MW) – processing wastage**
Assam	189	38	NA	NA	*0.2*	NA
Karnataka	8	15	2	*0.56*	*0.1*	*0.003*
Madhya Pradesh	894	179	NA	NA	1	NA
Maharashtra	743	149	NA	NA	1	NA
Manipur	41	8	NA	NA	*0.1*	NA
Meghalaya	41	8	NA	NA	*0.1*	NA
Nagaland	55	11	NA	NA	*0.1*	NA
Punjab	1018	204	*0.49*	*0.15*	2	*0.001*
Rajasthan	230	46	NA	NA	*0.4*	NA
Tripura	34	7	NA	NA	*0.1*	NA
Tamil Nadu	NA	0	21	6	NA	*0.04*
Others	11	22	*0.04*	*0.01*	*0.2*	*0.0001*
Total	**3,431**	**686**	**23**	**7**	**5**	***0.04***

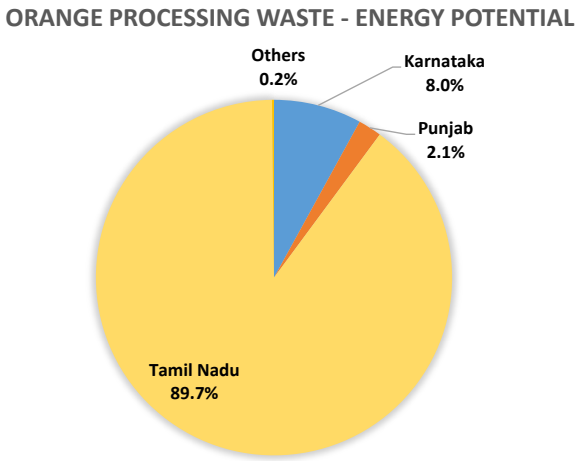
Source:[1] Indian Horticulture Database, National Horticulture Board, 2014

[2] Annual Survey of Industry, 2013-14 (as per NHB data base, the production quantity is nil, however Annual Survey of Industries data shows the presence of orange processing industry in the state. In view of the contradictory facts available from both the sources, we assume that raw orange is brought to Tamil Nadu from neighbouring states for processing, the same would be validated during the primary visits.)

***Biogas potential from orange raw and processing waste has been considered as 23.44m³/ ton considering methane yield of 0.33m³ CH4 /kg VS (http://www.mdpi.com/2077-0375/4/3/596) with assumed methane percentage of 60%; TS -7.5% and VS- 94.7% (http://www.ijaser.com/articles/vol4issue52015/vol4issue4/JASER4077.pdf).*

[15] http://nhb.gov.in/report_files/orange/ORANGE.htm





Raw material waste – Punjab is the largest producer of orange followed by Madhya Pradesh and Maharashtra contributing approximately 75% of the production and raw material wastage. Total estimated energy generation from raw orange wastage is 5 MW.

Processing waste - Citrus peel, remained after juice extraction, is the primary waste fraction amounting to almost 50% of the fruit mass. Tamil Nadu and Karnataka are generating almost 90% of the total orange processing waste at present. Currently waste from orange processing is further processed to dried pulp cattle feed and molasses, the latter being incorporated into the cattle feed or fermented for the production of valuable products like biogas, ethanol, citric acid, various enzymes, volatile flavouring compounds, fatty acids and microbial biomass. The total energy potential estimated from orange processing waste is 0.04 MW.

Seasonal variation

At organised scale, orange processing is being done in Tamil Nadu and Punjab. 90% of the orange processing is done in Tamil Nadu, however the processing is limited to few months only i.e. February, March, July and September.

State	January	February	March	April	May	June	July	August	September	October	November	December
Punjab												
Tamil Nadu												

Legend

Peak Season	
Lean Season	
No Production	
Major States	

Papaya

More than 70% of total papaya production is concentrated in 5 states i.e. Andhra Pradesh, Gujarat, Karnataka, West Bengal and Maharashtra. The fruit being perishable in nature poses problem in marketing and processing, therefore the processing industries are located near the production areas. Key products made from papaya are candy, jam, papad, pickle, canned and frozen papaya. Table 2-18 provides details of papaya production in various states, wastage details, processing capacity and estimated energy potential from raw fruit waste and energy potential from wastage from processing industry.

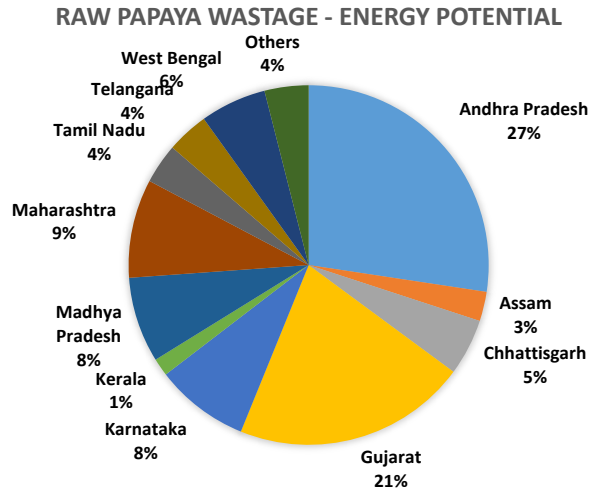
Table 2-18: Papaya production, processing share, waste generation and energy potential

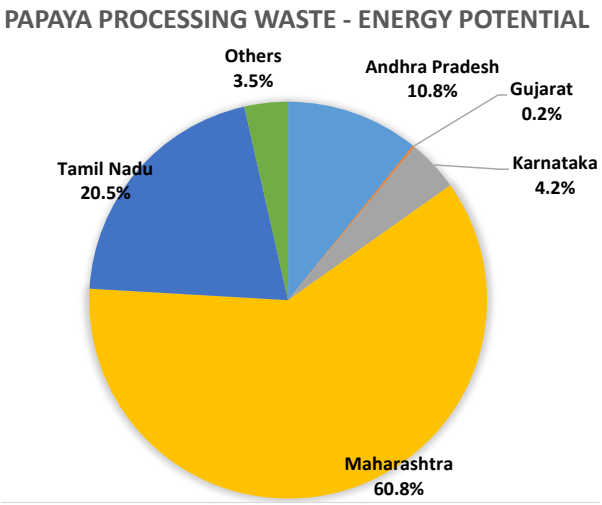
State	Papaya production[1] ('000 ton/annum)	Raw material wastage – 20% – per annum	Processing quantity[2] ('000 ton/annum)	Wastage in processing– per annum ('000 ton/annum)	Energy Potential (MW) – raw material wastage**	Energy Potential (MW) – processing wastage**
Andhra Pradesh	1,545	309	6	3	6	*0.06*
Assam	149	30	NA	NA	1	NA
Chhattisgarh	287	57	NA	NA	1	NA
Gujarat	1,186	237	*0.10*	*0.05*	5	*0.001*
Karnataka	476	95	2	1	2	*0.02*
Kerala	90	18	NA	NA	*0.4*	NA
Madhya Pradesh	434	87	NA	NA	2	NA
Maharashtra	501	100	35	17	2	*0.35*
Tamil Nadu	203	41	12	6	1	*0.12*
Telangana	213	43	NA	NA	1	NA
West Bengal	335	67	NA	NA	1	NA
Others	223	45	2	1	1	*0.02*
Total	**5,639**	**1,128**	**57**	**29**	**23**	***0.6***

Source: [1] Indian Horticulture Database, National Horticulture Board, 2014

[2] Annual Survey of Industry, 2013-14

***Biogas potential from papaya raw and processing waste has been considered as 82.69m^3/ ton considering methane yield of 0.42m^3 CH4 /kg VS (https://repository.ugm.ac.id/125397/) with methane percentage of 99.13%; TS -31.35% and VS- 92.12% (Production of Biogas from Fruit and Vegetable Wastes Mixed with Different Wastes, Environment and Ecology Research 3(3): 65-71, 2015).*





Raw material waste – Andhra Pradesh contributes to approximately 27% of the raw papaya wastage followed by Gujarat 21%, Maharashtra 9% and Karnataka 8%. Energy potential from the raw papaya wastage is estimated to be 23 MW.

Processing waste - Wastage in papaya processing are very high, approximately 40% to 50% of the total raw material. Currently all the waste is thrown in open or used for cattle feed in India. Maharashtra and Tamil Nadu are major states processing papaya and generating processing waste. Papaya processing waste has potential for energy generation and ethanol manufacturing. The total energy potential estimated from papaya processing waste is 0.6 MW.

Seasonal variation

Maharashtra and Tamil Nadu are the major papaya processing states. Papaya production and processing is done round the years in these states.

State	January	February	March	April	May	June	July	August	September	October	November	December
Andhra Pradesh												
Gujarat												
Karnataka												
Maharashtra												
Tamil Nadu												

Legend

Round the year

Peak Season

Lean Season

No Production

Major States

Vegetable Processing

Vegetable processing in India is being done majorly for tomato, potato and onion only. Production quantity, processing quantity, processing regions and wastage details for key vegetables in India is presented in Table 2-19.

Table 2-19: Vegetable production, processing and wastage details [16]

Vegetables	Total production quantity in ('000 ton per annum)	Wastage after production – 20% ('000 ton per annum)	Total processing quantity in ('000 ton per annum)	Processing wastage in ('000 ton per annum)	Type of processing waste	% of processing waste	Remark	Region
Brinjals	13,558	2,712	NA	NA	NA	NA	Minimal processing and wastage	NA
Cabbage	9,039	1,808	NA	NA	NA	NA	Minimal processing and wastage	NA
Cauliflower	8,573.30	1,715	NA	NA	NA	NA	Minimal processing and wastage	NA
Onion	19,401.90	3,880	109	38	Peel, stalks, roots	35%-40%	Potential for bioenergy	Maharashtra Gujarat
Peas	3,868.80	774	NA	NA	Peel	40%	Minimal processing and wastage	NA
Tomato	18,735.87	3,747	137	27	Pulp and juice	20%	Potential for bioenergy	Andhra Pradesh Telangana Tamil Nadu
Potato	41,555.40	8,311	124	19	Potato pulp and Juice	15%	Potential for bioenergy	West Bengal Madhya Pradesh Gujarat

[16] State wise data for vegetable production in India is given in Annexure 3.

Sweet Potato	1,087.90	218	NA	NA	NA	NA	Minimal processing and wastage	NA
Okra	6,346.42	1,269	NA	NA	NA	NA	Minimal processing and wastage	NA

Source: Indian Horticulture Database, National Horticulture Board, 2014

Source - https://www.researchgate.net/publication/224771051_The_Indian_potato_processing_industry-Global_comparison_and_business_prospects

Potato

West Bengal, Madhya Pradesh and Gujarat are major potato processing states in the country accounting for more than 90% of the total processing. Potatoes is processed for preservation and value addition in the form of wafers/ chips, powder, flakes, granules, canned slices etc. Chips making alone consumes 60% of the total raw potato in processing industry. The potato-processing industry in India can be split into the organized and unorganized sectors (60% of the total processing).

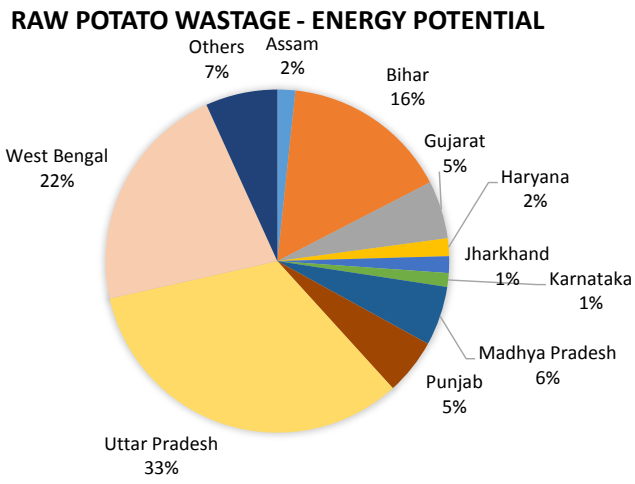
Table 2-20: Potato production, processing, waste generation and energy potential

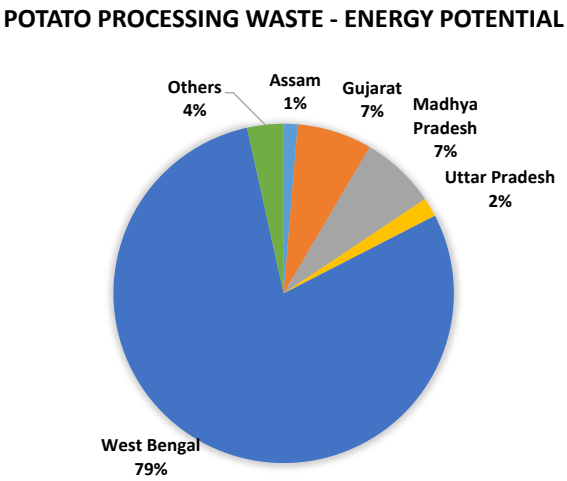
State	Potato production[1] ('000 tons per annum)	Raw material wastage – 20% – per annum	Processing quantity[2] ('000 tons per annum)	Wastage in processing ('000 ton per annum)	Energy Potential (MW) – raw material wastage**	Energy Potential (MW) – processing wastage**
Assam	700	140	1.64	*0.25*	5	*0.01*
Bihar	6,535	1,307	NA	NA	50	NA
Gujarat	2,267	453	8.79	1.32	17	*0.05*
Haryana	697	139	NA	NA	5	NA
Jharkhand	653	131	NA	NA	5	NA
Karnataka	540	108	NA	NA	4	NA
Madhya Pradesh	2,322.40	464	9	1	18	*0.05*
Punjab	2,189.20	438	NA	NA	17	NA
Uttar Pradesh	13,808.80	2,762	2	*0.34*	106	*0.01*
West Bengal	9,030.00	1,806	98	15	69	*0.56*
Others	2,813.20	563	4	*0.64*	21	*0.02*
Total	**41,555.40**	**8,311**	**124**	**19**	**318**	***0.71***

Source:[1] Indian Horticulture Database, National Horticulture Board, 2014

[2] Annual Survey of Industry, 2013-14

*** Biogas potential from potato raw and processing waste has been considered as 156.4m^3/ ton of solid waste (http://www.seai.ie/Renewables/Bioenergy/Bioenergy_Technologies/Anaerobic_Digestion/The_Process_and_Techniques_of_Anaerobic_Digestion/Gas_Yields_Table.pdf)*





Raw material wastage – Potato wastage is maximum in the state of Uttar Pradesh (33%), West Bengal (22%) and Bihar (16%). Estimated energy potential from potato wastage is 318 MW.

Processing waste - 15% of the total raw potato is wasted during potato processing which include raw pieces, pulp, cooked pulp and juice. Since these materials have a high moisture content, they are an eligible feedstock for anaerobic digestion. The total energy potential estimated from potato processing waste is 0.71 MW. West Bengal alone contribute 79% of the total potato processing waste in India.

Seasonal variation

Potato processing is done maximum in unorganised sector in India. In organised sector, West Bengal alone consumes 80% of the total processed potato of the country. Processing seasons in the state lasts for whole of the year as potato can be stored in cold storage for 10 to 12 months.

State	January	February	March	April	May	June	July	August	September	October	November	December
Assam												
Gujarat												
Madhya Pradesh												
Uttar Pradesh												
West Bengal												

Legend

Peak Season	
Lean Season	
No Production	
Major States	

Tomato

Almost 50% of the total tomato production is contributed by three states i.e. Andhra Pradesh (35%), Karnataka (10%) and Odisha (8%). Processed tomato products have wide applications in household consumption, food processing industry, snacks foods, hotels, restaurants and fast food joints. Tomato products can be grouped into many end-use categories like peeled, concentrated, partially dehydrated, strained and diced tomatoes, tomato juice, pulp, paste, powder and ketchup.

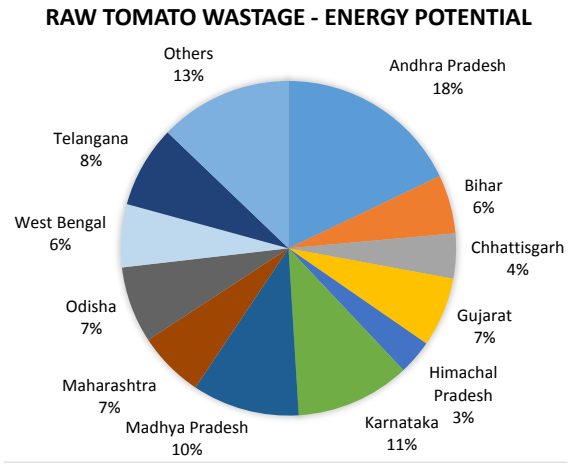
Table 2-21: Tomato production, processing share, waste generation and energy potential

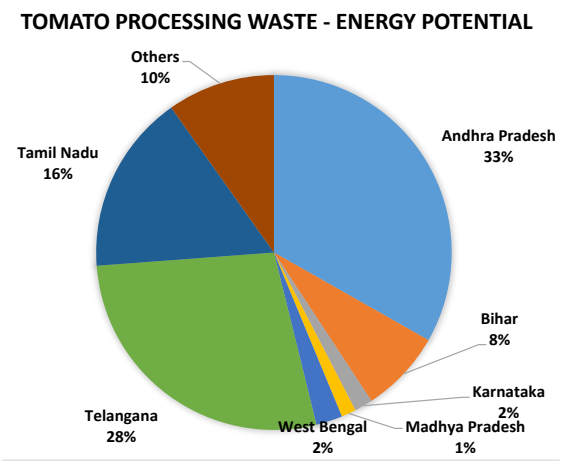
State	Tomato production[1] ('000 ton per annum)	Raw material wastage – 20% – per annum	Processing quantity[2] ('000 ton per annum)	Wastage in processing – 000 ton per annum	Energy Potential (MW) – raw material wastage**	Energy Potential (MW) – processing wastage**
Andhra Pradesh	3,354	671	46	9	21	*0.28*
Bihar	1,062	212	10	2	6	*0.06*
Chhattisgarh	814	163	NA	NA	5	NA
Gujarat	1,259	252	NA	NA	8	NA
Himachal Pradesh	627	125	NA	NA	4	NA
Karnataka	2,068	414	2	*0.46*	13	*0.01*
Madhya Pradesh	1,937	387	2	*0.37*	12	*0.01*
Maharashtra	1,200	240	NA	NA	7	NA
Odisha	1,386	277	NA	NA	8	NA
West Bengal	1,142	228	3	*0.66*	7	*0.02*
Telangana	1,484	297	38	8	9	*0.23*
Tamil Nadu	NA	NA	22	4	NA	*0.14*
Others	2,402	480	13	3	15	*0.08*
Total	**18,736**	**3,747**	**137**	**27**	**115**	***0.84***

Source: [1] Indian Horticulture Database, National Horticulture Board, 2014 [2] Annual Survey of Industry, 2013-14

*** Biogas potential from tomato raw and processing waste has been considered as 125.24m^3/ ton considering biogas yield of 0.8m^3 /kg VS* (http://dl.uctm.edu/journal/node/j2009-1/8_B_Kumanova_Martin_55-60.pdf),

TS – 16.86% and VS – 92.85% (Production of Biogas from Fruit and Vegetable Wastes Mixed with Different Wastes)





Raw material waste – Andhra Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Gujarat and Odisha are the major raw tomato waste generating states with total contribution 60% of the total. Estimated energy potential from tomato wastage is 115 MW.

Processing waste – Tomato pulp and peel constitute 20% of the wastage in tomato processing industry. Tomato waste has high potential to generate bioenergy through anaerobic digestion. The total energy potential estimated from tomato processing waste is 0.84 MW.

Andhra Pradesh, Telangana and Tamil Nadu are major states engaged in tomato processing. These three states are processing more than 75% of the total tomato processed in country and are major generator of waste from tomato processing.

Seasonal variation

Tomato processing is majorly done in Andhra Pradesh and Telangana with more than 50% of the total processing of India. Tomato is the round the year crop, therefore processing is also done for the round the year in these states.

State	January	February	March	April	May	June	July	August	September	October	November	December
Andhra Pradesh												
Telangana												
Bihar												
Karnataka												
Madhya Pradesh												
Tamil Nadu												
West Bengal												

Legend

Round the year
Peak Season
Lean Season
No Production
Major States

Onion

Almost 65% of the total onion production is contributed by three states i.e. Maharashtra (30%), Madhya Pradesh (15%) Karnataka (11%) and Gujarat (10%). Onion can be processed into a wide variety of products. Minimally processed ready to use or ready to cook fresh onions, onion paste, dehydrated onion flakes, onion powder, onion oil, onion vinegar, onion sauce, pickled onion, onion wine and beverage.

Table 2-22: Onion production, processing share, waste generation and energy potential

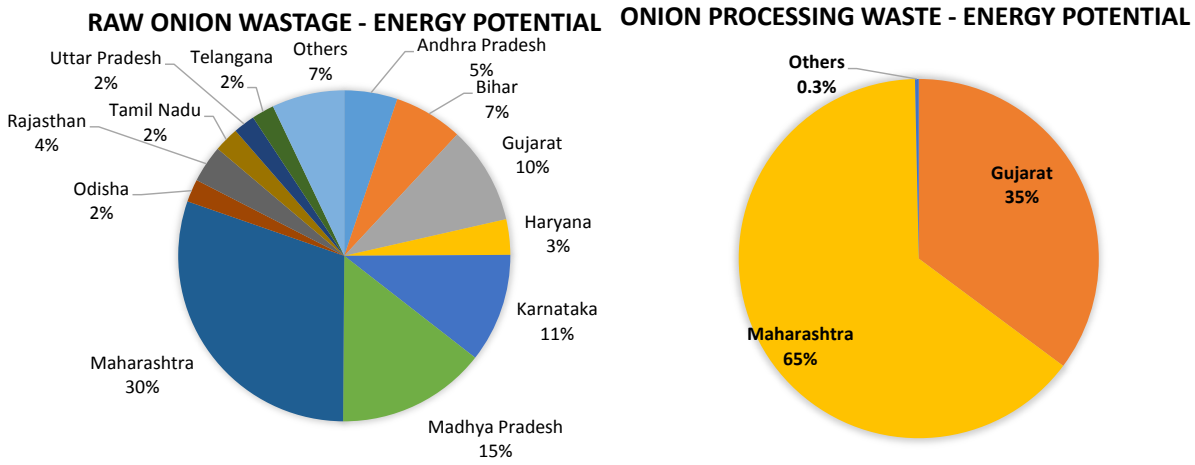
State	Onion production[1] ('000 ton per annum)	Raw material wastage – 20% – per annum	Processing quantity[2] ('000 ton per annum)	Wastage in processing- ('000 ton per annum)	Energy Potential (MW) – raw material wastage**	Energy Potential (MW) – processing wastage**
Andhra Pradesh	1,005	201	NA	NA	8	NA
Bihar	1,304	261	NA	NA	10	NA
Gujarat	1,851	370	38	13	14	*0.51*
Haryana	672	134	NA	NA	5	NA
Karnataka	2,065	413	NA	NA	16	NA
Madhya Pradesh	2,826	565	NA	NA	21	NA
Maharashtra	5,864	1,173	70	25	44	*0.93*

Odisha	432	86	NA	NA	3	NA
Rajasthan	705	141	NA	NA	5	NA
Tamil Nadu	473	95	NA	NA	4	NA
Uttar Pradesh	410	82	NA	NA	3	NA
Telangana	424	85	NA	NA	3	NA
Others	1,371	274	*0.36*	*0.13*	10	*0.005*
Total	**19,402**	**3,880**	**109**	**38**	**147**	***1.4***

Source: [1] Indian Horticulture Database, National Horticulture Board, 2014

[2] Annual Survey of Industry, 2013-14

***Biogas potential from onion raw and processing waste has been considered as 154.77m³/ ton considering methane yield of 0.41m³ l CH4/g VS with methane percentage of 65% (Methane yield 50- 80% , average value 65% taken); TS -46% and VS- 54% (http://www.uiennieuws.nl/kennis/docs/Anaerobic%20Digestion%20of%20Onion%20Wastes%20Using%20a%20Continuous%20Two.pdf)*



Raw material waste – Maximum raw material wastage is concentrated in the state of Maharashtra (30%), Madhya Pradesh (15%), Karnataka (11%) and Gujarat (10%). Energy potential from onion raw wastage is estimated to be 147 MW.

