Energy generation potential for Member States, barriers and challenges for implementation and recommendations

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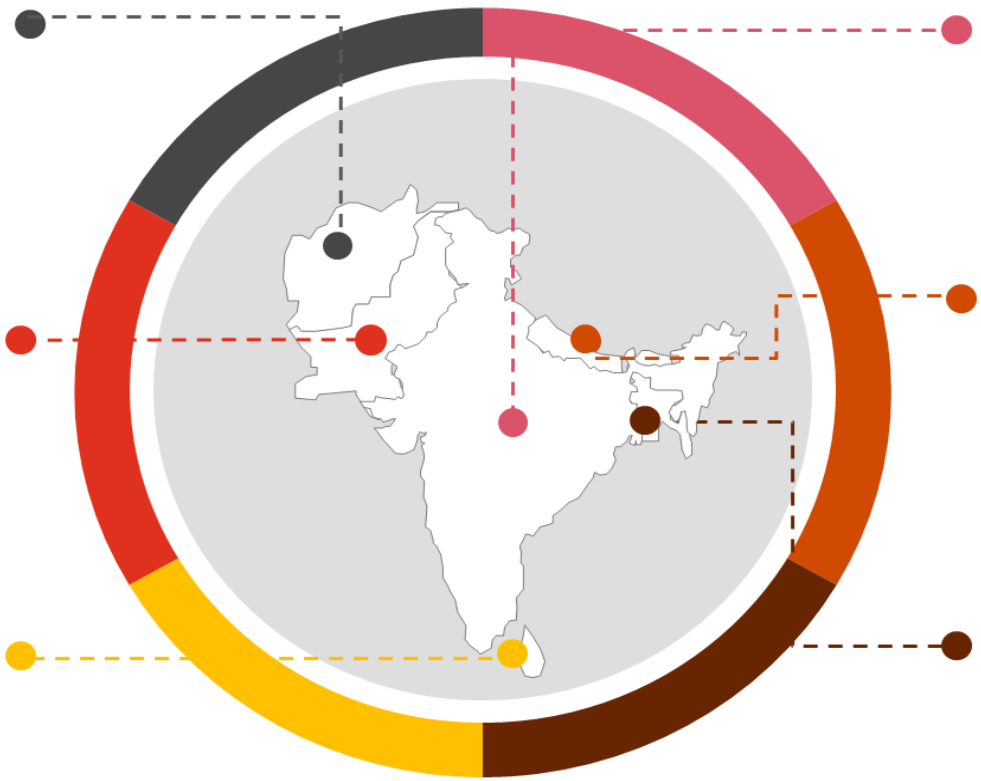
Power generation potential of SAARC countries*

India has the highest potential for power generation (5,395 MW), followed by Bangladesh (1,100 MW) and Pakistan (834 MW)

Power generation potential of SAARC Member States using rice and wheat straw residue