Processing waste - Large amount of onion waste is produced while processing which is almost 35% to 40% of total raw material. The main onion waste include onion skins, two outer fleshy scales, roots generated during industrial peeling and undersized malformed or damaged bulbs, all of which can be anaerobically digested in a bio-digester to produce bio-gas[17]. The total energy potential estimated from onion processing waste is 1.4 MW. Maharashtra and Gujarat together contribute almost 100% of the total onion processed in India.

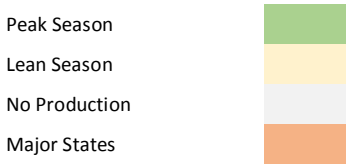
Seasonal variation

Onion is utilised for various processed food and sole onion processing is done for a very small quantity. Maharashtra consumes maximum onion for processing purpose. Onion processing takes place for whole of the years as onion can be preserved in cold storage up to 12 months of period.

State	January	February	March	April	May	June	July	August	September	October	November	December
Gujarat												
Maharashtra												

Legend

[17] http://www.dogr.res.in/index.php?option=com_content&view=article&id=68&Itemid=108&lang=en



Waste generation and energy potential from fruit and vegetable processing

Waste generation from fruit and vegetable processing has been assessed in the earlier sections for respective category for raw as well as processed material. However, for further assessment and shortlisting of states, energy potential from fruit and vegetable processing waste has been considered.

Solid waste from processing industry is generally in the form of peel, leaves and pulp from various types of fruit and vegetables. There is huge seasonal variation also for different products, hence availability of waste also gets impacted. A brief on type of waste generated from each of the product and wastage share in raw material is already presented in Table 2-12 and Table 2-19. Total waste generated from processing is 0.4 million ton per annum.

Fruits and vegetable processing solid wastes represent a potential energy source if they can be properly and biologically converted to methane for biogas production. Since these materials have a high moisture content, they are an eligible feedstock for anaerobic digestion (AD). Majorly cow dung is used as co-substrate with processing waste to generate biogas. In addition to cow dung, other potential co-digestion wastes are sewage, poultry litter and other animal waste in various proportions.

Table 2-23 presents summary of the energy potential from fruits and vegetable processing for various states. Based on this table, 4 major states have been shortlisted for fruits and vegetable sector as presented in Table 2-24.

Table 2-23: Energy potential from fruit and vegetable processing waste for different states[18] - MW

Sl. No	States/ UTs	Apple	Mango	Banana	Papaya	Pineapple	Orange	Potato	Tomato	Onion	Total	State share
1	Andhra Pradesh		2	*0.0007*	*0.1*				*0.3*		3	26%
3	Assam							*0.009*			*0.01*	0%
4	Bihar					*0.003*			*0.1*		*0.07*	1%
7	Gujarat		*0.5*	*0.09*	*0.001*			*0.05*		*0.5*	1	11%
9	Himachal Pradesh	*0.3*									*0.3*	2%
10	Jammu and Kashmir	*0.01*									*0.01*	0%
12	Karnataka		*0.2*		*0.02*	*0.03*	*0.003*		*0.01*		*0.2*	2%
14	Madhya Pradesh							*0.05*	*0.01*		*0.1*	1%
15	Maharashtra		*0.7*	*0.03*	*0.35*					*0.9*	2	19%
16	Manipur					*0.0007*					*0.0007*	0%
21	Punjab						*0.001*				*0.001*	0%
24	Tamil Nadu		3		*0.12*		*0.04*		*0.1*		3	27%
25	Telangana								*0.2*		*0.2*	2%
27	Uttar Pradesh							*0.013*			*0.01*	0.1%
29	West Bengal		*0.1*					*0.56*	*0.02*		*0.7*	7%
30	Uts & Others		*0.1*	*0.002*	*0.02*	*0.002*	*0.0001*	*0.024*	*0.1*	*0.005*	*0.3*	2%

[18] *The table presents energy potential from processing activity only and does not include energy potential from raw material wastage of fruits and vegetable. Given energy potential will form the base to select the major states for fruit and vegetable sector.*

Total	***0.3***	**7**	***0.1***	***0.6***	***0.04***	***0.04***	***0.7***	***0.8***	***1***	**11**	100%
Sector share	3%	62%	1%	5%	0.3%	0%	7%	8%	13%	100%	

Four major states generating maximum fruits and vegetable processing waste and maximum energy potential are Tamil Nadu, Andhra Pradesh, Maharashtra and Gujarat. Location of these states along with energy potential share is shown in Figure 2-17.

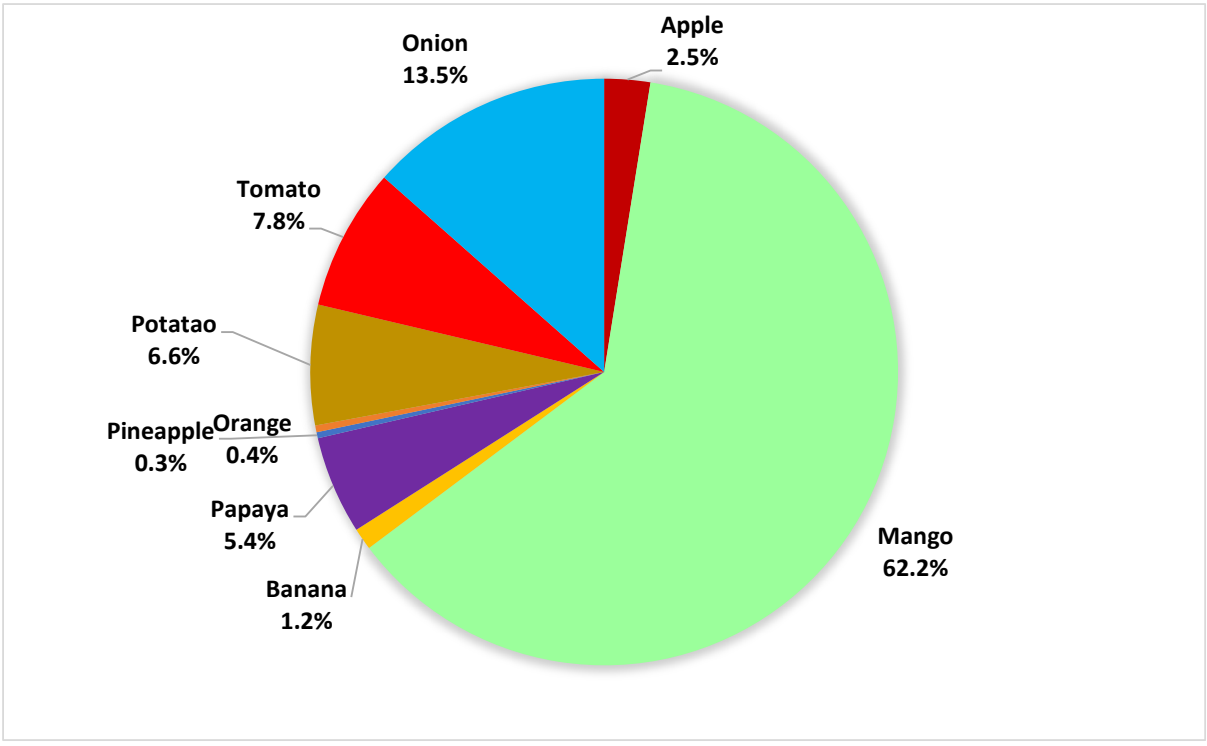
Following tables presents sector wise energy potential for the shortlisted four states.

Table 2-24: Energy potential in selected states - MW

States/ UTs	Mango	Banana	Papaya	Orange	Potato	Tomato	Onion	Others	Total
Andhra Pradesh	2	*0.0007*	*0.1*			*0.3*			**3**
Gujarat	*0.5*	*0.09*	*0.001*		*0.05*		*0.5*		**1**
Maharashtra	*0.7*	*0.03*	*0.4*				*0.9*		**2**
Tamil Nadu	*3*		*0.1*	*0.04*		*0.1*			**3**
Rest of India	0.4	*0.002*	*0.04*		*0.7*	*0.4*	*0.005*	*0.3*	**2**
Total	**7**	***0.1***	***0.6***	***0.04***	***0.7***	***0.8***	***1***	***0.3***	**11**
Major regions	Chittor, Andhra Pradesh Krishnagiri, Tamil Nadu Ratnagiri, Maharashtra	Gujarat Maharashtra	Maharashtra Tamil Nadu Andhra Pradesh	Tamil Nadu Karnataka	West Bengal Madhya Pradesh Gujarat	Andhra Pradesh Telangana Tamil Nadu	Maharashtra Gujarat	NA	NA

Sector wise share in total energy potential is presented in Figure 2-16. Mango processing has maximum energy potential with 62.2% of the share followed by onion 13.5% and tomato 7.8% and potato 6.6%.

Figure 2-16: Sector wise share in energy potential for selected states



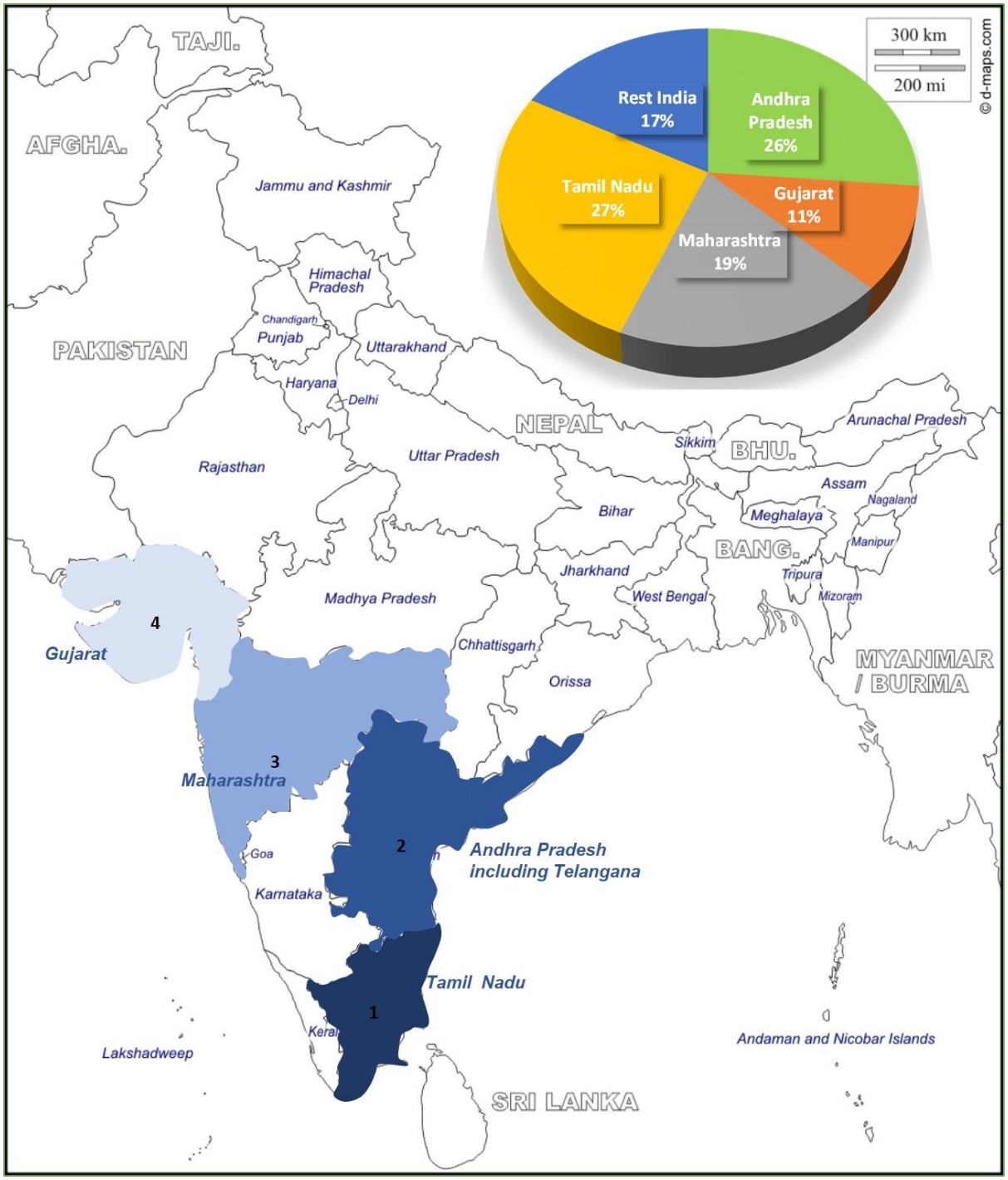
Fruits and vegetable is mixed with number of other food products and raw material for processing purpose such as milk, floor etc., therefore for conducting primary survey to the industries, food processing industrial units will be targeted. Existing waste to energy plants installed in the sector also consider multiple feed along with fruit and vegetable waste for getting better results for energy generation. List of major industries in food processing sector has been procured to from All India Dairy publication. State wise number of industries is provided in the table below. Industries from the shortlisted states will be visited for further validation of the data.

Table 2-25: State wise list of key food processing industries

States/ UTs	Dairy products	Food Processing	Bakery Industry	Confectionaries
Andhra Pradesh	120	16	4	3
Assam	13	2		
Bihar	28	5	1	
Chandigarh	29	3		1
Chhattisgarh	7	1	1	
Dadra & Nagar Haveli	1			
Daman	1			
Delhi	172	52	2	2
Goa	7			
Gujarat	131	60	3	1
Haryana	48	14		
Himachal Pradesh	9	5		
Jammu and Kashmir	6	2		
Karnataka	93	21	4	
Kerala	26	10	3	1
Madhya Pradesh	54	28	0	1
Maharashtra	314	80	37	20
Manipur	9			
Odisha	29	0	0	0
Punjab	56	17	3	3
Rajasthan	64	9	1	
Sikkim			1	
Tamil Nadu	73	22	3	2
Uttar Pradesh	92	19	2	3
Uttarakhand	10	2		
West Bengal	49	10		2
Total	**1441**	**378**	**65**	**39**

Source: All India Dairy

Figure 2-17: Major states with energy potential from fruits and vegetable processing waste

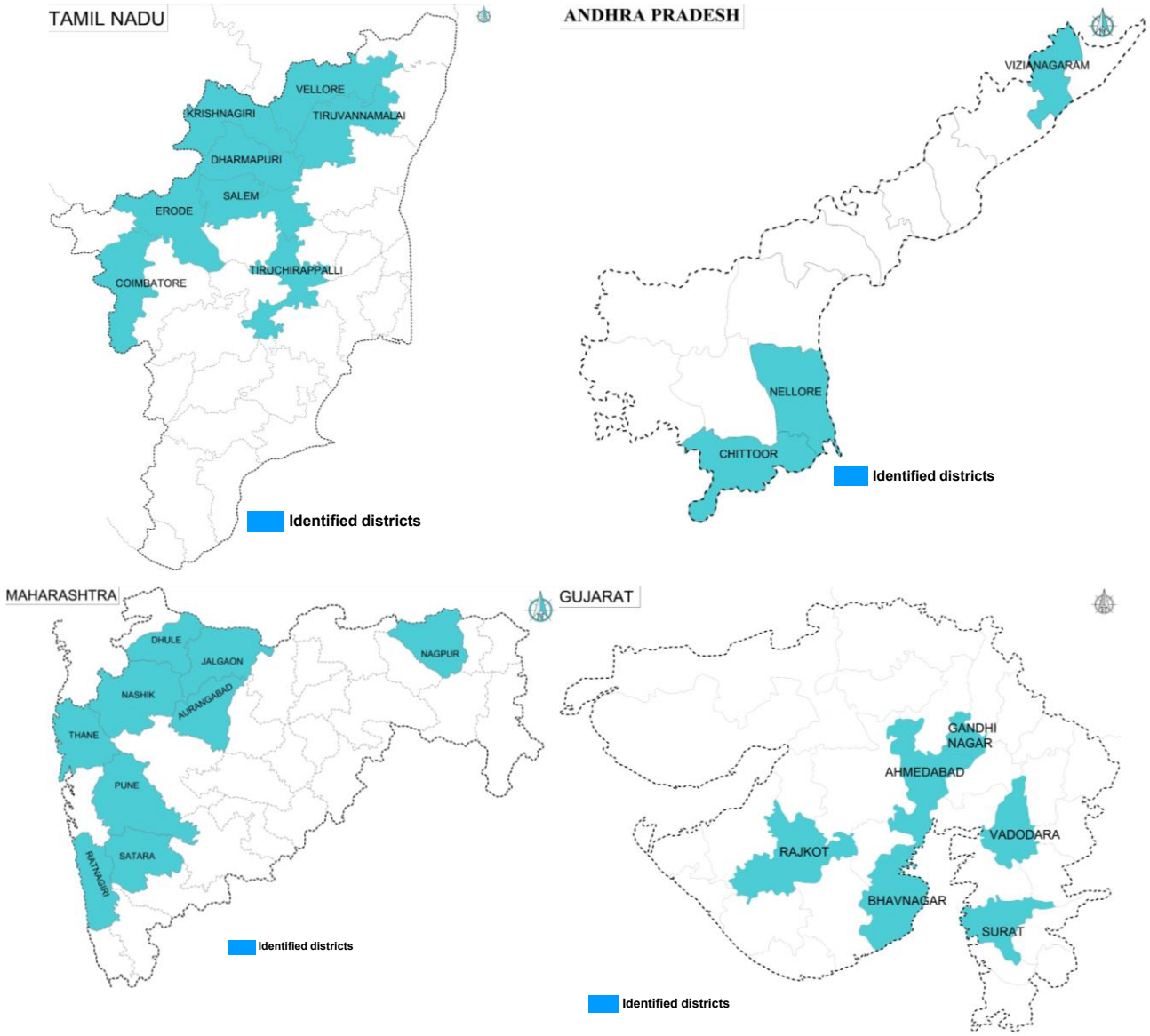


94% of the energy potential (8 MW) from fruit and vegetable processing sector is concentrated in four states only i.e. Maharashtra, Tamil Nadu, Gujarat and Andhra Pradesh. Major districts for each of the state have been identified based on various discussion held with Ministry of Food Processing (MOFPI), All India Food Processing Association (AIFPA) and information gathered from secondary sources (Table 2-26). Location of districts and their concentration in the respective states is shown in Figure 2-18.

Table 2-26: Identified districts in major states – energy potential from fruit and vegetable processing waste

Tamil Nadu	Andhra Pradesh	Maharashtra	Gujarat
Erode	Chittoor	Aurangabad	Ahmadabad
Coimbatore	Nellore	Dhule	Bhavnagar
Dharmapuri	Vizianagaram	Jalgaon	Gandhinagar
Krishnagiri		Nagpur	Rajkot
Salem		Nashik	Surat
Tiruchirappalli		Thane	Vadodara
Tiruvannamalai		Ratnagiri	
Vellore		Pune	
		Satara	

Figure 2-18: Identification of districts in the top 4states for energy potential – F&V processing waste



Existing WTE plants – food processing waste

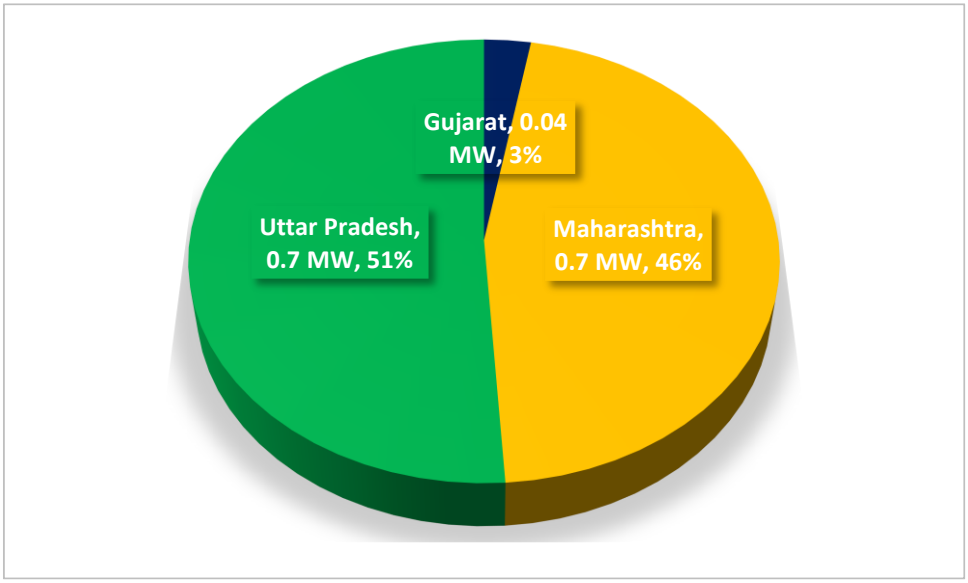
At present, five food processing waste to energy pants are under operation in India with total capacity of 1.43 MW. Among the 5 plants, 3 are in Maharashtra (0.7 MW), 1 each in Uttar Pradesh (0.73 MW) and Gujarat (0.04 MW).

Table 2-27: Details of WTE plants – food processing waste

Sl. No.	WTE plant location	Plant installed capacity	Year if installation	State
1	M/s. Vadilal Industries Limited, Village Pundhra, Taluka Mansa, Dist. Gandhinagar, Gujrat	0.04 MW	2014-15	Gujarat
2	Project for generation of 3430m^3 biogas / day from yeast industry liquid waste by M/s SAF Yeast Company Pvt. Ltd., Chiplun, District Ratnagiri (MS).	0.30 MWeq.	2009-10	Maharashtra
3	Food Processing Industry Liquid waste based biomethanation project by M/s Saf Yeast Co. Pvt. Ltd., Ratnagiri, Maharashtra,	0.36 Mweq. (4410m^3 /day)	2008-09	Maharashtra
4	Food industry waste based bio-methanation project by M/s Saf Yeast Co. Pvt. Ltd., 101, UPSIDC, Industrial Area, Sandila, Distt. Hardoi,	0.73 Mweq. (8820m^3 /day)	2006-07	Uttar Pradesh
5	Bio-methanization of food process plant at M/s Haldiram, Nagpur	Biogas generation – 2000m^3 /day	2008	Maharashtra

Source: MNRE

Figure 2-19: Share of states in WTE plants – food processing based



CASE STUDY - FRUIT & VEGETABLE PROCESSING WASTE

Bio-methanization of food process plant at M/s Haldiram, Nagpur

M/s Haldiram, located in Nagpur, Maharashtra is engaged in food processing industry has augmented Bio-methanization plant for generation of energy from food process waste. The generated energy is widely used in industrial plant itself. The Bio-methanization plant was established in 2008 and it is still functional.

Two type of Wastes are used in the plant i.e. Primary sludge of ETP and food processing waste. Food processing waste includes potato pulp & peel, banana leaf & peel and pumpkin peel. Sludge generated from ETP of plant is mixed with industrial waste for Bio-methanization process. Total quantity of waste feed in to the digester is 12-15 MT along with sludge from ETP.

The features of the plant is as below:

- Biogas generation – 2000m^3 /day
- Calorific value of Biogas – 5000 kcal/m^3
- Biogas application – Thermal for heating
- Saving in disposal cost incurred prior to the establishment of biomethanization – Rs 6.0 Lacs per year
- Total saving – Rs 27.0 Lacs per year
- Cost of project – Rs 50.0 Lacs
- Flat Pay back – Rs 1.5 years

The generated gas is used as a replacement of LPG and Diesel fuel.

Saving through replacement of LPG/LDO/FO/wood – Rs 20.0 lacs per year

2.4 Sugar Industry

India is the second largest sugarcane and sugar producing country in the world after Brazil with 18% and 40% of the total world production respectively (FOASTAT data 2016). In India, sugar industry is the second largest agro based industry after textile industry. Sugar industry establishes near the sugarcane production areas, the reason being, the raw material (sugarcane) is heavy, low value, weight losing and perishable which cannot be transported to long distance due to high cost involve.

As per the data available from the secondary sources, it is evident that sugarcane production is concentrated in few states only. Approximate 85% of the country's production is in the states of Maharashtra (34%), Uttar Pradesh (26.5%), Karnataka (14.70%) and Tamil Nadu (9%).

Location of sugar industry is directly proportional to the availability of raw material. Regions having high sugarcane production are also belt of sugar producing industries. At present, there are approx. 700 sugar industries in India, out of which 530 are in operation. These industries are mix of public private and cooperative units having total production capacity of 30 million ton per annum. As per the data available for the year 2014-2015, Maharashtra contributes 28%, Uttar Pradesh 29%, Karnataka 16% and Tamil Nadu 7% of the total sugarcane crushed quantities in India.

Figure 2-21: Top 4 sugarcane producing states – 2014-15

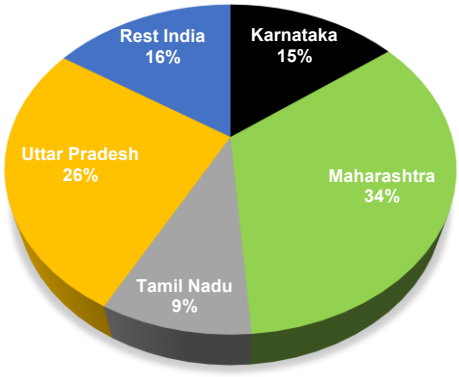


Figure 2-20: Top 4 sugarcane crushing states

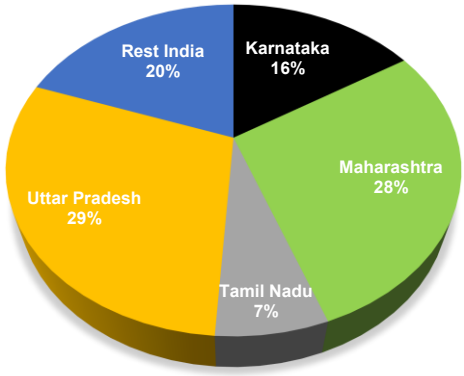


Table 2-28: State wise cane crushed, number of factories and waste generation

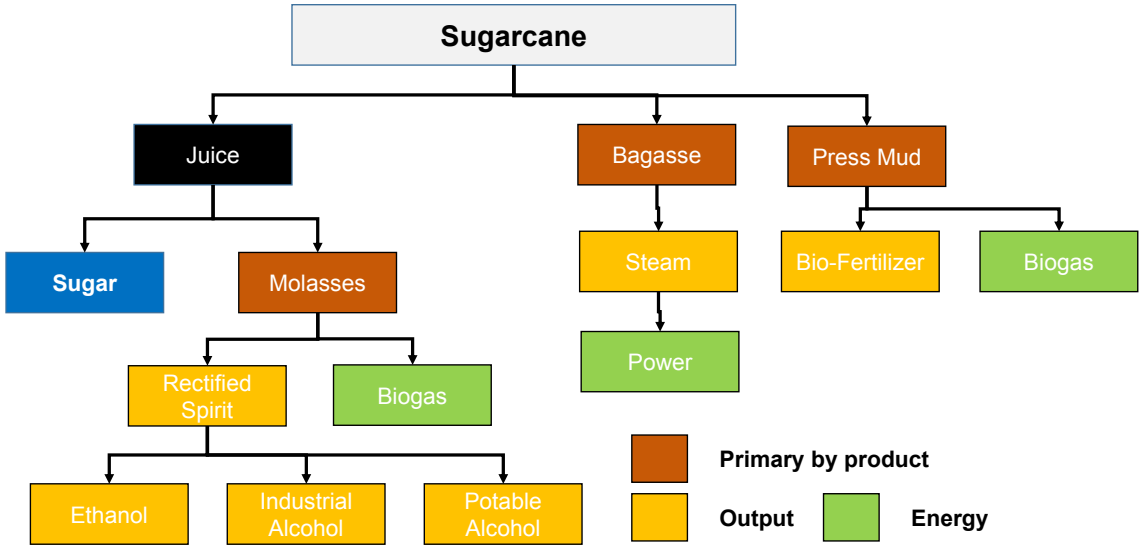
SN	States/ UTs	Cane crushed (in million ton) by sugar factories		Number of sugar factories - 2014-15	Press Mud Generation (in million ton/annum) 3% of cane crushed	Energy Potential Press Mud (MW)**
		2013-14	2014-15 (P)			
1	Andhra Pradesh	7	6	22	*0.18*	4
2	Bihar	7	6	11	*0.17*	4
3	Chhattisgarh	1	1	4	*0.03*	1
4	Gujarat	11	11	20	*0.33*	8
5	Haryana	6	6	14	*0.17*	4
6	Karnataka	38	45	65	1	33
7	Madhya Pradesh	3	4	15	*0.11*	3
8	Maharashtra	68	93	183	3	68
9	Pondicherry	*0.5*	0.4	2	*0.01*	*0.3*
10	Punjab	5	6	16	*0.17*	4
11	Rajasthan	*0.1*	0.1	1	*0.00*	*0.1*
12	Tamil Nadu	16	14	43	*0.42*	10
13	Uttar Pradesh	70	74	204	2	55
14	Uttarakhand	3	4	9	*0.11*	3
15	Telangana	3	3	10	*0.09*	2
16	Others	1	1	4	*0.02*	*0.5*
Total		**238**	**273**	**630**	**8**	**200**

Source: Handbook of Sugar Statistics, 2014-15, Indian Sugar Mills Association

** Biogas generated from Press Mud - 1 MT can generate 80 to 140m^3/day - assumed for calculation - 100m^3/day (http://www.iitmandi.ac.in/ireps/images/Presentation%20%20Waste%20to%20energy%20for%20IIT%20Mandi%2016th%20May.pdf)

Note: For waste calculation purpose 2014-15 provisional data for cane crushing in the factories has been referred.

Figure 2-22: Value chain of sugar industry



Waste stream from sugar industry (press mud)

Manufacturing of sugar generates large number of by-products or biomass wastage such as bagasse and press mud. As per the general standard, 1000 kg of sugarcane can produce 100 kg of sugar and rest of the raw material is converted into various types of by-products which are utilised for power generation, alcohol production, fertilizer production, fuel and biogas generation. Key by-products of sugarcane processing are bagasse, molasses, press mud and liquid waste (stillage or vinnasse or dunder).

Press mud: Press mud or filter cake is produced in vacuum filters and press filters during sugar manufacture process. The approximate quantity of press mud ranges from 3-8 % of the crushed cane, depending on the nature of sugar manufacturing process. Press mud is a solid residue, obtained from sugarcane juice before crystallization of sugar.

Press mud usage – Press mud is a discarded solid waste from sugar industry and generally used as bio-fertilizer in agriculture fields. Press mud is bulky in nature and has wax content which is harmful for soil if applied directly. Press mud is also sold as fertiliser after adding minerals by fertiliser manufacturing companies. Raw press mud from sugar industry is available at the rate of Rs400-500 per ton (as discussed with Balaji Sales, Surat). As of now, there is no proper mechanism to dispose press mud in India, various small scale sugar industries are dumping it as garbage also.

Press mud characteristics - It is a soft, spongy, lightweight, amorphous, dark brown to black coloured stuff. Typical characteristics of press mud from sugar factory are presented in Table 2-29. To validate the waste characterisation values, samples from sugar industries will be collected in the later stages for lab testing.

Table 2-29: Press mud characteristics

Parameters	Units	Press mud - value
TS	%	27.87[3]
VS	%	84[3]
BOD	%	22.2[3]
COD	%	117.6[3]
NH^3N	NA	NA
pH	NA	6 - 7[1]
Moisture content	%	60 – 85[2]
C-N ratio	NA	16 – 36[1]
Nitrogen	%	1.75[3]

Source:

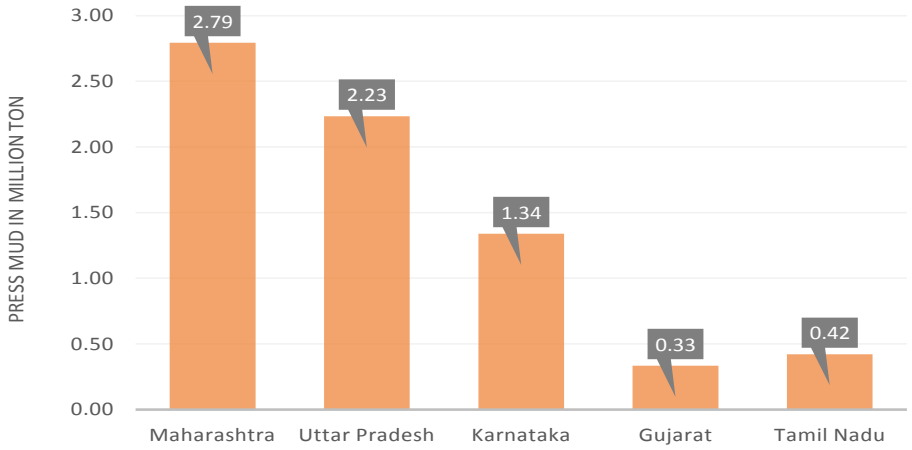
[1] http://www.globalsciencebooks.info/Online/GSBOnline/images/0812/DSDP_2(SI1)/DSDP_2(SI1)35-49o.pdf

[2] http://iosrjournals.org/iosr-jmce/papers/sicete(mech)-volume1/7.pdf

[3] https://www.scribd.com/doc/52908687/SUGAR-MILL-Press-mud-or-Filter-Cake-and-Spent-wash-Organic-Manure

Press mud generation - As a general standard, 1000 kg of sugarcane crushed produces 30 kg of press mud i.e. 3% of the total sugarcane crushed. Currently India produces approximate 8.2 million ton of press mud annually. The detailed data is presented in Table 2-28 for the year 2014-15. Maharashtra, Uttar Pradesh and Karnataka together produce 6.4 million ton of press mud (Table 2-28).

Figure 2-23: Top 5 states generating press mud



Seasonal variation in sugar industry (press mud)

Sugarcane is primarily grown in two types of agro climatic regions, tropical region includes Maharashtra, Andhra Pradesh, Tamil Nadu, Gujarat, Karnataka, Madhya Pradesh and Goa and sub-tropical includes states of Uttar Pradesh, Bihar, Uttarakhand, Punjab and Haryana. As mentioned earlier, sugarcane is weight losing crop and involves huge transportation cost, therefore industries are present near the production area. Due to dependency on crop availability, industry working duration also depend on availability of raw material.

Harvesting season of sugarcane in tropical region is December to May whereas in subtropical region harvesting is done from October to May. Between June and September there is no harvesting of the crop which has direct impact on the sugar production, hence sugar factories remain close during the period of June to September. Based on the data compiled from Handbook of Sugar Statistics, 2014-15, Indian Sugar Mills Association; it was observed that sugar production between June and October is almost nil i.e. only 1.7% of the total production and 97.3% between November and May. Same kind variation is seen in number of factories running throughout the year. Table 2-30 presents the data on state and month wise sugar production and number of factories operating.

Table 2-30: State and month wise sugar production – in lakh ton

S. No.	States	October	November	December	January	February	March	April	May	June	July	August	September	Total
1	Andhra Pradesh		0.43	2.13	2.36	2.37	1.27	0.27	0.03					8.86
2	Bihar		0.22	1.52	1.63	1.34	0.55							5.26
3	Gujarat	0.04	1.65	2.19	2.31	2.28	1.96	0.93	0.17					11.53
4	Haryana		0.05	1.03	1.24	1.16	1.25	0.95	0.08					5.76
5	Karnataka	0.85	2.35	9.23	10.70	9.98	9.36	5.59	1.00			0.70	0.22	49.98
6	Kerala & Goa			0.02	0.04	0.03	0.02							0.11
7	Madhya Pradesh & Rajasthan		0.14	0.66	0.96	1.07	0.72	0.77	0.19	0.05				4.56
8	Maharashtra	0.60	11.35	20.69	21.73	20.41	18.81	9.88	1.59					105.06
9	Punjab		0.02	1.13	1.36	1.25	1.20	0.42						5.38
10	Tamil Nadu & Pondicherry	0.10	0.15	0.56	1.30	2.67	2.75	1.95	0.84	0.20	0.30	0.83	0.85	12.50
11	Uttar Pradesh		1.00	15.95	16.80	15.84	13.81	7.16	0.45					71.01
12	Uttrakhand		0.01	0.77	0.79	0.73	0.63	0.32						3.25

S. No.	States	October	November	December	January	February	March	April	May	June	July	August	September	Total
13	Others- Assam, Orissa, Nagaland and West Bengal		0.02	0.09	0.13	0.15	0.09							0.48
All India		**1.59**	**17.39**	**55.97**	**61.35**	**59.28**	**52.42**	**28.24**	**4.35**	**0.25**	**0.30**	**1.53**	**1.07**	**283.74**
Month wise number of sugar factories in operation		**50**	**343**	**490**	**517**	**504**	**366**	**97**	**8**	**3**	**7**	**13**	**12**	

Source: Handbook of Sugar Statistics, 2014-15, Indian Sugar Mills Association

Table 2-31 presents state and month wise peak season and lean season for sugar production and availability of wastage particularly press mud.

Table 2-31: State and month wise sugar production and availability of press mud

States	October	November	December	January	February	March	April	May	June	July	August	September
Andhra Pradesh												
Bihar												
Gujarat												
Haryana												
Karnataka												
Kerala & Goa												
Madhya Pradesh & Rajasthan												
Maharashtra												
Punjab												
Tamil Nadu & Pondicherry												
Uttar Pradesh												
Uttarakhand												
Legend												
Peak Season												
Lean Season												
No Production												
Major States												

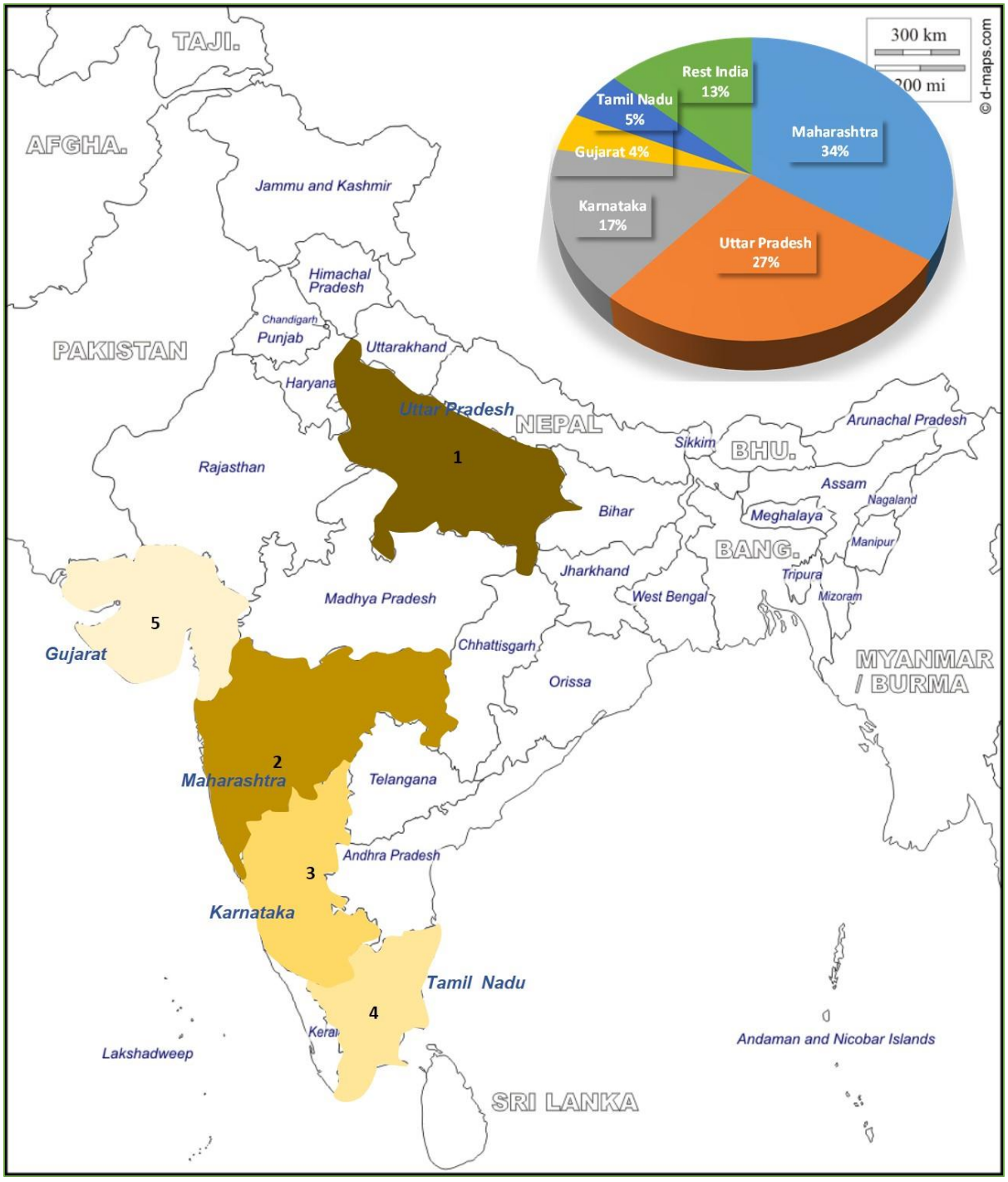
Source: Handbook of Sugar Statistics, 2014-15, Indian Sugar Mills Association

Energy potential

Press mud, which is generally discarded as a solid waste from sugar mills and used as a manure or as a landfill, is a useful substrate for biogas production. Press mud is rich source of methane and can be used for generating biogas. However, maximum energy potential can be tapped when mixed with cow dung/bagasse/ cane pith in various ratios.

The total energy potential from press mud is 200 MW, of which almost 174 MW can be generated from five states namely Maharashtra, Uttar Pradesh, Karnataka, Tamil Nadu and Gujarat. Location of major states and share in total energy potential is shown in Figure 2-24.

Figure 2-24: Location of top states generating press mud and energy potential



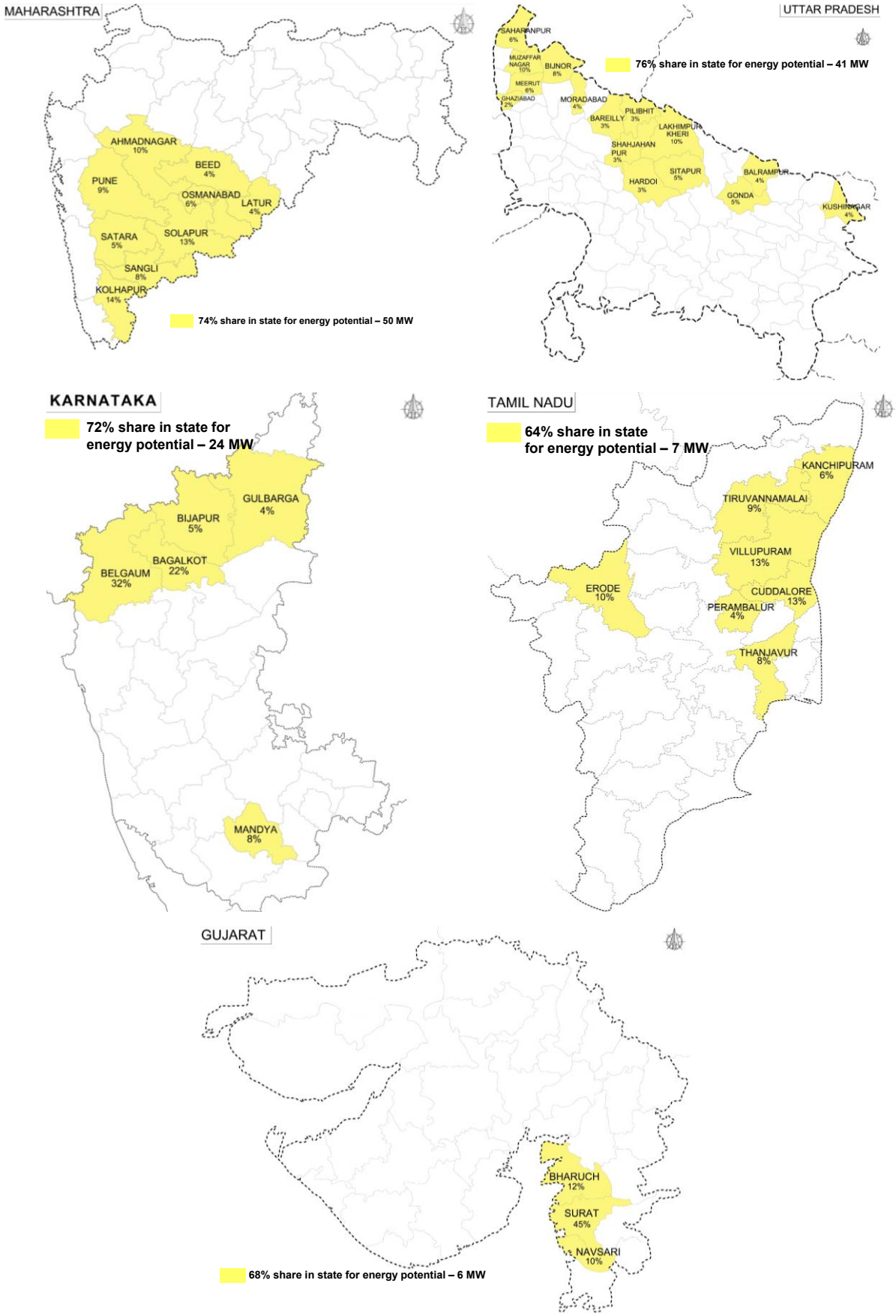
District level data has been compiled from Indian Sugar Mill Association's published list of sugar mills in India. Based on the daily crushing capacity of the plant in each of the district, major regions have been finalised. Table 2-32 presents the name of the districts and share in the states.

Table 2-32: Major districts in selected states – press mud availability

State	District	Share in state	State	District	Share in state
1. Maharashtra - 74% concentrated in these nine districts	Solarpur	13%	3. Karnataka - 72% concentrated in these six districts	Mandya	8%
	Pune	9%		Gulbarga	4%
	Ahmednagar	10%		Belgaum	32%
	Satara	5%		Bagalkot	22%
	Kolhapur	14%		Bijapur	5%
	Sangli	8%			
	Osmanabad	6%	4. Tamil Nadu - 64% concentrated in these seven districts	Caddalore	13%
	Latur	4%		Villupuram	13%
	Beed	4%		Erode	10%
2. Uttar Pradesh - 76% concentrated in these fifteen districts	Kushinagar	4%		Perambalur	4%
	Gonda	5%		Thanjavur	8%
	Balrampur	4%		Kanchee Puram	6%
	Sitapur	5%		Tiruvannamalai	9%
	Lakhimpur Kheri	10%	5. Gujarat - 68% concentrated in these three districts	Surat	45%
	Hardoi	3%		Navsari	10%
	Shahjahanpur	3%		Bharuch	12%
	Bareilly	3%	**Press mud** • Energy potential in India – 200 MW • Energy potential in 5 selected states – 174 MW • Energy potential in selected districts of 5 states – 128 MW		
	Pilibhit	3%			
	Bijnor	8%			
	Moradabad	4%			
	Saharanpur	6%			
	Muzzaffar Nagar	10%			
	Meerut	6%			
	Ghaziabad	2%			

Energy potential of the selected top five states in the sector is 174 MW which is 87% of the country share. Above table presents district share of the energy potential in selected states. Districts having energy potential more than the state's average energy potential has been selected for the above five states. Identified districts have 128 MW of energy potential contributing to 73% of the respective 5 states. Following figures shows location of the identified districts and share in the state. As evident from the figures, in all the state major portion of the energy potential is concentrated in a continuous belt or region.