Afghanistan (58 MW)
Surplus Residue: 1.4 Million Tonnes

Pakistan (834 MW)
Surplus Residue: 13 Million Tonnes

Sri Lanka (71 MW)
Surplus Residue: 1 Million Tonnes

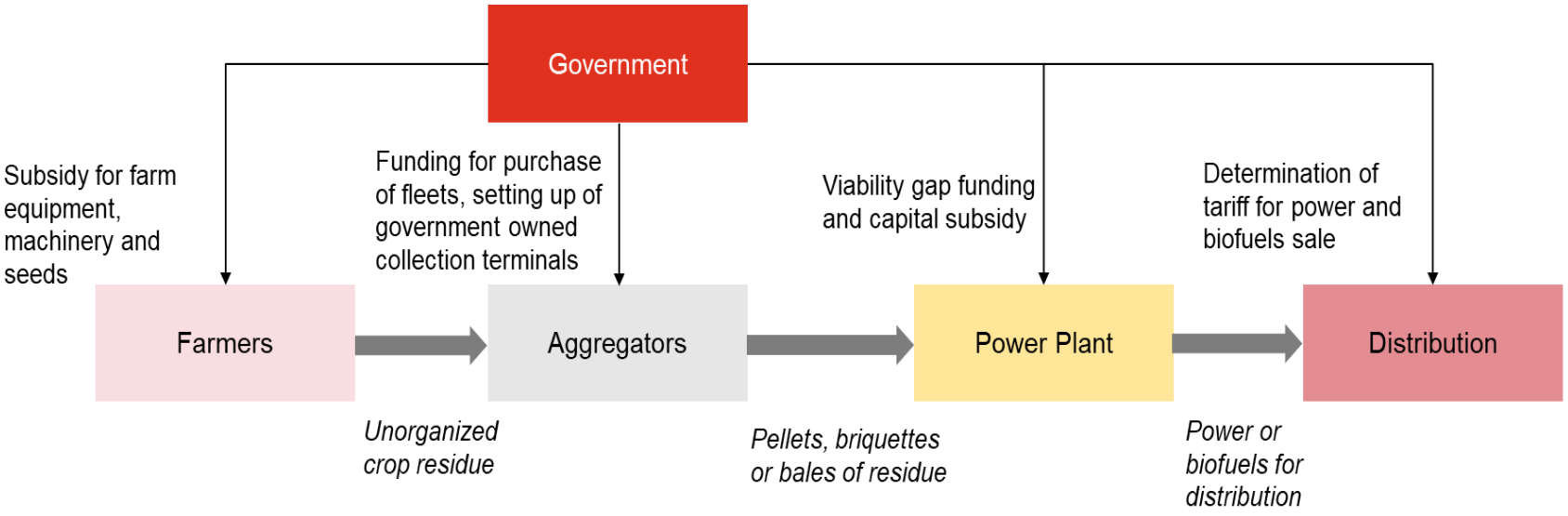
India (5,395 MW)
Surplus Residue: 80.3 Million Tonnes

Nepal (140 MW)
Surplus Residue: 3 Million Tonnes

Bangladesh (1,100 MW)
Surplus Residue: 15.6 Million Tonnes

Business Model for energy generation

Most common business model comprises of five key bodies: farmers, aggregators, power plant developer, distribution companies and the respective government



STAKEHOLDERS

Farmers	Aggregators	Power Plant	Distribution
• Farmers • Farmer associations • Government	• Private parties • Local entrepreneurs • NGOs • MSMEs • Power plant developer	• Private developer • Public sector developer • Local entrepreneurs • Government	• Distribution companies • Private plant owner • Oil companies • Regulatory body

Commercial aspects of gasification (1/4)

Case study of Punjab state of India

Introduction

- The commercial aspects of setting up biomass gasifier power plants in the Indian State of Punjab has been considered for illustration purpose.
- Punjab is one of the highest producers of rice, wheat and sugarcane in the country. The State is heavily dependent on rice-wheat cropping system and produces a huge quantity of crop residue.
- The rice stubble is burnt in the fields in the months of October-November within a period of 2-3 weeks for an economical and quick alternative to prepare the fields for the sowing of wheat. The farmers also complain of very high labor cost to manually remove the straw and stubble from fields.

Methodology: Rice and wheat production for the year 2018-19 in all the districts of Punjab has been considered for the study. The gross residue and surplus residue generation have been computed for all the districts to formulate an implementation plan.

Power generation potential calculation:

Annual power generation potential = (Total Surplus crop residue) x (Collection Efficiency) / (365 x 24 x P)

P= Tonnes of biomass required to produce 1 MW of electricity

Power Generation Potential of Punjab using only farm residue

Crops	Production (000 Tonnes)	Residue type	RPR	Gross Residue (000 Tonnes)	Surplus Residue (000 Tonnes)	Biomass Consumption ratio (P)	Power Generation Potential (MW)
Wheat	17,830	straw	1.5	26,745	5,884	1.4	360
Rice	19,136	straw	1.5	28,704	8,037	1.2	573
Total	**36,966**			**55,449**	**13,921**		**933**

Commercial aspects of gasification (2/4)

Case study of Punjab state of India

Technology Selection

Biomass gasification technology has been chosen for power generation due to its ability to work with a large range of residue type and size and wide operational range that can be scaled up from smaller capacities at a village level installation to larger capacities at a regional or zonal level.