Figure 2-25: Identification of districts in the top 5 states for energy potential – press mud



There are only two press mud based waste to energy plants operated at present with total capacity of 3.3 MW in Maharashtra. ‘

Table 2-33: Details of existing WTE plants – press mud

Sl. No.	WTE plant location	Plant installed capacity	Year if installation	State
1	M/s. Spetrum Renewable Energy Pvt. Ltd. Warana nagar, Kolhapur, Maharashtra(Bio-CNG)	1.66 MWeq.	2012-13	Maharashtra
2	Installation of Bio-gas based power project by M/s. Jain Irrigation Systems Ltd., Jalgaon	1.668 MW	2010-11	Maharashtra

Source: MNRE

PRESS MUD - CASE STUDY

Spectrum Renewable Energy Limited, Kodoli, Kolhapur

Spectrum Renewable Energy Private Limited (SREL) developed a large-scale biogas generation and bottling project at Kodoli near Kolhapur in the state of Maharashtra. It is a 100 TPD press mud to biogas and organic manure generation plant. This is first of its kind project, developed in partnership with a large farmers’ co-operative society. SREL is purifying and enriching about 20,000m^3 of biogas produced from press mud as well as spent wash which generates around 8000 kg Bio-CNG which is CNG grade fuel also called as CBG (compressed biogas). This is a price-competitive renewable energy that can be used in vehicles as well as heating application in heat treatment facilities replacing LPG (Liquefied Petroleum Gas), diesel or other fossil fuels. CBG can also be used for electrical power generation.

Salient features of the plant:

- Plant operation: 80 % is mechanical and 20 % is manual.
- Press mud is fed by a conveyer belt into feed tank.
- Feed tank is fitted with a mixer for making a uniform feed slurry and pumped (Wangen pump), into digesters through underground pipe line.
- Each digester is also equipped with gas capturing system to hold about 950m^3 of biogas. It is of German make; air inflated double membrane type, to prevent the heat loss from the digester top portion. It is also weather resistant.
- All the digesters are interconnected through pipes at the upper gas storage area to have equal gas pressure.
- All the digesters are fitted with safety valve to prevent over and under pressure.
- Biogas generated is continuously sucked by a blower (9.3kW) and supplied to gas cleaning system.
- The CBG stored in cylinders (cascades) is transported to the client place and used instead of diesel, LPG and furnace oil through PRV’s.
- Excess Biogas released during plant breakdown or in any other case of emergency is burned by flare unit.
- Gas Generator of 340 kW capacity is installed at the site which operates 100% on H2S free Biogas.
- It generates power for fulfilling plant auxiliary consumption.
- The generator generates approx. 2.5 units per m^3 of gas.

Source: http://www.mahaurja.com/PDF/BEPolicies/2.1%20Success%20Story%20on%20%20Bio%20CNG.pdf

2.5 Matrix on Estimated Generation of Industrial Organic Waste

Energy potential matrix for cattle, sugar industry, poultry farm and fruit and vegetable processing for different states is compiled from earlier sections and presented in Table 2-34. For each of the sector top 4-5 states have been highlighted with different shades. Replication of state in reference to all the sectors is clearly apparent from the table, e.g. Maharashtra is one of the top 5 states for all the four sectors, Gujarat / Tamil Nadu for three sectors. Total energy potential in the selected sectors is 1535 MW in India.

In total, 9 states have been shortlisted for further evaluation, micro level energy potential estimation and region finalisation. Next chapter details out the regional level assessment of these states.

Table 2-34: Energy potential matrix for four identified sectors

S. No	States/ UTs	Sugar - Press mud	Poultry	Cattle farm	F&V processing	Total
1	Andhra Pradesh	7	60	50	*3*	**117**
2	Arunachal Pradesh		*0.0*	*0.1*		***0.2***
3	Assam		1	4		**5**
4	Bihar	4	5	65	*0.1*	**74**
5	Chhattisgarh	1	12	5		**18**
6	Goa		*0.1*	*0.3*		***0.4***
7	Gujarat	8	8	77	*1*	**94**
8	Haryana	4	39	41		**84**
9	Himachal Pradesh		1	10	*0.3*	**11**
10	Jammu and Kashmir		5	12		**17**
11	Jharkhand		2	6		**8**
12	Karnataka	33	40	40	*0.2*	**113**
13	Kerala		12	8		**20**
14	Madhya Pradesh	3	5	52	*0.1*	**60**
15	Maharashtra	68	55	56	*2*	**181**
16	Manipur		*0.1*	*0.5*		**1**
17	Meghalaya		*0.1*	*0.2*		***0.4***
18	Mizoram		*0.01*	*0.1*		***0.1***
19	Nagaland		*0.05*	1		**1**
20	Odisha		7	9		**16**
21	Punjab	4	14	44		**62**
22	Rajasthan	*0.1*	5	88		**93**
23	Sikkim		*0.02*	1		**1**
24	Tamil Nadu	10	93	42	*3*	**148**
25	Telangana		63	27	*0.2*	**92**
26	Tripura		1	1		**2**
27	Uttar Pradesh	55	10	195	*0.01*	**260**
28	Uttarakhand	3	4	9		**15**
29	West Bengal		22	17	*0.7*	**40**
30	Uts & Others	1	1	2	*0.3*	**4**
Total		**200**	**462**	**862**	**11**	**1535**
Top states - Press mud						
Top states - Poultry litter						
Top states - Cattle dung						
Top states - Fruits and vegetable processing waste						
States identified for further evaluation						

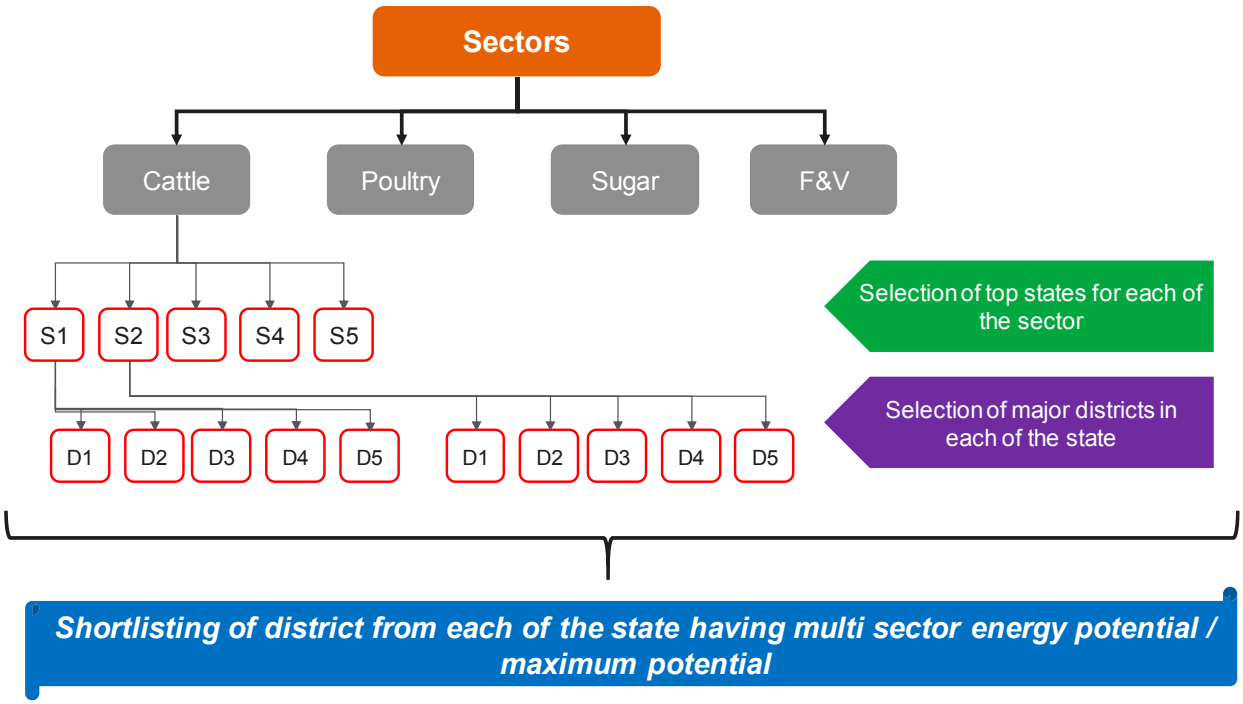
3.0 SHORTLISTING OF STATES

3.1 Methodology

In the previous chapter, all the four sectors are detailed out in term of state wise waste generation, energy potential, shortlisting of major states and identification of major districts in the shortlisted states. For cattle, sugar and poultry sector, 5 top states have been finalised and 4 for fruits and vegetable processing sector. As mentioned earlier also, total 9 states have been shortlisted for further assessment.

Figure 3-1 shows the process to finalise the micro level region in the shortlisted states. 9 states having maximum energy potential for all the sectors and districts in each of these 9 states have already been identified and mapped in the previous chapter. In this chapter, availability of multi category waste in all the districts of the selected states will be mapped. Finalisation of the region would be established on two key factors, first is availability of multi-sector waste together in one region and another is maximum energy potential concentrated in a region for one or more sectors.

Figure 3-1: Methodology for finalisation of the region/districts



3.2 Identification of Micro Regions / Districts

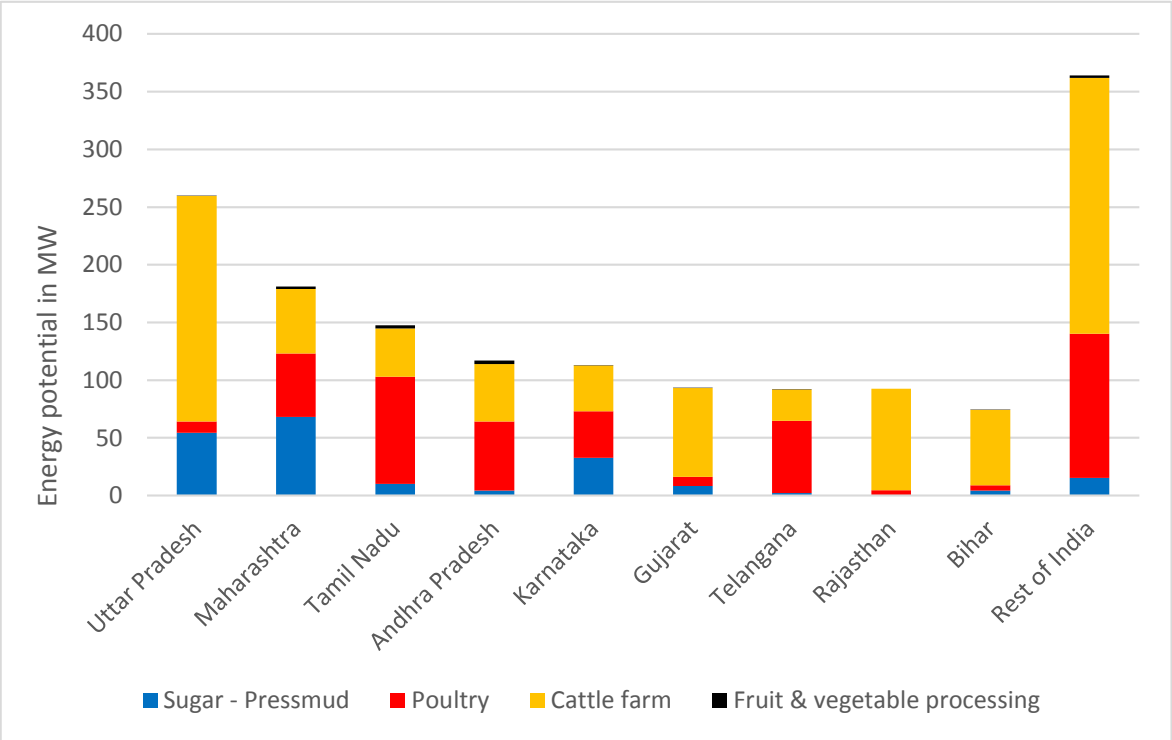
Energy potential and share of 9 states in respective sectors is presented in Table 3-1. Uttar Pradesh has maximum share followed by Maharashtra, Tamil Nadu, Andhra Pradesh, Karnataka, Gujarat, Telangana, Rajasthan and Bihar. First 6 states are one of the top states for more than one sector, whereas Telangana (poultry), Rajasthan (cattle) and Bihar (cattle) falls under top category only for one sector.

Table 3-1: Energy potential matrix of top states for four sectors - MW

States	Sugar	Poultry	Cattle	F&V processing	Total	State share	Top sectors
Uttar Pradesh	55	10	**195**	*0.01*	260	**17%**	Cattle, sugar
Maharashtra	**68**	55	56	2	181	**12%**	Cattle, sugar, poultry, F&V
Tamil Nadu	10	**93**	42	**3**	148	**10%**	Sugar, poultry, F&V
Andhra Pradesh	4	60	50	3	117	**8%**	Poultry, F&V
Karnataka	33	40	40	*0.2*	113	**7%**	Sugar, poultry

States	Sugar	Poultry	Cattle	F&V processing	Total	State share	Top sectors
Gujarat	8	8	77	*0.3*	94	**6%**	Sugar, cattle, F&V
Telangana	2	63	27	*0.2*	92	**6%**	Poultry
Rajasthan	NA	5	88		93	**6%**	Cattle
Bihar	4	5	65	*0.01*	74	**5%**	Cattle
Rest of India	15	125	222	2	364	**24%**	
Total	**200**	**462**	**862**	**11**	**1535**	**100%**	
Top states - Press mud							
Top states - Poultry litter							
Top states - Cattle dung							
Top states - Fruits and vegetable processing waste							
States identified for further evaluation							
Major states							

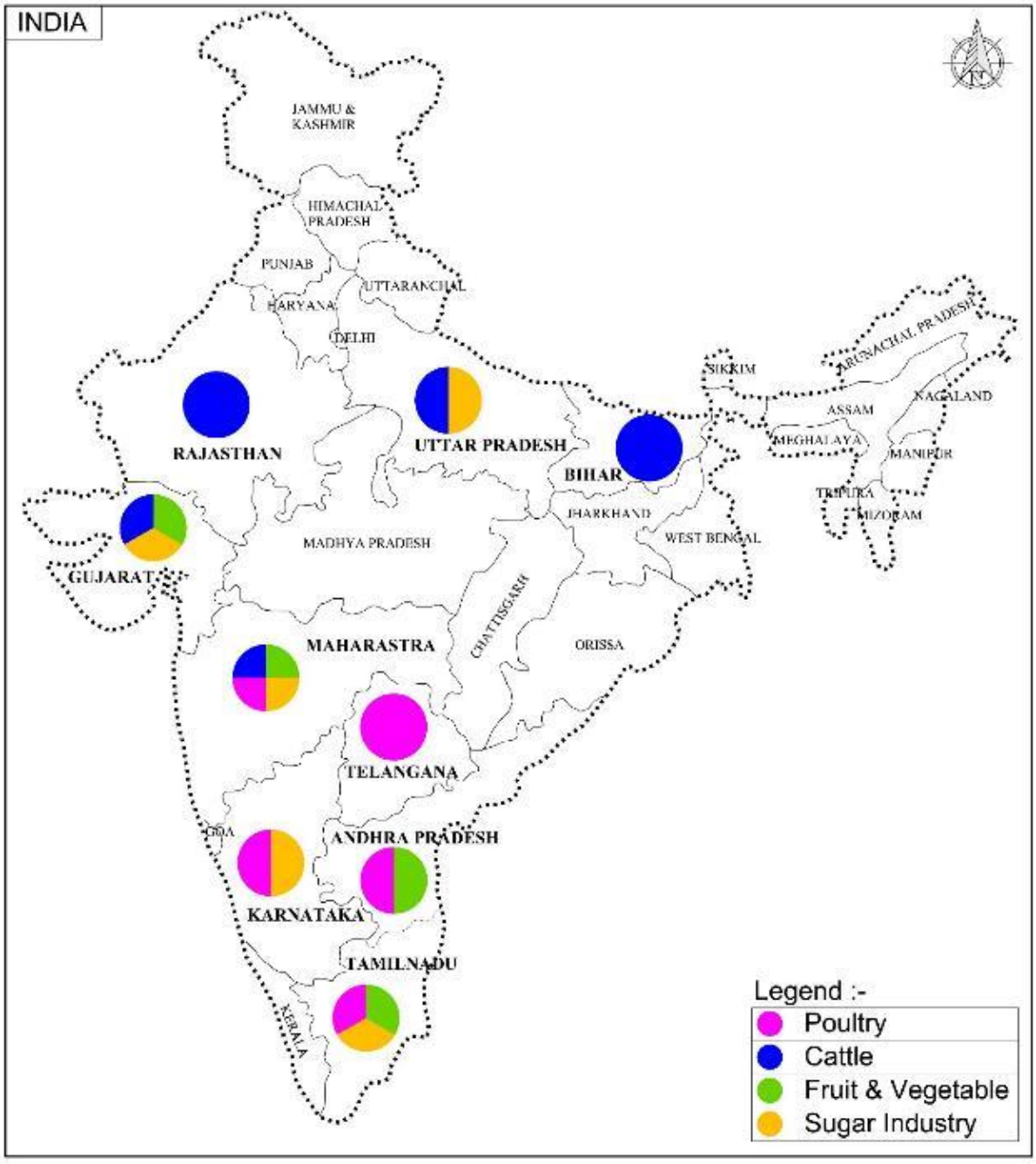
Figure 3-2: Sector wise energy potential for selected states



In further section, details pertaining to energy potential, multi waste availability in each of the district, existing waste to energy plants etc. have been given for nine selected states. Detail mapping for waste availability and energy potential at country, state and district level has also been presented.

All the four sectors have been mapped in each of the state, irrespective of state's ranking in the sector, e.g. Uttar Pradesh is one of the top state for sugar and cattle sector, however while mapping the energy potential rest two sectors i.e. poultry and fruits and vegetables have also been considered. All sector mapping will give an understanding of the overall potential and region identification.

Figure 3-3: Location of identified states and availability of multiple waste in each state



Uttar Pradesh

17% of industrial organic waste energy potential share of India in selected four sectors is contributed by Uttar Pradesh (UP). In cattle farm sector (195 MW), Uttar Pradesh stands at first place and in sugar industry (55 MW) at second place. In the poultry sector, UP contributes 10 MW of energy potential and for fruits and vegetable processing only 0.01 MW. Total energy potential including all the four sectors is 260 MW.

Spread of energy potential in the districts of UP for four sectors is already presented in the earlier chapter in the respective sections. However, in this section, each of the district is assessed based on multi-sector potential and regional concentration. Districts largely contributing to the four sectors and having maximum potential are referred and presented in Figure 3-4. Total energy potential in the identified districts is 132 MW which is 51% of the state energy potential.

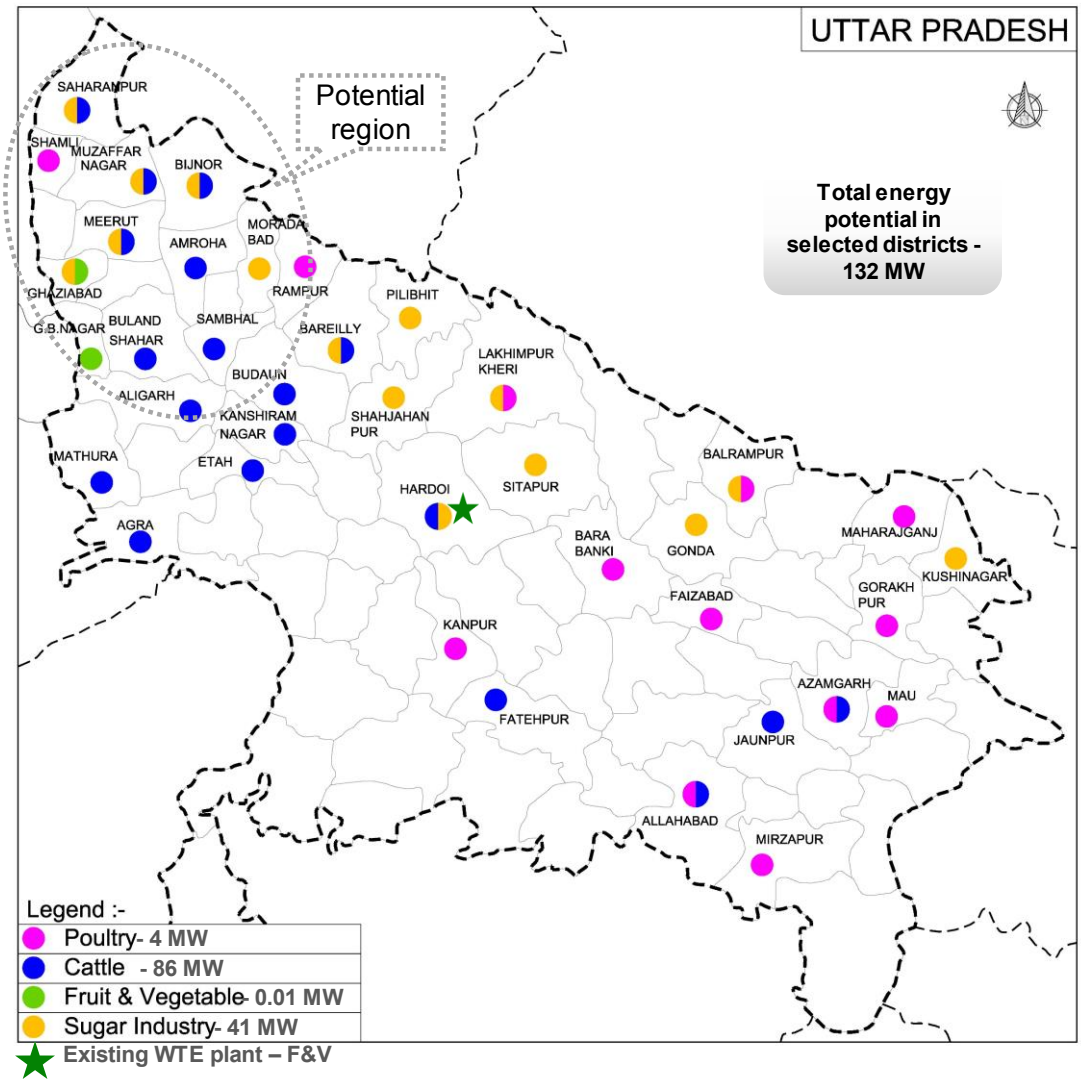
Being the largest state in terms of population and maximum number of districts, cattle population is not concentrated at one place, however it is scattered throughout the state. Although, major part of the energy

potential from cattle dung is concentrated in western part of the state, with some spread in the south-eastern part. Selected districts are contributing 44% (86 MW) of energy potential of states energy potential in cattle sector.

With respect to sugar industry, the whole state is divided into three parts, i.e. eastern UP, western UP and central UP. Based on the data assessed from Indian Sugar Mill Association's published list of sugar industry, it has been estimated that sugar industry is largely concentrated in western UP and its adjoining parts falling under central UP. In the selected districts, 76% of the state's energy potential from press mud is concentrated.

Poultry farms (4 MW in selected districts) are also scattered throughout the state, with some major patches in eastern UP. Fruits and vegetable processing is very limited in the state and majorly located in western UP, particularly in Ghaziabad and Gautam Budh Nagar. One waste to energy plant based on fruit and vegetable processing waste is in Hardoi district.

Figure 3-4: Location of identified districts and energy potential in Uttar Pradesh for four sectors



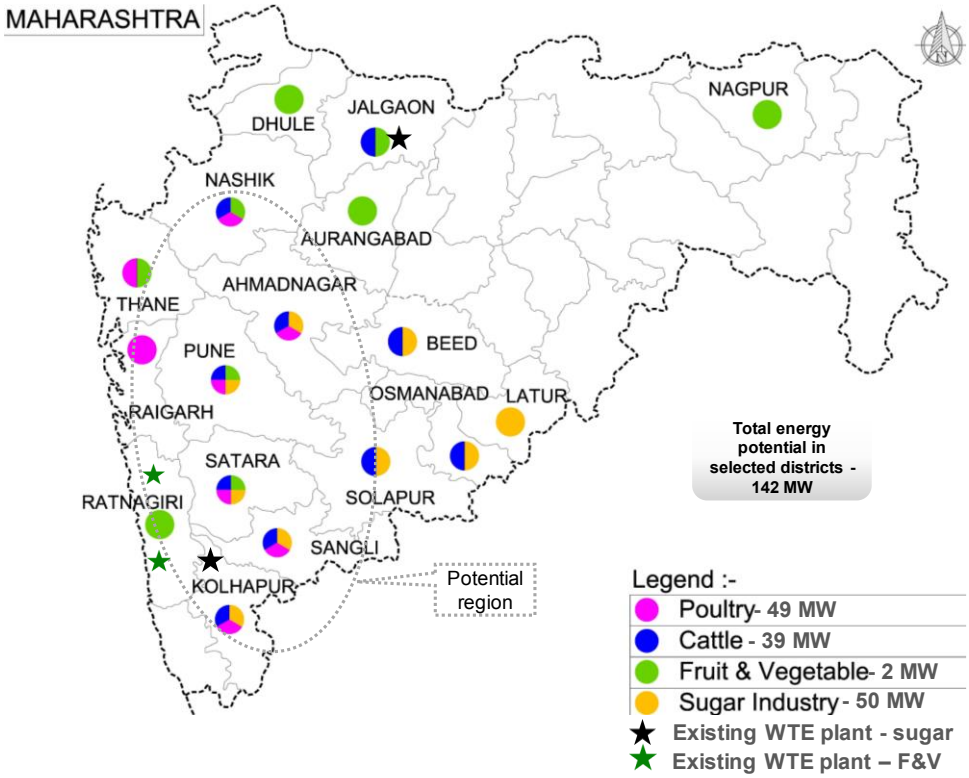
Maharashtra

Maharashtra is second major state contributing 12% of the total energy potential of India from selected four sectors. Another reason for Maharashtra being an important state is that it stands in list of one of the top states for all the four sectors. Total energy potential in the state is 181 MW, distributed among four sectors i.e. 68 MW from sugar industry, 56 MW from cattle, 55 MW from poultry and 2 MW from F&V processing.

District level concentration of industries is presented in Figure 3-5. 78% of the state's energy potential (142 MW) is concentrated in the identified districts, majorly concentrated in western part of the state. Satara, Pune, Sangli, Kolhapur, Ahmednagar are covering almost all the sectors in Maharashtra. Ratnagiri, Thane, Aurangabad,

Jalgaon and Nagpur are hub of fruits and vegetable processing. Selected districts represent 69% (39 MW) of energy potential from cattle dung, 89% (49 MW) from poultry litter and 74% (50 MW) from press mud. Below figure is also showing the potential region for further assessment and surveys.

Figure 3-5: Location of identified districts in Maharashtra for four sectors



Tamil Nadu

Tamil Nadu share is 10% (148 MW) in total India's energy potential for selected four sectors. Tamil Nadu ranks as top state for poultry (93 MW) and F&V (3 MW) sector. For sugar industry (10 MW) the state ranks at number four.

Districts shown in Figure 3-6 together contribute 76% of the total state's energy potential i.e. 112 MW. In poultry sectors, Tamil Nadu has maximum energy potential among all the states. 86% (49 MW) of the state potential is concentrated in eight districts only, out of which 50% is available in Namakkal district. North-western part of the state has strong poultry sector base.

Fruits and vegetable processing sector is concentrated in north-western part of the state. Krishnagiri is famous for mango processing and export.

Cattle population concentration is also found in north-western part of the state. 55% (23 MW) of the energy potential from cattle sector is present in selected districts. Sugar industry is present in northern and north eastern part of state with 64% (7 MW) of the state's share.

Namakkal, Erode, Salem, Krishnagiri, Vellore, Dharmapuri and Tiruvannamalai are some of the potential districts having energy potential for more than one sector. These districts would be further evaluated for site visits and surveys. Three poultry litter based waste to energy plants are situated in Namakkal district.

Figure 3-6: Location of identified districts in Tamil Nadu for four sectors

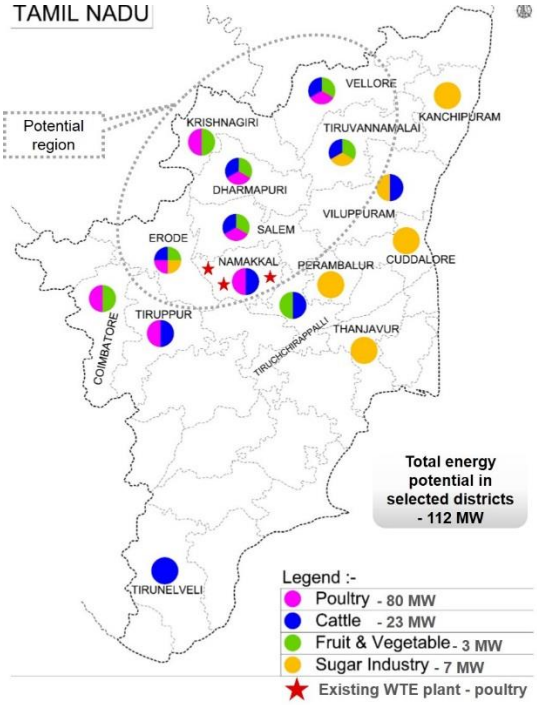
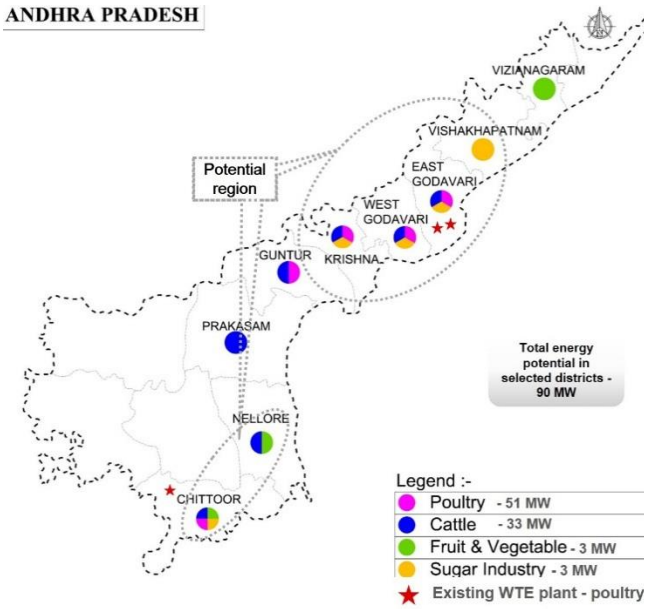


Figure 3-7: Location of identified districts in Andhra Pradesh for four sectors



Andhra Pradesh

Andhra Pradesh stands at number 4 position among 9 states, having 8% of the country's energy potential share in selected four sector. Total energy potential of the state is 117 MW shared by poultry 60 MW, cattle 50 MW, sugar 4 MW and F&V 3 MW. Andhra Pradesh is one of the top state for poultry and F&V sectors.

Figure 3-7 presents location of districts having 77% (90 MW) share of state energy potential for all the sectors. As shown in the map most of the potential is present in 5-6 districts only. Poultry and sugar is concentrated in central part of the state, cattle sector is scattered in southern and central part whereas F&V is present in northern and southern region. East Godawari, West Godawari, Chittoor are the major districts with presence of more than one sector.

Despite Chittoor being in extreme southern part of the state, it is one of the potential region representing all the four sectors. The identified districts would be further evaluated with respect to availability of waste and actual potential at the site.

There are three poultry based waste to energy plants in Andhra Pradesh, two located in East Godawari and one in Chittor district.

Karnataka

Karnataka is one of the shortlisted state having energy potential of 113 MW which is 7% of the total estimated potential of the country. Karnataka ranks third in sugar industry sector (33 MW) and fifth in poultry sector (40 MW). State's contribution for cattle farm (40 MW) and F&V sector is not remarkable and scattered also.

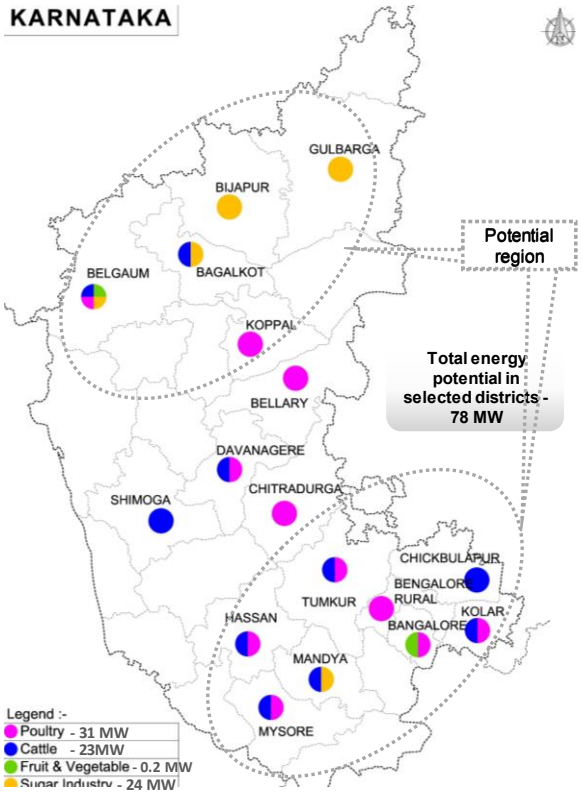
Districts shown in Figure 3-8 contribute almost 69% of the state's energy potential which is 78 MW.

Almost 65% (24 MW) of the sugar industries are present in four districts only namely Gulbarga, Bijapur, Bagalkot and Belgam. Poultry sector focused in eastern belt of the state and some part in southern region with 77% share (31 MW).

Keeping in mind the fact of maximum energy potential and availability of multi sector waste, northern part and southern part has been identified as potential regions for further evaluation.

Northern part has majorly sugar industry, whereas in southern part has mix of poultry and cattle.

Figure 3-8: Location of identified districts in Karnataka for four sectors



Gujarat

Total energy potential for four sectors in Gujarat is 94 MW i.e. 6% of the total country's potential. Gujarat stands third in cattle sector with 77 MW, fourth in F&V sector 0.3 MW and fifth in sugar industry sectors with 8 MW. In poultry sector, total potential is 8 MW.

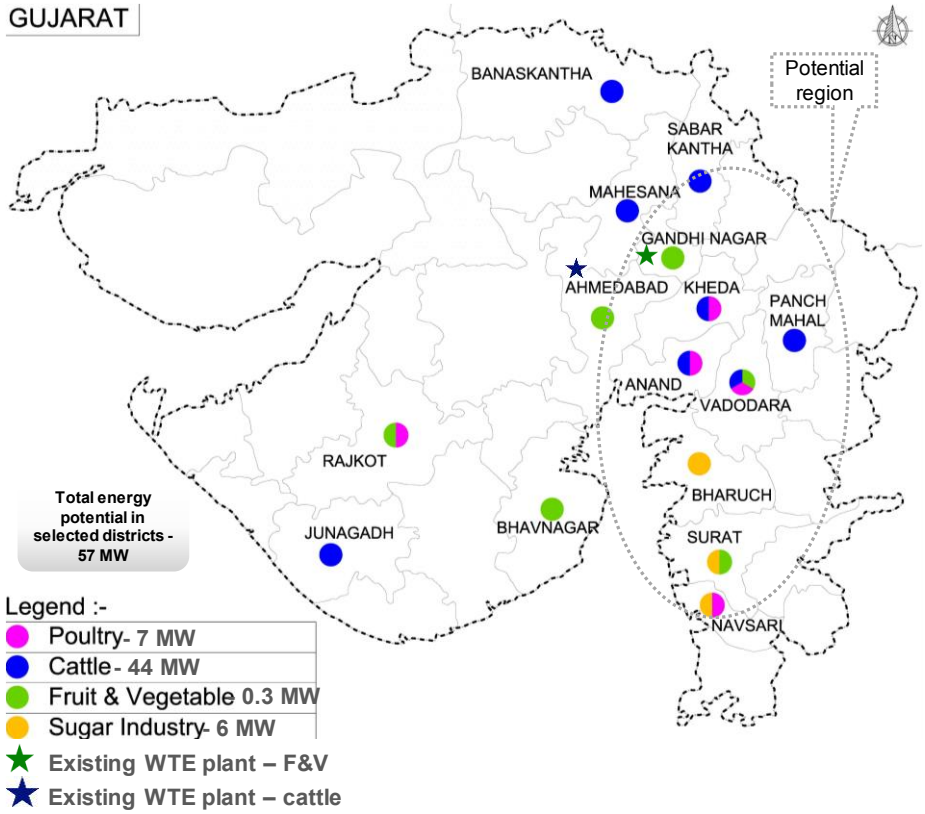
Figure 3-9 presents the location of identified districts, contributing 60% of the state potential. Whole of eastern belt of the state is having potential for all the sector. Vadodara, Suart, Kheda, Anand, Navasari and Sabar Kantha are the major districts in the region having potential from more than one sector. In addition to these districts, Bhavnagar, Gandhinagar, Ahmedabad are specialised for F&V processing.

57% of cattle sector share of Gujarat is concentrated in selected districts which is 44 MW. Whole of north eastern part of state is well known for cattle population concentration and house of large dairy based industrial units.

Fruit and vegetable processing sector is remarkably present in various districts such as Vadodara, Surat, Ahmedabad, Gandhinagar etc. 68% of energy potential from sugar industry is present in selected districts i.e. 6 MW, located in Surat, Navasari and Bharuch. 79% of states energy potential from poultry sector is present in five of the districts namely Rajkot, Navasari, Vadodara, Kheda and Anand.

One waste to energy plant based on fruits and vegetable processing is located in Gandhinagar and one plant based on cattle dung is situated in Ahmedabad. All the selected districts will be further evaluated for data validation and site visits.

Figure 3-9: Location of identified districts in Gujarat for four sectors



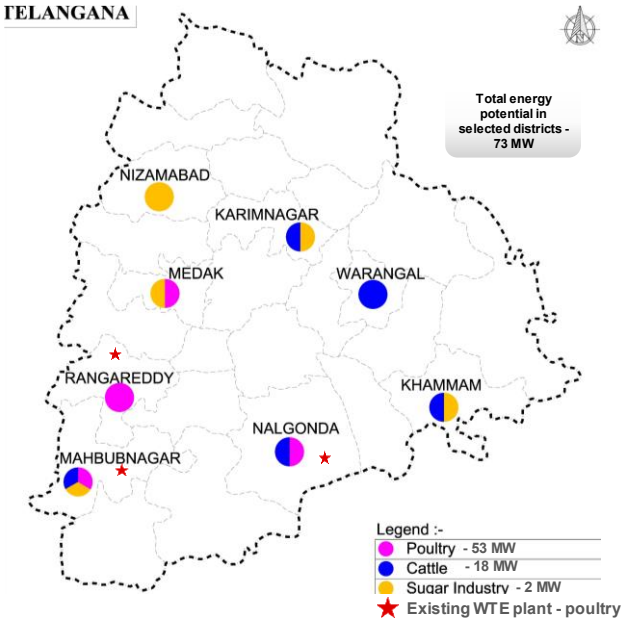
Telangana

Telangana comes at number seven in term of country's potential with 6% of the share and 92 MW energy potential. Among the four sectors, Telangana is at second place in energy potential from poultry sector which is 63 MW. Sugar industry, cattle sector and F&V processing sector is very limited in the state.

96% of the total poultry sector of the state is present in 4 districts namely Medak, Rangareddy, Nalgonda and Mahbubnagar located in western and southern part. Alone Medak's share is 37% among these four districts.

Cattle population is also very scattered in the state and so is the energy potential. Karimnagar, Warangal, Khammam, Nalgonda and Mahbubnagar shows the presence of energy potential from cattle sector.

Figure 3-10: Location of identified districts in Telangana for three sectors



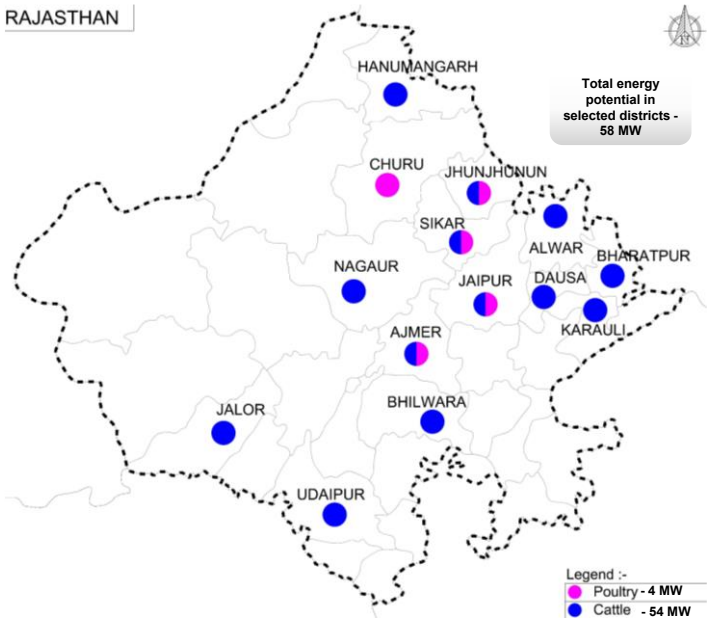
Rajasthan

Total energy potential in Rajasthan is 94 MW shared largely by cattle sector 88 MW and poultry sector 6 MW.

With 88 MW of potential in the cattle sector Rajasthan is the second largest state having cattle population concentration after Uttar Pradesh. Districts showing in Figure 3-11 represents 61 % of the state's potential in the sector i.e. 54 MW largely located in eastern part of the state.

92% (4 MW) of the energy potential from poultry sector is confined to five districts only i.e. Churu, Jhunjhunu, Sikar, Jaipur and Ajmer. Ajmer alone contributes 50% of these districts.

Figure 3-11: Location of identified districts in Rajasthan for two sectors



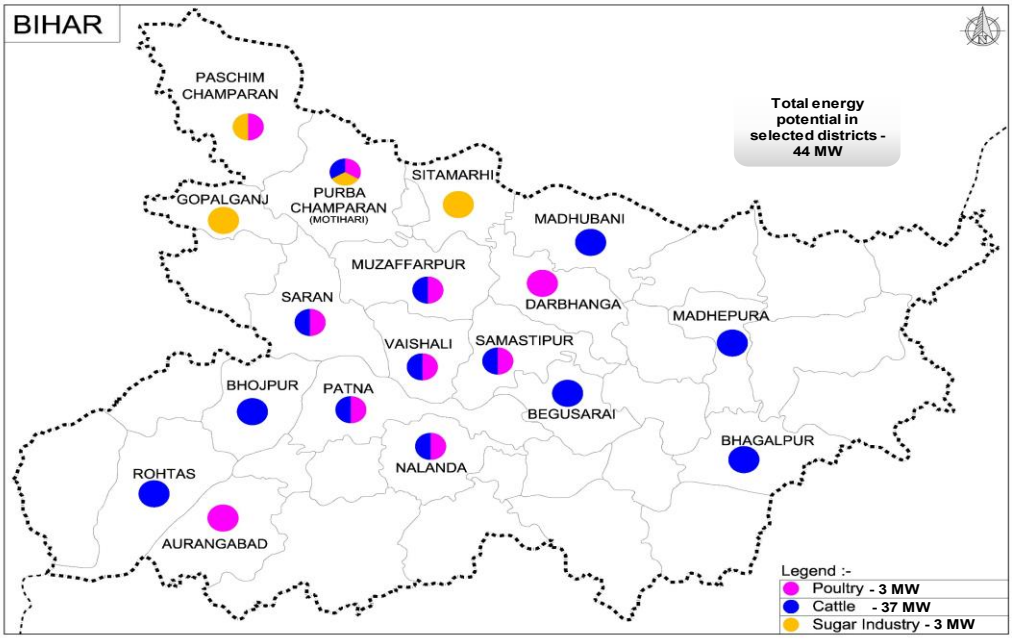
Bihar

Bihar stands at 9th rank among the selected 9 states with energy potential of 74 MW (5%). Bihar is at fourth position with respect to energy potential from cattle sector (65 MW). Potential from poultry and sugar industry sector is only 5 and 4 MW respectively.

Cattle and poultry sectors are scattered throughout the state, whereas sugar industry is limited to north-western part only.

Figure 3-12 shows the location of the identified districts having maximum energy potential (44 MW). Looking at the map, it is evident that there is no particular region or belt in the state where energy potential is concentrated. Selected districts represent 57%, 72% and 78% of states energy potential from cattle sector, poultry sector and sugar industry respectively.

Figure 3-12: Location of identified districts and energy potential in Bihar for three sectors



3.3 Finalisation of the States and Districts

Energy potential assessment for all the 9 states has been done in the above section. Based on the earlier mentioned factors i.e. concentration of maximum energy potential, multi-sector presence in one region; selected states have been looked upon. Below table justifies the rational to select or reject the state.

Table 3-2: Rational to select or reject the state

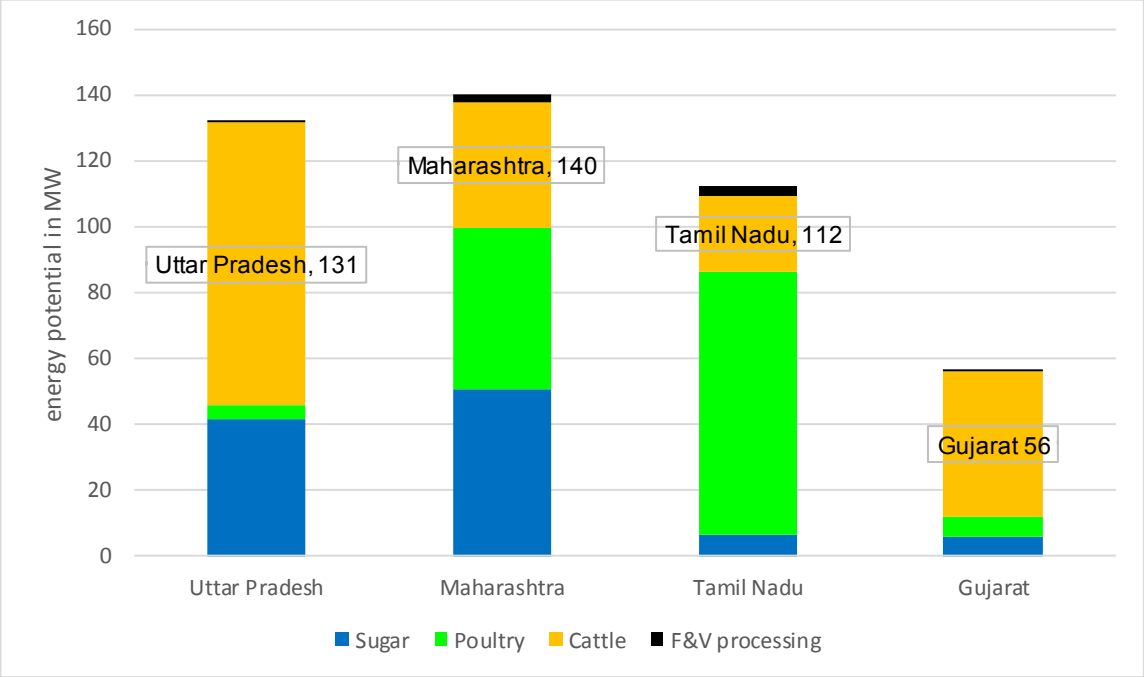
Sl. No.	State	Status	Rational to select/reject
1	Uttar Pradesh	Selected	• Maximum energy potential in country. • One of the top state in cattle and sugar sector. • Multi-sector concentration in one region.
2	Maharashtra		• Second largest state in terms of energy potential. • One of the top state in all the four sectors. • All the sectors are concentrated on one region. • Presence of industrial organic waste based waste to energy plants.
3	Tamil Nadu		• One of the top state in three sectors. • Concentration of energy potential in one region. • Presence of multi-sector in one region. • Presence of industrial organic waste based waste to energy plants.
4	Gujarat		• One of the top state in three sectors. • Concentration of energy potential in one region. • Presence of multi-sector in one region. • Representing eastern part of the country. • Presence of industrial organic waste based waste to energy plants.
5	Andhra Pradesh	Not selected	• Energy potential is scattered throughout the state.
6	Karnataka		• Energy potential is scattered throughout the state. • Absence of multi-sector waste in one region.
7	Telangana		• Energy potential is scattered throughout the state. • Unavailability of all the sectors. • Major share of the potential in one sector only. • Absence of multi-sector waste in one region.
8	Rajasthan		• Limited to two sectors only. • Major share of the potential in one sector only. • Absence of multi-sector waste in one region.
9	Bihar		• Energy potential scattered throughout the state. • Unavailability of all the sectors. • Major share of the potential in one sector only. • Absence of multi-sector waste in one region.