Cost of residue

- The cost of procuring from farmers and mills is around 43 – 57 USD per tonne.
- The CERC* has determined a base price of USD 54/Tonne for rice and wheat-based crop residues which has been considered for development of model.

Size of plant

It is recommended to implement biomass- gasifier plants of 10 MW each in different locations in the State to take advantage of lower transport cost and local labor for plant operations.

Collection Centers

- Recommended to set up multiple collection points in different districts.
- Capacity to store between 5,000 tonne - 10,000 tonne of rice husk and straw residue.
- Recommended to have collection centers within 20 km of nearby farms.

Suggested Collection Centers for residue collection and storage in tonnes

Region	Residue that can be stored (75% collection efficiency)	Residue that can be stored (100% collection efficiency)
North	723,000	964,000
East	844,000	1,125,000
West	1,447,000	1,929,000
South	1,266,000	1,688,000
Central	1,748,000	2,331,000
Total	**6,028,000 Tonnes**	**8,037,000 Tonnes**

Commercial aspects of gasification (3/4)

Case study of Punjab state of India

Sale of power:

- 100% household electrification achieved in Punjab, which will add substantially to the energy demand of the State.

Capital cost:

- Capital cost of USD 846,970/MW has been assumed as per CERC guidelines for FY 2019-20 for biomass gasifier plants.
- Capital subsidy of USD 214,285/MW is provided by the MNRE* which further reduces the capital cost of installation to USD 632,685/MW.

Financial assumptions:

- Debt: Equity ratio of 70:30 has been considered as per industry standards.
- Cost of funds has been anticipated at 10.4% and a discount factor of 10% has been considered.

Operation and maintenance:

- The O&M cost has been considered at USD 70,000/MW with an escalation of 3% over the useful life of the project.

Commercial details of the commercial model for 10 MW biomass-gasifier plant

Particular	Unit	Without Capital Subsidy	With Capital Subsidy
Capital Cost	USD Mn	8.47	6.33
Debt	USD Mn	5.93	4.43
Equity	USD Mn	2.54	1.90
First year: Fixed cost (A)	USD/kWh	0.035	0.029
First year: Variable Cost (B)	USD/kWh	0.048	0.048
First year: Total tariff (A+B)	USD/kWh	0.08	0.08
First year: Revenue	USD Mn	5.53	5.53
Levellized tariff for 20 years	USD/kWh	0.0825	0.0825
Debt repayment period	Years	14	14
Breakeven period	Years	7	4

Commercial aspects of gasification (4/4)

Case study of Punjab state of India

Cluster-wise implementation plan for Punjab State

Particular	North	East	West	South	Central
Number of 10 MW biomass-gasifier power plants	7	8	14	12	17
Total cluster-wise installation capacity	70	80	140	120	170
Surplus Residue to be stored (75% collection efficiency)	723,000 Tonnes	844,000 Tonnes	1,447,000 Tonnes	1,266,000 Tonnes	1,748,000 Tonnes
Capital Investment (Million USD)	58	68	117	102	141

Given the success of a single biomass-gasifier power plant the model can be replicated in the other districts to explore the full potential of the crop residue generated.