Final four selected states for further study are Uttar Pradesh, Maharashtra, Tamil Nadu and Gujarat. Table 3-3 presents the sector wise energy potential in selected districts for shortlisted 4 states.

Table 3-3: Energy potential in selected districts of the shortlisted states - MW

District share in MW	Sugar	Poultry	Cattle	F&V processing	Total
Uttar Pradesh	41	4	86	*0.01*	132
Maharashtra	50	49	39	2	140
Tamil Nadu	7	80	23	3	112
Gujarat	6	6	44	*0.3*	56
Total	104	139	192	5	440
Share in total country's energy potential	**52%**	**30%**	**22%**	**49%**	**29%**

Figure 3-13: State wise energy potential for four sectors



Final selection of the districts has been done from the identified potential regions mapped in the earlier section. Districts having maximum energy potential, multi waste availability and installed waste to energy plants have been selected for site surveys and data validation. Table 3-4 presents the name of the identified districts in the 4 states in respective sectors.

Table 3-4: Identified districts for site survey

State	State departments	Sugar	Cattle	Poultry	F&V
Uttar Pradesh	Lucknow / Kanpur				
		Muzaffarnagar	Muzaffarnagar		
					Hardoi
		Bijnaur	Bijnaur		
		Meerut	Meerut		
		Ghaziabad			Ghaziabad
		Moradabad			
					Gautam Budh Nagar
				Shamli	
Maharashtra	Mumbai				
		Satara	Satara	Satara	Satara
		Ahmedanagar	Ahmedanagar	Ahmedanagar	
		Pune	Pune	Pune	Pune
					Ratnagiri
Tamil Nadu	Chennai				
			Krishinagiri		Krishinagiri
			Salem	Salem	Salem
			Namakkal	Namakkal	
		Erode	Erode	Erode	Erode

State	State departments	Sugar	Cattle	Poultry	F&V
Gujarat	Ahmedabad				Ahmedabad
			Vadodara	Vadodara	Vadodara
			Ananad	Ananad	
		Gandhinagar			
		Surat			Surat
		Bharuch			

Detail work plan and site visit schedule is given in the next chapter.

4.0 STAKEHOLDERS IDENTIFICATION

Stakeholder consultation is the process which includes identification of project's key stakeholders, assessment of their interests, roles and responsibilities and the ways in which these interests affect project implementation and viability. Stakeholder analysis for the current project is the core activity of the project, since it would contribute to the information on the status of existing operating facility in the sector, key players in the sectors, availability of raw material and its current usage, willingness of the concerned people to invest in the sector. In addition, the consultation process would also result into concerns and issues people are facing in the sector and ways and means to overcome the same. Therefore, during the whole process, out team would try to capture two sets of information, first is facts and figure and another is qualitative discussion with respect to gaps, issues, concerns suggestions, etc.

Stakeholder consultation would be limited to four identified sectors i.e. cattle, poultry, fruits & vegetables and sugar industry. For all the sector, four states have been shortlisted based on the energy potential and availability of the multi-sector raw material. Within each of the selected state, micro level regions have been selected for further evaluation and assessment. In four states and respective regions, stakeholder consultation would be held with government departments, ministries, state nodal agencies (SNAs), technology providers, industries and plant operators.

Stakeholders would be further consulted on the role & responsibility they furnish at different level in the respective identified sectors. Details like generation / collection and transportation of waste, seasonal variation in the availability of waste, waste processing technologies, plant operating status etc. would also form a part of consultation. Detail list of stakeholders is provided in the further sections.

4.1 Objective

The stakeholder's consultation for the project will be done to access the current industrial organic waste generation and current usage, availability, pricing, characteristics and identify issues related to the project already implemented. The envisaged objectives for stakeholder consultations /discussion are:

- Validate the existing information on waste quantification and energy potential estimated from various secondary sources with specialised inputs from the key stakeholders;
- Waste availability, pricing and characterization (if available) of organic industrial wastes for identified sectors.
- Identify sampling locations for collection of representative samples of each feed stock from four states.
- Information pertinent to the current disposal methods, treatment methods etc.
- Identify any other issues / concerns of stakeholders which could impact on the resource availability, supply and requirement.

The stakeholder consultations process will help gather all information which will be used for validation of a regional "Consolidated Matrix on Availability, Utilization & Pricing of Industrial Organic Waste".

4.2 Type of Stakeholder

The first step for an effective stakeholder analysis is to identify the key stakeholders for the project, which includes people who can contribute to decision making process. For the current project, a large array of government departments at the central, state level and district level, co-operative, industrial associations, research institutes, service provider for WTE for industrial sector and community residing around the project location directly benefited from the project are key contributors. Details of different type of stakeholder identified for the project is provided below:

i. Government departments

a. Central Government Department
   - Ministry of New and Renewable Energy (MNRE)
   - National Dairy Development Board
   - Ministry of Food Processing Industries
   - National Centre of Organic Farming
   - The Agricultural and Processed Food Products Export Development Authority (APEDA)
   - Department of Agriculture & Cooperation, Ministry of Agriculture, Government of India
   - Ministry of Agriculture and Farmers Welfare
   - Directorate of Sugarcane Development
   - Department of Animal Husbandry Dairying & Fisheries (DADF)
   - Central Poultry Development Organization
   - Micro, Small and Medium Enterprises Department
   - Ministry of Chemical and Fertilizer
   - Natural Gas Companies
   - Petroleum Explosive Safety Organization (PESO)
   - Chemical and Organic Fertilizer Companies

b. State Government Department
   - State Nodal Agency for New and Renew Energy Development
   - State Animal Husbandry Department/Directorate - dairy and poultry department
   - State Industry Department (Sugar/Agro/Food)
   - Department of Agriculture
   - Director of Horticulture
   - Directorate of Sugarcane Development

c. Government Department at Regional /District Level
   - District Industries Centre

- Animal Husbandry Department
- Agriculture Department

ii. Cooperative/ Federations
- Milk Cooperatives /Farmers Federation
- Sugar Cooperative/Federation
- Poultry Federation of India

iii. Industrial Associations
- Indian Sugar Mills Association (ISMA)
- Poultry Farmers Association
- All India Food Processors' Association (ALFPA), New Delhi
- Indian Biogas Association (IBA)

iv. Universities and Research Institute
- National Institute of Horticulture Research, Bangalore
- The Directorate of Poultry Research (DPR), ICAR
- The Indian Institute of Sugarcane Research (IISR), Lucknow
- Vasantdada Sugar Institute
- IICT Hyderabad
- Central Food Technological Research Institute (CFTRI)

v. Industries/other stakeholder generating industrial organic waste
- Selected Cattle farm
- Selected Poultry Farm
- Selected Sugar Industry
- Selected fruit & vegetable Industry

vi. Service provider for WTE for industrial sector/ WTE facility (bio-methanation)
- MAILHEM Engineering Pvt.
- Perfect Bio-Waste & Power Management Pvt. Ltd
- Green elephant, India
- Enkem engineering pvt.
- Organic recycling system (ORS)
- Spectrum renewable energy ltd
- Bharat biogas limited, Gujarat

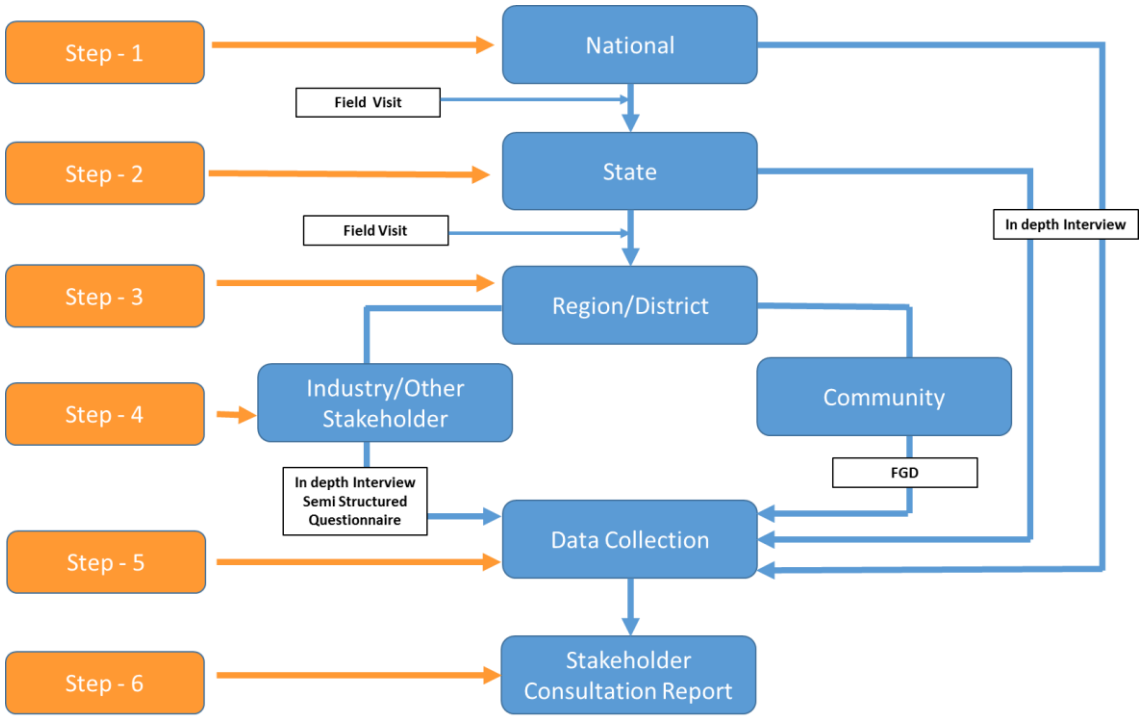
vii. Community/industry benefited from WTE facilities

4.3 Consultations Process & Methodology

The consultation process would follow top down approach as presented in Figure 4-1. At the initial stage, central level departments and ministries would be consulted to understand their vision and challenges at a larger scale for the selected sectors. Followed by central level discussions, state level departments and agencies will be contacted to get an idea regarding the ongoing or proposed initiative and current practices of waste management in the four selected sectors. At regional or micro level, consultations would be held with sectoral industries, technology providers, WTE plant operators and waste collectors to visualize the implementation part of the sector particularly nature and severity of the organic waste availability and its transformation into energy.

Results of stakeholder consultation would be summarised and based on the inferences, final outcomes would be derived in terms of finalisation of the waste quantity and pricing, combinations of different wastes as an input to biogas plant, requirement of financial assistance, locations of new plant and operating procedures, stimulus required for commercialization of biogas power, bottled carbon dioxide, bio-CNG and organic fertilizers.

Figure 4-1: Methodology for stakeholder consultation



Stakeholder consultation would be undertaken at individual and group level discussions and visual observation and industry and facility itself. Type of discussions and relevant stakeholders are discussed further.

Detail one to one discussions: The team would meet concerned person from respective departments at central and state level. The discussion would be focused on the government's vision for waste management in the selected sectors, efforts made in the past for the same and proposed plan of action based on the experience, possible funding schemes, key prerequisites for setting up waste to energy facility and their willingness to target the sectors.

Research institutes/Agriculture Universities would also be consulted to understand their achievements in R&D of bio-methanation technology and its applications which can be demonstrated for commercialization, ongoing research activities and support required from state or central government. The team would capture suggestions of relevant experts from visited institute.

The representatives of industries, technology providers, plant operators and waste collectors would also be called for arranging meeting their concerned representatives. At the waste generating industries, consultation would cover key points regarding types of waste generated, ratio of raw material and waste quantity, current usage of the waste and selling price of the waste. Whereas with respect to technology providers and plant operators, key points would cover installed / running capacity of the plant, availability of the waste, seasonal variation in waste, ratio of other waste mixed with the primary waste, regularity in energy generation, economic viability of the project and benefits of end user consuming energy generated at the plant.

Focus group discussion (FGD): FGDs will be conducted with the communities getting energy from the existing operating WTE plants for the selected four sectors. Discussion would be focused around various factors affecting end consumer such as frequency of the energy supplied, disruptions in the supply, energy charges, changes in the energy pricing, willingness to continue and any other issues faced by the community.

Visual observations / walk in interview: The visual observations and quick discussion in cattle farm, poultry farm, sugar industry and fruit and vegetable processing industry will be documented. The best practices and case studies wherever observed will be documented.

Individual / group discussions and primary survey would provide understanding of the sector at ground level, achievements, constraints and future vision. The expected outcomes would present an overview of the sector in country and selected states. Summary of expected outcomes from the discussions is presented in Table 4-1. Detail questionnaires for each of the stakeholder is provided in Annexure 2.

Table 4-1: Sector wise expected outcomes

Sector	Expected Outcome
Policy interventions to set up WTE plants	• Action plan / vision for development of WTE sector at national scale • State policies to support for promotion of WTE through organic waste • Permits or approvals required for setting up WTE project • Mandates to set up WTE plant • Policy for performance based incentive in WTE sector • Policy for Public Private Partnership (PPP) options in the WTE sector • Legislation in the state for WTE sector • Research and Development policy of state in WTE sector
Financing strategy / subsidy available	• Financial assistance available from central and state government for promoting WTE • Financial institutions providing loan for WTE plant set up • Eligibility / limitation to get financial assistance • Share of financial assistance between centre / state / beneficiary • Pay-back period of the loan
Technology options	• Type of technology available in WTE plant • Preferred technology option for plant operators and reasoning • Pros and cons of existing plant technology option • Technology used by maximum plant operators and reasoning • Suggestion for alteration in the technology
Research and development activities	• Characterisation of raw organic waste – press mud / poultry litter / cattle dung / fruits and vegetables processing waste • Calorific value of the waste and energy potential • Co-substrate of wastes and their ratios • Variation in waste quantification for different varieties of raw material – press mud / poultry litter / cattle dung / fruits and vegetables processing waste • Ratio of waste to the raw material
Fruit & Vegetable Processing industry	• Any seasonal variation in the processing activities • Types of other material mixed with fruits and vegetables • Type of waste / by products after processing – in segregated form or mixed • Ratio of waste to the raw material • Existing waste management practice – disposal / selling • Selling price for waste / type of sellers
Sugar Industry	• Any seasonal variation in the processing activities • Ratio of waste (press mud) to the raw material • Existing utilisation of press mud • Existing waste (press mud) management practice – disposal / selling • Selling price for waste / type of sellers
Cattle/Poultry Farm	• Number of cattle / poultry birds in farm • Fluctuation in the number of poultry birds / cattle throughout the year • Quantum of waste generated • Current disposal practice of cow dung & poultry litter • Selling price of cow dung & poultry litter
WTE Plant	• Installed and operating capacity of the plant • Information related to feedstock availability, transportation and supply • Catchment area of the waste • Pros and cons of waste to energy technology • Utilization of energy generation from waste

Sector	Expected Outcome
	• Total cost of WTE project • O & M of WTE project • Payback period of loan provided in WTE project • Transportation cost of the waste

4.3.1 State Wise List of Selected Stakeholders and expected outcome

Key stakeholders have been identified for all four selected sectors at national level, state level and district/regional level. Identification of stakeholders is done for four states (Maharashtra, Gujarat, Tamil Nadu and Uttar Pradesh) in this section (Table 4-2).

The analysis of stakeholder consultations will enable us to validate the secondary data, availability of quantum of organic industrial waste, project financing including transportation/operation cost/raw material cost etc. The role and responsibility of existing institutions responsible for provision and facilitation of infrastructure pertaining to WTE plants in the states will be analysed. Based on stakeholder analysis, a regional "Consolidated Matrix on Availability, Utilization & Pricing of Industrial Organic Waste" will be developed. The expected outcome of the stakeholder analysis is provided below:

Figure 4-2: Identified stakeholder, survey tools & expected outcome

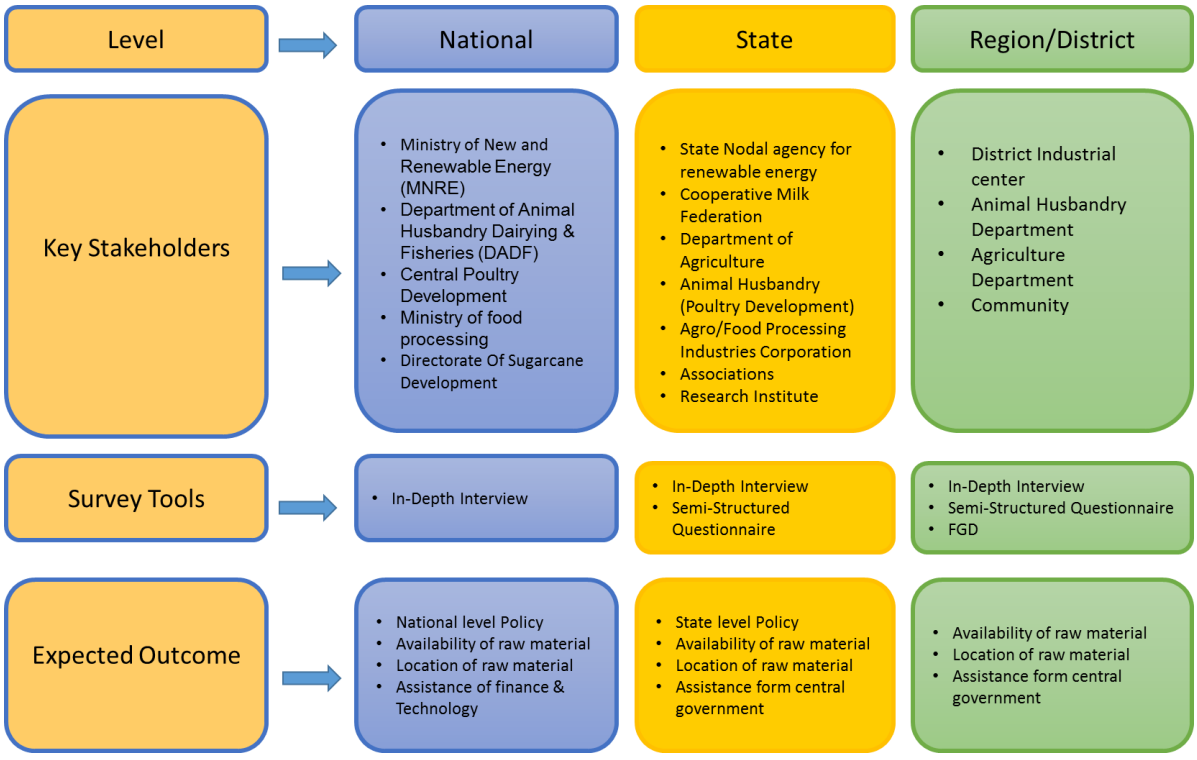


Table 4-2: Outcome of the stakeholder discussions

Level	Sector	Department	Expected Outcome
Central	Energy Sector	Ministry of New and Renewable Energy (MNRE) Ministry of Chemical and Fertilizer	• Central government policies for organic waste • Technology used for WTE • Planning & intervention in this sector • Kind of support provided to state government or implementers

Level	Sector	Department	Expected Outcome
		Natural Gas Companies	• Technology/Financial assistance provided • Data related to selected sector in terms of location/quantum
		Petroleum Explosive Safety Organization (PESO)	
		Chemical and Organic Fertilizer Companies	
		Indian Biogas Association (IBA)	
	Cattle Farm	National Dairy Development Board	• Number of operational cattle farms • Quantum of organic waste generated • Innovative ideas considered converting animal manure toenergy • Role of NDDB in the sector • Data related to cattle/ cattle farm at national, state and district level
		Department of Animal Husbandry Dairying & Fisheries (DADF)	• Number of operational cattle farms • Growth in the sector
	Poultry	Poultry Federation of India, Gurgaon, Haryana	• Role & responsibility of CPDO in terms of WTE • Coordination with MNRE/state govt for WTE • Technology used for generation of energy • Consideration of converting poultry litter to energy • Quantity of feedstock supply is required for the facility to operate effectively • Seasonal fluctuations of waste generation and composition • Collected feedstock require pre-treatment for the Waste to Energy facility • Safe treatment and disposal of by-products
	Fruit & Vegetable Processing	Ministry of Food Processing Industries	• Policies related to WTE • Total number of fruit & Vegetable processing units in India (state & district wise) • Quantum of F&V processed
		IICT Hyderabad	
		Central Food Technological Research Institute (CFTRI)	
		National Horticulture Board	• Production of fruit & vegetable • Storage of F&V • Seasonal variation of availability of F&V in India
		Ministry of Agriculture and Farmers Welfare, Krishi Bhawan	•
	Press Mud	Directorate of Sugarcane Development	• Policies promoting WTE • Current usage of by-products • Seasonal variation of availability of press mud in India
		Department of Food and Public Distribution	
Gujarat	Nodal Agency	Gujarat Energy Development Agency (GEDA), Govt of Gujarat	• State government policies for organic waste • Technology used for WTE • Planning & intervention in this sector • Kind of support provided to implementers • Financial assistance received from central govt and provided to implementers • Data related to selected sector in terms of location/quantum

Level	Sector	Department	Expected Outcome
	Service provider for WTE	Bharat Biogas Limited, Gujarat	• Information related to installed and operating capacity of the plant, feedstock availability, transportation and supply • Financial part of WTE project • O & M of WTE project
	Cattle farm	Gujarat Cooperative Milk Marketing Federation Ltd. (GCMMF)	• State Govt. policies to support WTE • Number of operational cattle farms • Quantum of organic waste generated • Current & proposed transportation and disposal plan • Innovative ideas considered converting animal manure to energy • Assistance to implementing agency (technology & Finance) • Data related to cattle/ cattle farm, animal manure at national district level
	Poultry	Animal Husbandry (Poultry Development), Gandhinagar, Govt of Gujarat	• Role & responsibility of state department in terms of WTE • Quantum of raw material available • Coordination with MNRE or central govt for WTE • kind of technology is used for generation of energy • Quantity of feedstock supply is required for the facility to operate effectively • Seasonal fluctuations of waste generation and composition • Collected feedstock require pre-treatment for the Waste to Energy facility • Safe treatment and disposal of by-products
	Fruit & Vegetable Processing	Gujarat Agro Industries Corporation, Gandhinagar Department of Agriculture & Cooperation, Govt of Gujarat	• Production of fruit & vegetable • Role for development of value addition in F&V • Storage of F&V • Seasonal variation of availability of F&V in India
		Director of Horticulture, Gujarat State	• Production of fruit & vegetable • Role for development of value addition in F&V • Storage of F&V • Seasonal variation of availability of F&V in Gujarat
		Anand Agriculture University	• Potential of availability of selected sector in the state
	Press Mud	Gujarat State Federation of Co-operative Sugar Factories Limited, Govt of Gujarat	• Production of sugarcane in state & districts (if district wise data available) • Number of sugarcane industry • Number of sugarcane industry having WTE • Policies promoting WTE • Seasonal variation of availability of press mud in India & states
Maharashtra	Nodal Agency	Maharashtra Energy Development Agency (MEDA), Government of Maharashtra	• Production of sugarcane in state & districts (if district wise data available) • Number of sugarcane industry • Number of sugarcane industry having WTE • Policies promoting WTE • Seasonal variation of availability of press mud in India & states
	Cattle Farm	Department of Animal Husbandry, Mumbai	• Number of operational cattle farms • Quantum of organic waste generated • Current & proposed transportation and disposal

Level	Sector	Department	Expected Outcome
			plan • State Govt. policies to support WTE • Innovative ideas considered converting animal manure to energy • Assistance to implementing agency (technology & Finance) • Data related to cattle/ cattle farm, animal manure at national district level
	Poultry	Central Poultry Development Organisation Western region Mumbai	• Role & responsibility of state department in terms of WTE • Quantum of raw material available • Coordination with MNRE or central govt for WTE • kind of technology is used for generation of energy • Quantity of feedstock supply is required for the facility to operate effectively • Seasonal fluctuations of waste generation and composition • Collected feedstock require pre-treatment for the Waste to Energy facility • Safe treatment and disposal of by-products
		Poultry Breeders Welfare Association (Maharashtra)	• Total number of poultry & poultry farms in the state • Potential of poultry business in Maharashtra • Current use of poultry litter in the state
	Fruit & Vegetable Processing	Maharashtra State Horticulture & Medicinal Plant Board	• Production of fruit & vegetable • Role for development of value addition in F&V • Storage of F&V • Seasonal variation of availability of F&V in Maharashtra
		Maharashtra Agro Industries Development Corporation Ltd (MAIDC)	• Total number of Agro industries in the state • Quantum of processed food & industrial effluent generated • Policies related to safe disposal of industrial effluent • Policies related to WTE • Technological/Financial support for WTE
	Press Mud	Maharashtra State Co-Operative Sugar Factories Federation Ltd	• Production of sugarcane in state & districts (if district wise data available) • Number of sugarcane industry • Number of sugarcane industry having WTE • Policies promoting WTE • Seasonal variation of availability of press mud in India & states
		Vasantdada Sugar Institute (VSI), Manjari, Pune	• Characteristics of press mud • Percentage of press mud generated from sugar industry • Study related to press mud (calorific value, BOD, COD)
Tamil Nadu	Nodal Agency	Tamil Nadu Energy Development Agency (TEDA), Govt of Tamil Nadu	• State government policies for organic waste • Technology used for WTE • Planning & intervention in this sector • Kind of support provided to implementers • Financial assistance received from central govt and provided to implementers • Data related to selected sector in terms of location/quantum
	Cattle Farm	Directorate of Animal Husbandry and Veterinary Services	• Quantum of Organic waste generated • Current & proposed transportation and disposal plan

Level	Sector	Department	Expected Outcome
			• State Govt. policies to support WTE • Innovative ideas Considered Converting Animal Manure to Energy • Assistance to implementing agency (technology & Finance) • Data related to cattle/ cattle farm, animal manure at district level
		Department of Animal Husbandry Dairying & Fisheries (DADF)	• State Govt. policies to support WTE • Number of operational cattle farms • Quantum of organic waste generated • Current & proposed transportation and disposal plan • Innovative ideas considered converting animal manure to energy • Assistance to implementing agency (technology & Finance) • Data related to cattle/ cattle farm, animal manure at state & district level
		Tamil Nadu Cooperative Milk Producers' Federation Ltd.	
	Poultry	Tamil Nadu Poultry Farmers Association, Namakkal	• Total number of members in the association, poultry farms, poultry • Role of development of poultry • Coordination with MNRE/state govt for WTE • Current & proposed disposal of poultry litter • Kind of support looking from central & state government
	Fruit & Vegetable Processing	Directorate of Horticulture and Plantation Crops, Govt of Tamil Nadu	• Production of fruit & vegetable • Role for development of value addition in F&V • Storage of F&V • Seasonal variation of availability of F&V in Tamil Nadu
		Micro, Small and Medium Enterprises Department (Rural Industries including Cottage Industries, Small Industries)	• Total number of Agro industries in the state • Quantum of processed food & industrial effluent generated • Policies related to safe disposal of industrial effluent • Policies related to WTE • Technological/Financial support for WTE
	Press Mud	Tamil Nadu Co-op. Sugar Federation Ltd. Govt of Tamil Nadu	• Production of sugarcane in state & districts (if district wise data available) • Number of sugarcane industry • Number of sugarcane industry having WTE • Policies promoting WTE • Seasonal variation of availability of press mud in India & states
Uttar Pradesh	Nodal Agency	Non-conventional Energy Development Agency (NEDA), Govt of Uttar Pradesh	• State government policies for organic waste • Technology used for WTE • Planning & intervention in this sector • Kind of support provided to implementers • Financial assistance received from central govt and provided to implementers • Data related to selected sector in terms of location/quantum
	Cattle Farm	Animal Husbandry Department	• Number of operational cattle farms • Quantum of Organic waste generated • Current & proposed transportation and disposal plan • State Govt. policies to support WTE • Innovative ideas considered converting animal manure to energy
		Pradeshik Cooperative Dairy Federation (PCDF)	

Level	Sector	Department	Expected Outcome
			• Assistance to implementing agency (technology & Finance) • Data related to cattle/ cattle farm, animal manure at national district level
	Poultry	Department of Animal Husbandry, Lucknow, Govt of Uttar Pradesh	• Role & responsibility of state department in terms of WTE • Quantum of raw material (poultry Litter) available • Coordination with MNRE or central govt for WTE • kind of technology is used for generation of energy • Quantity of feedstock supply is required for the facility to operate effectively • Seasonal fluctuations of waste generation and composition • Collected feedstock require pre-treatment for the Waste to Energy facility • Safe treatment and disposal of by-products • Data of number of poultry & poultry farms in state wise
	Fruit & Vegetable Processing	Plant & Food Processing Department, Govt of Uttar Pradesh	• Production of fruit & vegetable • Role for development of value addition in F&V • Storage of F&V • Seasonal variation of availability of F&V in Uttar Pradesh
	Press Mud	Uttar Pradesh Cooperative Sugar Factories Federation Ltd.	• Production of sugarcane in state & districts (if district wise data available) • Number of sugarcane industry • Number of sugarcane industry having WTE • Policies promoting WTE • Seasonal variation of availability of press mud in states
		The Indian Institute of Sugarcane Research (IISR), Lucknow	• Characteristics of press mud • Percentage of press mud generated from sugar industry • Study related to press mud (calorific value, BOD, COD)
		National sugar Institute, Kanpur	

4.4 Team Composition and Time Line

The core team members of Arcadis will cover all four states for the field visit for the smooth execution of the assignment in a timely manner. The major responsibilities of team members will include finalisation of field plan with coordination of stakeholders, stakeholder consultations using checklists and quality of data. The field visit for key stakeholder consultation will involve eight weeks of work on the developed methodology, tools and sampling. Detail time line and scheduling of the primary survey is provided further for the selected states.

Work Plan

Task No.	Activity	Months from Start of Assignment													
		Work completed				July		August		September		October		November	
	Fortnights	*1*	*2*	*1*	*2*	*1*	*2*	*1*	*2*	*1*	*2*	*1*	*2*	*1*	*2*
Phase I	**Identification and quantification of organic waste**														
A1	Inception meeting														
A2	Literature review														
	Monthly Progress Report 1 - Identification and quantification of industrial organic waste in India			***D1***											
Phase II	**Identification of potential states**														
B1	Organic waste generation in identified sectors														
B2	Identification of four potential states														
B3	Identification of stakeholders and future course of action														
	Monthly Progress Report 2 - Identification of potential states and estimation of organic waste							***D2***							
Phase III	**Secondary data validation and sampling**														
C1	Development of questionnaire														
C2	Primary survey and site visits														
C3	Stakeholder consultations														
	Monthly Progress Report 3 - Primary Survey for data collection and selection of strategic location to set up bio-methanation plant								***D3***						
Phase IV															
D1	Collection and testing of samples														
D2	Characterisation of samples														
D3	Development of decision making matrix														
	Monthly Progress Report 4 - Collection and characterisation of various samples									***D4***					
Phase V	**Development of bio resource map**														
E1	GIS mapping of assessed parameters														
	Monthly Progress Report 5 - – Bio resource map											***D5***			
Phase VI	**National / State / Regional level conferences**														
	National level conference														
	State level conference 1 – 4														
	Monthly Progress Report 6 – Final bio resource mapping report after incorporating comments from consultations														***D6***

4.5 Resource Mobilisation Strategy

As per the requirement of the project, our team will be mobilized and start the project activities as per the detail activity scheduled. We envisage commencing the field visit in the selected states, districts and industrial units to get the information on the nature and severity of the organic waste availability and its transformation into energy.

The team of professionals will work in close consultations with various stakeholders. The team will be interacting with the stakeholders and the personnel concerned in particular of the Industry, renewable energy sector and end users.

The resource mobilisation strategy has been planned in three levels State Level, regional/District Level and End User Level. Details of these three levels are mentioned as below:

1st Step: Central Level – The 1st step includes all central level organisations. The team will commence meeting with central level agencies then move for different state level stakeholders.

2nd Step: State Level – The 2nd step includes all state level organisations. The field team will start kick-off meeting with state level nodal agency then move for different state level stakeholders. Considering this method, it will imply to all four selected states. It will help to understand their ongoing and proposed activities, policies and expectations from different stakeholders.

3rd Step: Regional/District Level- This 3rd step includes regional/district level where region/district level department will be covered. These departments are very important as they work or interact near vicinity of waste to energy plant and source of industrial waste.

4th Step: Industry & End User Level- In the 4th step, the visiting team will visit cattle farm, poultry farm, sugar industry and fruit & vegetable processing industry.

5th Step: Data Compilation - In the 5th step, all data, information and observation collected from field will be compiled and analysed.

6th Step: Stakeholder Report - In the 6th step, a detailed report based on data analysis will be prepared in view of stakeholder consultation objective for Development of a regional "Consolidated Matrix on Availability, Utilization & Pricing of Industrial Organic Waste".

4.6 Support Required from UNIDO

We will require the following support from the client during execution of the study:

- **A.** Revised authorisation letters for establishing of contacts with state and district level
- **B.** Department specific letters addressed for support consultants for smooth study
- **C.** Shortlisting of the states and districts at micro level.

4.7 Way Forward

Current report presents the snapshot of the first progress report and detailing of the four identified sectors. Cattle farm, poultry farm, sugar industry and F&V industry details have been provided in the various section with respect to location of the sectors, waste quantification, energy potential, waste characterization etc. Shortlisting

of major states for each of the sector followed with micro level region identification has been covered in detail. The report also focuses on state wise mapping of the data assessed for respective sections. Based on the state / district level mapping and data assessment, four states have been shortlisted for primary survey and stakeholder consultations.

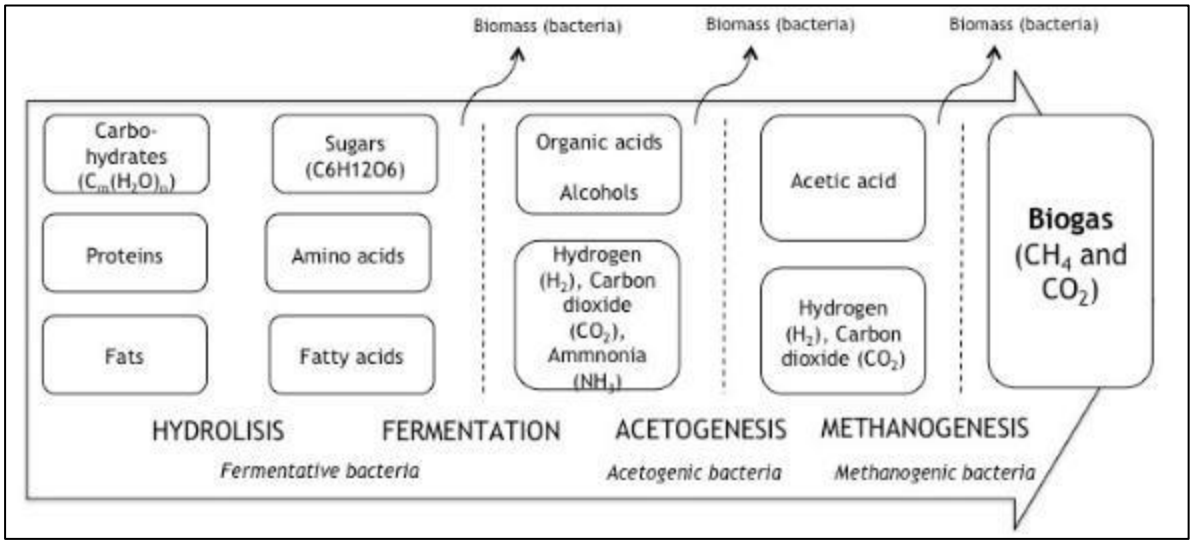
Along with sectoral details, the current report identifies key stakeholders and strategy to implement stakeholder consultation at various levels i.e. central, state, districts or regional. To make the decision-making process inclusive, representatives from all the departments / agencies / industries / technology providers / existing WTE plants have been identified for each of the shortlisted state.

Next deliverables on the project will focus on results derived from site visits and stakeholder consultations. Results of the secondary study captured for all the sectors would be validated at ground level in terms of waste quantification, regional presence, waste characterisation, waste availability, seasonal variation and current waste disposal methods. Outcomes of the primary visits, consultations and visual surveys would be summarised and presented in the next phase of the project.

Annexure 1 - Anaerobic Digestion/Bio-methanation

Anaerobic Digestion/Bio-methanation

Bio-methanation involves controlled biological degradation of organic wastes by microbial activity in the absence of oxygen. The process involves the anaerobic (without air) decomposition of wet organic wastes to produce a methane-rich biogas fuel and a small amount of residual sludge that can be used for making compost. It takes place in digester tanks or reactors, which enable control of temperature and pH levels for optimizing process control. Methane-rich gas produced is suitable as fuel for energy generation. The residual sludge is also produced, which is suitable for enriching compost materials. Input preparation or source separation is required to ensure that waste is free of non-organic contamination.



There are many different anaerobic digestion types available in the markets that vary in process configurations and operating conditions. The design considerations and operating conditions of these treatment trains may be suitable for a particular type of feedstock or feedstocks mix but may not be applicable or economical for others. That is why digester type and technology should be selected based on the indented feedstock's characteristics and availability (the amount to be treated) as well as desired output and process economy in mind.

These different anaerobic digestion (AD) types based on their feed type, operating conditions and process configuration can be classified into four different groups:

1. AD based on Digester's Feeding Mode (Continuous and Batch)
2. AD based on Feedstock's Solid Content (Dry and wet fermentation)
3. AD based on Digester's Operating Temperature (Mesophilic and Thermophilic)
4. AD based on Digester's Stages and Reactor Configuration (Single stage and Two/Multi stage)

A brief description of the types of the Anaerobic Digestion is as follows:

1. Anaerobic Digestion based on Digester's Feeding Mode

Anaerobic Digestion based on Digester's Feeding Mode are of two types:

a. Batch-load digesters which are filled all at once, sealed, and emptied when the raw material has stopped producing gas; and

b. Continuous-load digesters which are fed a little, regularly, so that gas and fertilizer are produced continuously

2. Anaerobic Digestion based on Feedstock's Solid Content

Different anaerobic digestion systems can handle waste with different dry matter (DM) and moisture contents; they are classified as dry fermentation system and wet fermentation system.

a. In dry fermentation systems, the material processed during dry AD is normally around 25 – 30% DM and has the consistency of thick porridge. In constant flow digesters this must always be mechanically stirred, not only to prevent settling and unequal pocketing, but also to assist the flow of the material through the reactor. Dry digesters are ideally suited to high DM feedstock such as energy crops, garden wastes and mechanically recovered municipal wastes in MBT plants.

b. Wet Fermentation systems - When DM concentrations are below 15% the process is described as wet. A wet digester will typically process a slurry of around 10% DM which has the consistency of thin soup and must be constantly stirred to prevent suspended solids from precipitating. Stirring is usually either mechanical in which case a rotating paddle is the preferred method, or gas, in which case the biogas given off is redirected through the substrate to ensure stirring. Wet digesters are nearly always constant flow digesters. Wet digesters are ideally suited to the processing of low DM feedstock such as farm slurries and source separated food wastes.

3. Anaerobic Digestion based on Digester's Operating Temperature

The anaerobic digestion is categorized into mesophilic and thermophilic based on the digester's operating temperature:

a. Mesophilic digestion is the most commonly used process for anaerobic digestion, in particular waste sludge treatment. Digestion takes place over a period of 15 to 40 days at a temperature of 30 to 40oC .It is usually more robust than the thermophilic process, but the biogas production tends to be less, and additional sanitization such as pasteurization is usually required.

b. Thermophilic digestion is less common and not as mature a technology as mesophilic digestion. The reactor is heated to 55 ^{o}C and held for a period of 12 to 14 days. Thermophilic digestion systems provide higher biogas production, faster throughput and an improved pathogen and virus 'kill', but the technology is more expensive, more energy is needed and it is necessary to have more sophisticated control & instrumentation.

4. AD based on Digester's Stages and Reactor Configuration (Single stage and Multi stage)

c. Single stage reactors make use of one reactor for both acidogenic phase as well as methanogenic phase. A single-stage digestion system is one in which all of the biological reactions occur within a single sealed reactor or holding tank. Utilising a single stage reduces construction costs, however facilitates less control of the reactions occurring within the system. Acidogenic bacteria, through the production of acids, reduce the pH of the tank. Methanogenic bacteria, as outlined earlier, operate in a strictly defined pH range. Therefore, the biological reactions of the different species in a single-stage reactor can be in direct competition with each other.

d. Multi stage AD processes was intended to improve digestion by having separate reactors for the different stages of AD, thus providing flexibility to optimize each of these reactions. Typically, two reactors are used, the first for hydrolysis/liquefaction-acetogenesis and the second for methanogenesis. In a two-stage or multi-stage digestion system, different digestion vessels are optimised to bring maximum control over the bacterial communities living within the digesters. Acidogenic bacteria produce organic acids and more quickly grow and reproduce than methanogenic bacteria. Methanogenic bacteria require stable pH and temperature in order to optimise their performance.Under typical circumstances, hydrolysis, acetogenesis, and acidogenesis occur within the first reaction vessel. The organic material is then heated to the required operational temperature (either mesophilic or thermophilic) prior to being pumped into a methanogenic reactor. The initial hydrolysis or acidogenesis tanks prior to the methanogenic reactor can provide a buffer to the rate at which feedstock is added.

Annexure 2 – Questionnaires for stakeholder consultation

A. State Renewable Energy Department

The State Renewable Energy Department is the nodal agency for all matters relating to new and renewable energy for the state. The broad aim of the department is to develop and deploy new and renewable energy for supplementing the energy requirements of the state. The objective of consultations with the department is to understand the current scenario in WTE sector, state government policies and issues related to the sector.
The expected outcome of the discussion would be collecting information about the state government policies for organic waste, planning & intervention in this sector, availability of raw material for WTE plant in the state, financial & technological assistance provided to the sector and to collect data of selected sector in terms of location/quantum available with the department.

1. Name of the department?
2. Name & designation of the Official contacted?
3. What is the department's role & responsibility for promoting organic WTE? (particularly in selected four sectors)
4. Does the department have separate division dealing with organic waste?
5. Is there any seasonal variation of availability of organic waste? (If yes, list the details)?
6. Total number of WTE plant operational in the state? (collect data of all WTE operational plant)
7. What are the other state government departments working on WTE on organic waste?
8. What type of technology available in WTE plants in the state?
9. What is ratio of waste mixing for feeding the WTE plants?
10. What kind of technological assistance central govt provides to state for promoting WTE through organic waste?
11. What are the main concerns related to utilization of organic waste?
12. Share the list of technology providers in the state.
13. What kind of financial assistance central govt provides to state for promoting WTE through organic waste?
14. Name the departments providing financial assistance for WTE development.
15. What are the financial institutions providing loan in WTE sector with their terms & conditions?
16. What are the terms and conditions (eligibility) for providing financial assistance?
17. Share the total financial assistance provided to
    i. State government by Central government/other agencies
    ii. To different sectors in WTE by state government

18. What types of permits or approvals are required for setting up WTE project in the state?
19. What kind of state policies to support for promotion of WTE through organic waste?
20. Does the state have any action plan for development of WTE sector?
21. Does the state have any policy for performance based incentive in WTE sector?
22. Does the state have any policy for developing Public Private Partnership in the WTE sector?
23. Does any legislation in the state for WTE sector?
24. What are the research and development policy of state in WTE sector?
25. Suggestions / strategies and methods adopted for improving new and renewable energy sector?

B. Agriculture/Horticulture Department

The Agriculture/Horticulture Department is the nodal agency for development of agriculture/horticulture in the state. The objective of consultations with the department is to understand the current scenario of production of fruit & vegetable, commercialisation/ value addition of fruit & vegetable particularly through food processing industry in the state.

The expected outcome of the discussion would be collecting information about the type of fruit & vegetable grown in the state, area/extension of fruit & vegetable cultivated, quantum of production of fruit & vegetable, Seasonal variation of availability of F&V, Storage of F&V, any linkage of grown F& V to Fruit Processing Industry, marketable surplus of fruits and vegetables in the State

1. Name of the department?
2. Name & designation of the Official contacted?
3. List of fruits & vegetables used in processing in the state/region/district.
4. What are the seasonal variation of cultivation & harvesting of fruits & vegetables used in processing in the state/region/district?
5. Is sufficient cold storage / warehouse available for storage of fruits & vegetables?
6. What percentage of grown fruits & vegetables and sugarcane has been processed?
7. Suggestions / strategies on organic waste.

C. Food Processing / Agricultural Department / District Industries Centre

The objective of visiting district level Food processing/Agriculture Department/ District Industries Centre because it takes care of agriculture/Micro Small and Medium Enterprises of the district by providing incentives and financial assistance to the aspiring and existing entrepreneurs. The department has better understanding of industrial scenario in the district.

The expected outcome would be collecting information about the type of fruit & vegetable processed in the district, catchment area of the industry, quantum of fruit & vegetable processed and waste generated, seasonal variation of availability of F&V, supply chain of the processing Industry and technological/financial support for WTE.

1. Name of the department?
2. Name & designation of the official contacted?
3. What are numbers of fruit & vegetable processing/ sugar units operational in the state/region/district
4. Provide the list of fruits & vegetables used in processing in the state/region/district.
5. What are the seasonal variation of availability of sugarcane/fruits & vegetables used in processing in the state/region/district?
6. What is the quantum of sugarcane/ fruit & vegetable processed in the state/region/district?
7. How much industrial organic waste is generated from these industry?
8. What are the methods of disposal of industrial organic waste?
9. Is the industrial organic waste is sold to WTE plant? If yes, detail out the list of WTE plants?
10. What percentage of industrial organic waste is used in WTE?
11. On what cost the industrial organic waste is sold to WTE plant?
12. What kind of state policies available to support for promoting WTE through organic waste?
13. Suggestions / strategies and methods adopted for improving new and renewable energy sector?

D. Poultry/ Animal Husbandry Department

The Animal Husbandry Department is the nodal agency for providing services for matters relating to livestock/poultry production, protection & improvement of stocks and dairy development in the state. The department also formulates policies and programmes in the field of animal husbandry. The objective of consultations with the department is to understand the growth & development in the sector, availability & commercialisation of cow dung and poultry litter and its linkages with WTE plant.

The expected outcome of the discussion would be collecting information about the number of cattle & cattle farm, number of poultry & poultry in farm sector, spread of cattle/poultry farm in the state and quantum of cow dung & poultry litter available in the state.

1. Name of the department?

2. Name & designation of the official contacted?

3. What are the total number of cattle/ poultry & cattle/ poultry farm in the state/region/district?

4. Quantum of waste generated in the farm in the state/region/district?

5. What is the method of calculating quantum of waste?

6. What is the current method of disposal of waste generated in the farm? Also tell about the previous method?

7. What types of permits or approvals are required for setting up cattle farm/poultry farm?

8. What are the policies of central/state government for providing assistance to cattle farm/poultry farm contributing organic waste to WTE?