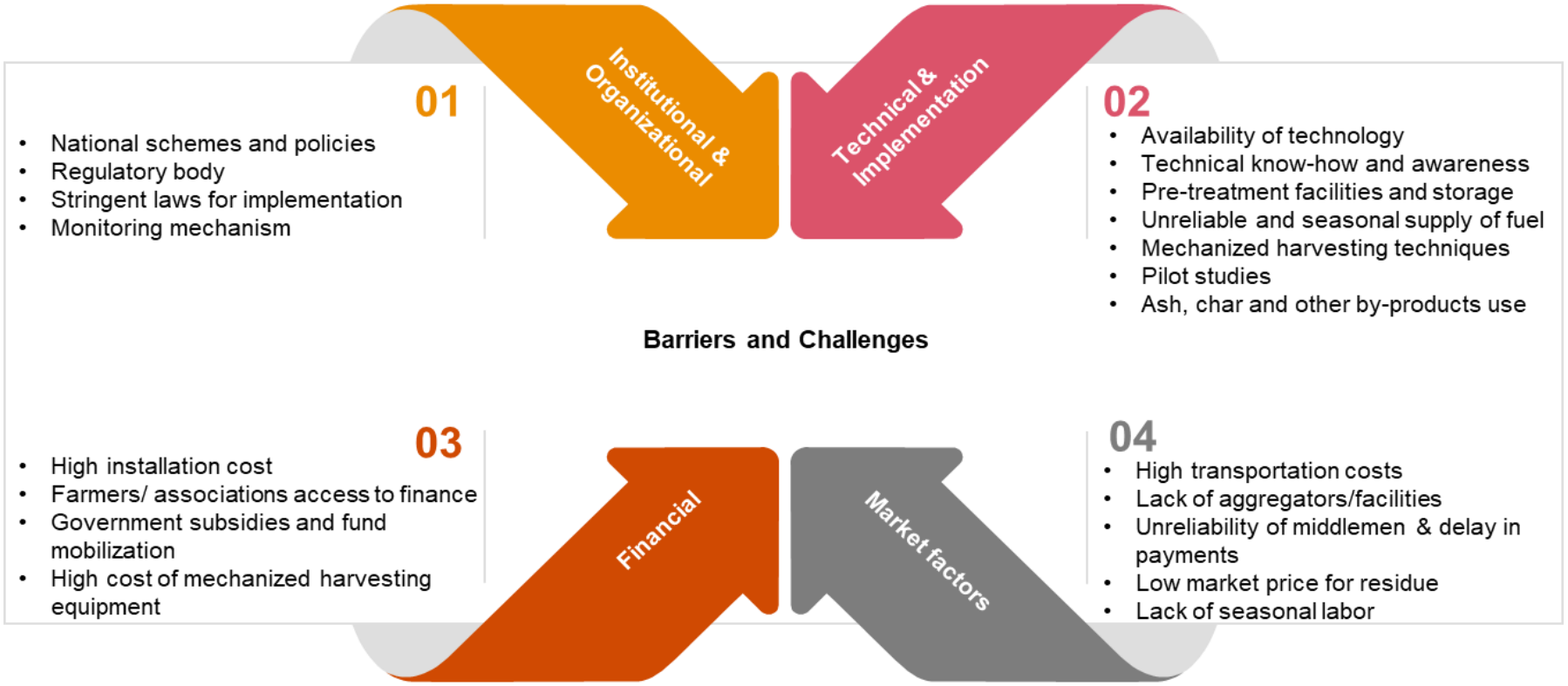
With a cluster-wise decentralized implementation of biomass gasifier plants the logistics can be handled efficiently. It is recommended to sign fuel procurement contracts with the farmers to ensure availability of residue and sustainability of the projects.

Barriers and challenges

Barriers and challenges

The key challenges have been divided into four broad categories i.e. institutional and Organizational, technical and Implementation, financial, market factors

In general, the deployment of biomass generated energy programs in the SAARC countries has been slow. Although there is an established high volume of crop residue available in these countries, the adoption and implementation of biomass derived energy projects face several issues. The key challenges have been divided into four broad categories:



Conclusion and Recommendations

Country-wise implementation plan (1/6)
Afghanistan

Wheat production in the country account for over 80% of the total crops cultivated annually. Taking into consideration the high heating values (17-18 MJ/kg) of their residue, it is suggested to install wheat residue-based gasifier plants in areas with high production and easy aggregation. ~70% of wheat is cultivated in concentrated locations in the North and North-Western regions of Balkh, Kunduz, Takhar, Faryab, Herat. The region-wise implementation plan is provided below. The power generation potential has been derived for a residue collection efficiency of 50%.