9. Suggestions / strategies and methods adopted for maximum utilization of organic waste from cattle farm/poultry farm?

E. Existing WTE Plant

The objective of visiting WTE plant to understand practical modality, economically viable and sustainability of the plant. energy access. The expected outcome of the discussion would Factors for setting the WTE plant at this location, Seasonal variation of availability of organic waste, kind of technology is used for generation of energy, kind of support (technology/financial) from central/state Govt., permits or approvals required for setting WTE plant, type of consumers (Industrial/HH) of energy and commercial viability for setting WTE Plant.

1. Name & location of the Waste to Energy Generation Plant
2. Name & designation of the person contacted
3. Year of establishment of waste to energy plant
4. Installed and operating capacity of the plant
5. Organic waste used as a feedstock in the plant
6. Characteristics of organic waste used as a feedstock in the plant
7. Factors for setting the WTE plant at this location
8. What is the catchment area of organic waste availability and supplying energy to end users?
9. Do the catchment area have enough animal manure/fruit & vegetable industrial waste/ poultry litter/ press mud to fuel an energy recovery project?
10. What quantity of feedstock supply is required for the facility to operate effectively to WTE plant?
11. How the quantum of available organic waste is calculated in the area?
12. Is there any seasonal variation of availability of organic waste?
13. The cost of organic waste at the source and at the WTE plant?
14. Does collected organic waste require pre-treatment for the waste to energy facility? If yes, list the details.
15. What kind of technology is used for generation of energy?
16. Generated energy is used in industry (as a captive power plant) or supplied to grid.
17. What type of consumers of energy, if it is supplied to nearby areas,
    a. Household
    b. Industrial
    c. Commercial
18. Detail out the total number of consumers in each type.
19. The energy charge taken from consumers from different type?

20. Is there any variation between demand and supply in the area? (for the entire year)
21. How much quantum of waste generated in the industry?
22. What are the disposal methods of waste generated in the industry?
23. What is the capital cost and operating cost of the WTE plant?
24. What types of financing are available for the project?
25. What types of permits or approvals are required for setting up the project?
26. What is the payback period of the project?
27. How much is the Operation & Management cost of the plant
28. Suggestions / strategies and methods adopted for improving WTE sector?

F. Industry Association

Industry association is a collective organization of industries registered/operational in the state. The association deals to safeguard the interest of their member industries and engage themselves in negotiations with government bodies. The objective of discussion with industry association is to understand the view of industries in terms of current issues and suggestion on government policies for development of WTE sector.
The expected outcome of the discussion would be to get information about number of agro industries in the state, quantum of processed food & industrial waste/effluent generated, policies related to safe disposal of industrial waste/effluent, policies related to WTE and technological/Financial support for WTE.

1. Name of the Industry Association?
2. Name & designation of representative contacted?
3. What types of financing are available for the setting cattle farm/ poultry farm/ fruit & vegetable industry/ sugar industry (press mud)?
4. What types of permits or approvals are required for setting cattle farm/ poultry farm/ fruit & vegetable industry/sugar industry (press mud)?
5. What kind of policies/assistance provided by Central/State government for setting cattle farm/ poultry farm/ fruit & vegetable industry/sugar industry (press mud)?
6. Suggestions / strategies and methodology adopted for sale/disposal of organic waste?

G. Cattle Farm/ Poultry farm

The objective of consultations with cattle & poultry farm is to grass root reality of the sector, availability & commercialisation of cow dung and poultry litter and its linkages with WTE plant.

The expected outcome of the discussion would be collecting information about the number of cattle & cattle, quantum of cow dung & poultry litter available, transportation etc.

1. Name & location of the Cattle Farm/ Poultry farm?
2. Name & designation of representative contacted?
3. Year of establishment of cattle farm/ poultry farm
4. What is the total number of cattle/ poultry in the farm?
5. Quantum of waste generated in the farm?
6. What is the method of calculating quantum of waste?
7. What is the current method of disposal of waste generated in the farm ? Also tell about the previous method?
8. How much percentage of generated organic waste is sold to WTE plant?
9. What is the mode of transportation of organic waste?
10. The cost of animal manure/ poultry litter sold to WTE plant?
11. What types of permits or approvals are required for setting up cattle farm/poultry farm?
12. What kind of assistance (financial or technological) provided from central/state government?
13. What are the policies of central/state government for providing assistance to cattle farm/poultry farm contributing organic waste to WTE?
14. Suggestions / strategies and methods adopted for maximum utilization of organic waste from cattle farm/poultry farm?

H. Fruit & Vegetable Processing Industry/ Sugar Industry

The Food Processing/Fruit & Vegetable Processing/ Agro Processing Department is the nodal agency for development of agro industry in the state. The objective of consultations with the department is to understand the current scenario of fruit & vegetable processing, factors behind development of Fruit & Vegetable Processing Industry and industrial effluent management.

The expected outcome of the discussion would be collecting information about the type of fruit & vegetable processed in the state, catchment area of the industry, quantum of fruit & vegetable processed and waste generated, management of industrial waste, seasonal variation of availability of F&V, supply chain of the processing Industry and technological/financial support for WTE.

1. Name & location of the Fruit & Vegetable Processing Industry/ Sugar Industry?
2. Name & designation of representative contacted?
3. Year of establishment of Fruit & Vegetable Processing Industry/ Sugar Industry
4. What is the installed and operational capacity of the plant?
5. What type of raw material is used in the industry? (for Fruit & vegetable Industry)
6. Total quantum of raw material handled in the industry.
7. Total quantum of waste generated in the industry?
8. What is the characteristics of organic waste generated in the industry?
9. What is the current method of disposal of waste generated in the industry? Also tell us about the previous method?
10. How much percentage of total generated organic waste is sold to WTE plant?
11. What is the mode of transportation of organic waste?
12. On what cost the fruit & vegetable industrial waste/ press mud is sold to WTE plant?
13. What are the policies of central/state government for providing assistance to industries contributing organic waste to WTE?
14. Suggestions / strategies and methods adopted for maximum utilization of organic waste generated in in your plant?

I. Research Institute

The objective of consultations with the research institute is to understand the research and development of organic waste of selected sector, potentiality of organic waste to generate energy.

The expected outcome of the discussion would be collecting information about the characteristics of raw material and organic waste of selected sector, catchment area, technology used to get WTE of organic waste.

1. Name of the Research Institute?
2. Name & designation of representative contacted?
3. Does the institution undertake any R&D activities on organic wastes? (list the details of organic waste)
4. What is the characteristics of organic waste (for selected sector)?
5. What is the calorific value of the organic waste and quantity of bio gas generated from it?
6. What kind of technology used to get WTE in the state/region/district?
7. Suggestions / strategies and methods adopted for maximum utilization of organic waste?

J. Focus Group Discussion – End User

The objective of interaction with community is to understand their perspectives in terms of availability of power & their role in contribution of WTE.

The expected outcome of the discussion would be various factors affecting end consumer such as frequency of the energy supplied, disruptions in the supply, energy charges, changes in the energy pricing, willingness to continue and any other issues faced by the community.

1. Name of the head of the household
2. Address of the household
3. Prime occupation of the household
4. What is the source of energy of their household?
5. Do they contribute/sale raw material to waste to energy generation plant?
6. If yes, which kind of raw material available at their household level?
7. How much time they have electricity?
8. Is there any seasonal variation in supply of electricity?
9. How much electricity bill is paying per month & Rs./unit?
10. What are the other benefits of waste to energy plant/electricity?

Annexure 3 – List of cattle breeding farm / semen bank / livestock farm / dairy farm

Sl. No.	State	District	Cattle breeding farm / semen bank / livestock farm / dairy farm
1	Andhra Pradesh	Guntur	Buffalo Breeding Centre
2	Andhra Pradesh	Kurnool	Cattle breeding farms, Govt of AP, Directorate of Animal Husbandry
3	Andhra Pradesh	Cuddapah	Frozen semen bank - Govt of AP, Directorate of Animal Husbandry
4	Andhra Pradesh	Krishna	Frozen semen bank - Govt of AP, Directorate of Animal Husbandry
5	Andhra Pradesh	Hyderabad	Frozen semen bank - Govt of AP, Directorate of Animal Husbandry
6	Andhra Pradesh	Karimnagar	Frozen semen bull station - Govt of AP, Directorate of Animal Husbandry
7	Andhra Pradesh	Nellore	Frozen semen bank - Govt of AP, Directorate of Animal Husbandry
8	Andhra Pradesh	Chittoor	Frozen semen bank - Govt of AP, Directorate of Animal Husbandry
9	Andhra Pradesh	Medak	Frozen semen bank - Govt of AP, Directorate of Animal Husbandry
10	Andhra Pradesh	Kurnool	Frozen semen bull station - Govt of AP, Directorate of Animal Husbandry
11	Andhra Pradesh	Nalgonda	Frozen semen bank - Govt of AP, Directorate of Animal Husbandry
12	Andhra Pradesh	Nizamabad	Frozen semen bank - Govt of AP, Directorate of Animal Husbandry
13	Andhra Pradesh	Prakasam	Frozen semen bank - Govt of AP, Directorate of Animal Husbandry
14	Andhra Pradesh	East Godavari	Frozen semen bank - Govt of AP, Directorate of Animal Husbandry
15	Andhra Pradesh	Anantapur	Frozen semen bank - Govt of AP, Directorate of Animal Husbandry
16	Andhra Pradesh	Srikakulam	Frozen semen bank - Govt of AP, Directorate of Animal Husbandry
17	Andhra Pradesh	West Godavari	Frozen semen bank - Govt of AP, Directorate of Animal Husbandry
18	Andhra Pradesh	Chittoor	Frozen semen bank - Govt of AP, Directorate of Animal Husbandry
19	Andhra Pradesh	Visakhapatnam	Frozen semen bull station - Govt of AP, Directorate of Animal Husbandry
20	Andhra Pradesh	Warangal	Frozen semen bank - Govt of AP, Directorate of Animal Husbandry
21	Andhra Pradesh	Khammam	Frozen semen bank - Govt of AP, Directorate of Animal Husbandry
22	Andhra Pradesh	Guntur	Jersey farm - Andhra Pradesh dairy development coop. federation ltd
23	Andhra Pradesh	Chittoor	Chamarthi Dairy Farm
24	Andhra Pradesh	Hyderabad	Military Farm
25	Andhra Pradesh	Chittoor	Yasoda Dairy Farm
26	Andhra Pradesh	Guntur	Ongole Cattle Breeding Project
27	Arunachal Pradesh	Dibang valley	Cattle breeding farm - Directorate of Animal Husbandry & Vet. Services
28	Arunachal Pradesh	Changlang	Cattle breeding farm - Directorate of Animal Husbandry & Vet. Services
29	Arunachal Pradesh	Upper subansiri district	Cattle breeding farm - Directorate of Animal Husbandry & Vet. Services
30	Arunachal Pradesh	Kameng	Cattle breeding farm - Directorate of Animal Husbandry & Vet. Services
31	Arunachal Pradesh	Tawang	Cattle breeding farm - Directorate of Animal Husbandry & Vet. Services
32	Arunachal Pradesh	West siang	Cattle breeding farm - Directorate of Animal Husbandry & Vet. Services
33	Arunachal Pradesh	East siang	Cattle breeding farm - Directorate of Animal Husbandry & Vet. Services
34	Arunachal Pradesh	Lower dibang valley district	Cattle breeding farm - Directorate of Animal Husbandry & Vet. Services
35	Arunachal Pradesh	Siang	Cattle breeding farm - Directorate of Animal Husbandry & Vet. Services
36	Arunachal Pradesh	Lohit	Cattle breeding farm - Directorate of Animal Husbandry & Vet. Services
37	Assam	Kamrup	Cattle breeding farm - Assam agricutural university
38	Assam	Barpeta	Livestock farm - Government of Assam, AH &Vet. Dept
39	Assam	Kamrup	Livestock farm - Government of Assam, AH &Vet. Dept
40	Assam	Sibsagar	Livestock farm - Government of Assam, AH &Vet. Dept
41	Assam	Dibrugarh	Livestock farm - Government of Assam, AH &Vet. Dept
42	Assam	Darrang	Livestock farm - Government of Assam, AH &Vet. Dept
43	Assam	Cachar	Frozen semen bank - Government of Assam, AH & Vet. Dept
44	Bihar	Buxar	Cattle breeding farm - Animal Husbandry Deptt. Bihar

Sl. No.	State	District	Cattle breeding farm / semen bank / livestock farm / dairy farm
45	Bihar	Bhagalpur	Hariana cattle breeding farm, frozen semen banks - Animal Husbandry Deptt.
46	Bihar	Muzaffarpur	Hariana cattle breeding farm, frozen semen banks - Animal Husbandry Deptt.
47	Bihar	Patna	Hariana cattle breeding farm, frozen semen banks - Animal Husbandry Deptt.
48	Bihar	Purnea	Hariana cattle breeding farm, frozen semen banks - Animal Husbandry Deptt.
49	Bihar	Ranchi	Hariana cattle breeding farm, frozen semen banks - Animal Husbandry Deptt.
50	Bihar	Patna	Exotic Cattle Breeding Farm - Govt. of Bihar
51	Bihar	Misamari	Military Farm
52	Chhattisgarh	Durg	Bull Mother Experimental Farm
53	Goa	South Goa	Livestock farm - Govt. of Goa, Animal Husbandry
54	Gujarat	Anand	Breeding farm - Amul research and development association
55	Gujarat	Junagadh	Cattle breeding farm, Frozen semen bank
56	Gujarat	Surat	Central cattle breeding farm (GOI)
57	Gujarat	Rajkot	Gayatri buffalo breeding farm
58	Gujarat	Surat	Semen bank - Department of Animal Husbandry - Government of Gujarat
59	Gujarat	Sabar kantha	Semen bank - Department of Animal Husbandry - Government of Gujarat
60	Gujarat	Mehsana	Semen bank - Department of Animal Husbandry - Government of Gujarat
61	Gujarat	Rajkot	Frozen semen bull station - Department of Animal Husbandry - Government of Gujarat
62	Gujarat	Vadodara	Semen bank - Department of Animal Husbandry - Government of Gujarat
63	Gujarat	Rajkot	Akshar purushottam mandir gaushala
64	Gujarat	Mehsana	Agro consumer products, cattle breeding, oil mill - Asha agro consumer sansthan
65	Gujarat	Sanand	BAIF - Magazari farm
66	Gujarat	Kutch	Bidda pinjrapole and gaushala
67	Gujarat	Kheda	Bochasanwasi shree akshar purushottam gaushala trust
68	Gujarat	Ahmedabad	Godhneshwar farm
69	Gujarat	Anand	Semen production centre - Kaira district co-operative milk producer's union ltd
70	Gujarat	Bhavnagar	Lok bharti gaushala
71	Gujarat	Mehsana	Mansa gaushala trust
72	Gujarat	Kheda	Sabarmati ashram gaushala
73	Gujarat	Rajkot	Shri bhuvaneshwari pith gaushala
74	Haryana	Wardha	Cattle breeding institute
75	Haryana	Hisar	State cattle breeding project
76	Haryana	Jind	Abhimanya dairy farm
77	Haryana	Hisar	Government live farm hisar
78	Haryana	Karnal	Gupta dairy farm
79	Haryana	Bhiwani	Shree gaushala trust
80	Haryana	Jind	Shree gaushala
81	Haryana	Panipat	Shree gaushala society
82	Himachal Pradesh	Mandi	Frozen semen bank - Government of Himachal Pradesh
83	Himachal Pradesh	Shimla	Frozen semen bank - Government of Himachal Pradesh
84	Himachal Pradesh	Sirmur	Department of cattle breeding farms - Government of Himachal pradesh
85	Himachal Pradesh	Kangra	Cattle breeding farm - Government of Himachal Pradesh
86	Himachal Pradesh	Bilaspur	Cattle breeding farm - Government of Himachal Pradesh
87	Himachal Pradesh	Sirmur	Cattle breeding farm - Government of Himachal Pradesh
88	Himachal Pradesh	Mandi	Cattle breeding farm - Government of Himachal Pradesh
89	Himachal Pradesh	Mandi	Cattle breeding farm - Government of Himachal Pradesh
90	Himachal Pradesh	Mandi	Indo-German cattle breeding farm
91	Himachal Pradesh	Kangra	Jersey cattle breeding farm
99	Himachal Pradesh	Solan	Military Farm
92	Jammu & Kashmir	Changspa Leh	Govt. Farms Cattle Breeding cum Research Farm
93	Jammu & Kashmir	Ranbirbagh	Semen Bull Station Frozen Semen Project

Sl. No.	State	District	Cattle breeding farm / semen bank / livestock farm / dairy farm
94	Jammu & Kashmir	Leh	Bull Mother Farms
95	Jammu & Kashmir	Kargil	Bull Mother Farm
96	Jharkhand	Hazaribagh	Gauriakarma Exotic Cattle Breeding Project
97	Jharkhand	Ranchi	Military Dairy Farm
98	Jharkhand	Ranchi	Milk Supply-cum-Dairy Farm
100	Karnataka	Chickmagalore	Amrithmahal Cattle Breeding Station
101	Karnataka	Tumkur	Hallikar Cattle Breeding Station
102	Karnataka	Dharwad	Khillar Cattle Breeding Station
103	Karnataka	Bangalore North	Central Cattle Breeding Farms
104	Karnataka	Bidar	Dairy Cattle Breeding Station, Veterinary College,
105	Karnataka	Bangalore	Dairyteck;Breeding & Management of Cows and Buffaloes.
106	Karnataka	Bangalore	State Livestock Breeding and Training Centre
107	Karnataka	Dharwad	Livestock Breeding Farm
108	Karnataka	Raichur	Livestock Breeding Farm,
109	Karnataka	Bangalore	Nandini Sperm Station
110	Karnataka	Koila, D. K.	Semen Collection Centre, Livestock Breeding Farm
111	Karnataka	Bangalore	State Semen Collection Centre and Livestock Breeding Farm,
112	Karnataka	Bangalore	Vishvaneedam Dairy Farm
113	Kerala	NA	Buffalo Breeding Farm, Kuriottumala
114	Madhya Pradesh	Sajapur	Cattle Breeding Farm, Agar
115	Madhya Pradesh	NA	Cattle Breeding Farm Gadhi Balaghat
116	Madhya Pradesh	NA	Cattle Breeding Farm Imlikheda Chindwara
117	Madhya Pradesh	NA	Cattle Breeding Farm Minora Tikamgarh
118	Madhya Pradesh	NA	Cattle Breeding Farm Ratona Sagar
119	Madhya Pradesh	Bhopal	Cattle Breeding Farm Bhadbhada
120	Madhya Pradesh	Shajapur	Cattle Breeding Farm
121	Madhya Pradesh	Khargaon	Cattle Breeding Farm
122	Madhya Pradesh	Jabalpur	Bull Rearing Farm Amanala
123	Madhya Pradesh	Indore	Kasturbagram Krishi Kshetra (Goshala)
124	Maharashtra	Parbhani	Cattle Cross Breeding Project, Veterinary College
125	Maharashtra	Amravati	Deptt. of Animal Husbandry-Cattle Breeding Farm
126	Maharashtra	Nagpur	Frozen Semen Banks-Nagpur (Frozen Semen Bull Station)
127	Maharashtra	Pune	Pune (Frozen Semena Bull Station)
128	Maharashtra	Amravati	Bull Mother Farms
129	Maharashtra	Pune	Military Farms
130	Manipur	Senapati	Regional Crossbreed Cattle Breeding Farm
131	Manipur	NA	Frozen Semen Bull Station, Prompat
132	Meghalaya	Ri Bhoi	Regional Cross bred Cattle Breeding Project, Kyrdemkulai,
133	Meghalaya	Jaintia Hills	Cattle Farm, Khliehtyrshi
134	Meghalaya	West Garo Hills	Cattle Farm, Rongkhon
135	Meghalaya	East Garo Hills	Songsak (Buffalo Farm)
136	Nagaland	Kohima	Directorate of Veterinary & A.H., Regional Cattle Breeding Farm
137	Odisha	Sambalpur	Central Cattle Breeding Farm
138	Odisha	Koraput	Central Cattle Breeding Farms
139	Odisha	Sambalpur	Exotic Cattle Breeding Farm
140	Odisha	Cuttack	Livestock Breeding Farm
141	Punjab	Amritsar	Frozen Semen Banks-cum-Bull Stations
142	Punjab	Ludhiana	Buffalo and Cattle Breeding Farms.
143	Punjab	Amritsar	Amritsar Pinjrapole Gaushala (Regd.),
144	Punjab	Nabha	DK-AI Centre & Semen Bank
145	Punjab	Patiala	Exotic Cattle farms

Sl. No.	State	District	Cattle breeding farm / semen bank / livestock farm / dairy farm
146	Punjab	Ludhiana	Sahiwal Cattle Farm,
147	Punjab	Amristar	Josan Dairy Farm,
148	Punjab	Birsarangwal	Military Farms
149	Rajasthan	Sriganganagar	Central Cattle Breeding Farms
150	Rajasthan	Jaisalmer	Government of Rajasthan, AH Dept.-Cattle Breeding Farms
151	Rajasthan	Sri Ganga Nagar	Gurudesh Cattle Breeding Farm
152	Rajasthan	Jaipur	SKN College of Agriculture Dairy Farm
153	Tamil Nadu	Avadi	Central Cattle Breeding Farms
154	Tamil Nadu	Thanjavur	Exotic Cattle Breeding Farm
155	Tamil Nadu	Krishnagiri	District Livestock Farm
156	Tamil Nadu	Tirunelveli	District Livestock Farm
157	Tamil Nadu	Nilgiris	District Livestock Farm
158	Tamil Nadu	Pudukottai	District Livestock Farm
159	Tamil Nadu	Thanjavur	District Livestock Farm
160	Tamil Nadu	Sivagangai	District Livestock Farm,
161	Tamil Nadu	Thiruvarur	Livestock Farm
162	Tamil Nadu	Kodivalli	District Livestock Farm
163	Tamil Nadu	Jamunapari	District Livestock Farm
164	Tamil Nadu	Jamunapar	District Livestock Farm
165	Tamil Nadu	Jamunapari	District Livestock Farm
166	Tamil Nadu	Jamunapari,	Livestock Farm
167	Tamil Nadu	Periyar	Buffalo Frozen Semen Bank
168	Tamil Nadu	Salem	Subam Dairy Farms
169	Tamil Nadu	Nilgiris	Nucleus Jersey & Stud Farm (Bull Mother Farm)
170	Tripura	Radha-kishorepur	Cattle Breeding Farm
171	Tripura	Noagaon, Tripura (W).	Frozen Semen Bull Station
172	Uttar Pradesh	Rae Bareli	Animal Breeding Centre (Unit of the National Dairy Dev. Board),
173	Uttar Pradesh	Kanpur	Model Dairy Cattle Breeding Farm
174	Uttar Pradesh	Kanpur	Govt. Cattle Breeding & Dairy Farm
175	Uttar Pradesh	Lakhimpurkheri	Central Cattle Breeding Farms
176	Uttar Pradesh	Kanpur	Bull Mother Farm
177	Uttar Pradesh	Agra.	Military Farms
178	West Bengal	Nadia	Frozen Semen Bull Station & LN Plant,
179	West Bengal	Paschim Medinipur	Frozen Semen Bull Station & LN Plant,
180	West Bengal	Murshidabad	Frozen Semen Bull Station
181	West Bengal	Kolkata	Central Semen Bank Central Spare Parts Depot Regional Kit Bank LN Plant Belgachia -I & II,
182	West Bengal	Nadia	Frozen Semen Bull Station & LN Plant, Haringhata
183	West Bengal	Paschim Medinipur	Frozen Semen Bull Station & LN Plant, Salboni
184	West Bengal	Murshidabad,	Frozen Semen Bull Station
185	West Bengal	Panagarh	Military Farms

UNITED NATIONS
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