Particular	Details
Total Surplus Residue Potential for energy generation	1.4 Million MT
Residue Collection Efficiency	50%
Total Power Generation Potential	58 MW

Region wise implementation

Location	North	East	West	South
Province name	Balkh and Kunduz Provinces	Ghazni Province	Herat Province	Helmand Province
Plant capacity (MW)	32	12	7	7
Annual requirement ('000 tonnes)	Wheat straw: 388	Wheat straw: 141	Wheat straw: 85	Wheat straw: 92
Capital investment (USD Million)	27	141	6	6

Country-wise implementation plan (2/6)
Bangladesh

Rice and wheat contribute ~47% in total production and are most prone to in-situ burning after their harvest. Given the complementary nature of their production and harvesting, it is recommended to implement smaller size biomass gasifier plants that will run alternatively on rice and wheat residues. This will also ensure reduced capital costs, land requirement and storage space for the residue. Accordingly, the plant capacities have been optimized and will operate on a residue collection efficiency of 75%.

Particular	Details			
Total Surplus Residue Potential for energy generation	15.6 Million MT			
Residue Collection Efficiency	75%			
Total Power Generation Potential	1,100 MW			
Region wise implementation				
Location	**North**	**East**	**West**	**South**
Province name	Rangpur, Sylhet and Mymemshing	Dhaka and Chittagong	Rajshahi and Khulna	Barishal
Plant capacity (MW)	359	269	317	68
Annual requirement ('000 tonnes)	Rice straw: 3,774 Wheat straw: 416	Rice straw: 2824 Wheat straw: 179	Rice straw: 3,334 Wheat straw: 473	Rice straw: 717 Wheat straw: 5
Capital investment (USD Million)	304	228	269	58

Country-wise implementation plan (3/6)
India

In India, rice and wheat contribute ~30% of the total food crop production. Considering only the field-based residues from rice and wheat, it is recommended to implement smaller size biomass gasifier plants that will run alternatively on rice and wheat residues. This will also ensure reduced capital costs, land requirement and storage space for the residue. Accordingly, the plant capacities have been optimized and will operate on a residue collection efficiency of 75%.

Particular	Details			
Total Surplus Residue Potential for energy generation	80.3 Million MT			
Residue Collection Efficiency	75%			
Total Power Generation Potential	5,395 MW			
Region wise implementation				
Location	**North**	**East**	**West**	**South**
Province name	Uttar Pradesh, Haryana and Punjab	West Bengal and Bihar	Maharashtra and Madhya Pradesh	Tamil Nadu and Karnataka
Plant capacity (MW)	1,207	1,252	664	711
Annual requirement ('000 tonnes)	Rice straw: 9,959 Wheat straw: 14,805	Rice straw: 13,160 Wheat straw: 1,727	Rice straw: 4,979 Wheat straw: 8,143	Rice straw: 7,469 Wheat straw: 113
Capital investment (USD Million)	1,023	1,060	562	602

Country-wise implementation plan (4/6)
Nepal

The total energy potential in Nepal is considered using cereal crops- rice and wheat. The implementation plan has been recommended keeping in the mind the areas with highest production and easy aggregation. Given the complementary nature of their production and harvesting, it is recommended to implement smaller size biomass gasifier plants that will run alternatively on rice and wheat residues. This will also ensure reduced capital costs, land requirement and storage space for the residue. Accordingly, the plant capacities have been optimized and will operate on a residue collection efficiency of 50% given the difficulties in aggregation due to the hilly terrain of the country.

Particular	Details			
Total Surplus Residue Potential for energy generation	3 Million MT			
Residue Collection Efficiency	50%			
Total Power Generation Potential	140 MW			
Region wise implementation				
Location (regions)	**Eastern**	**Central**	**Western**	**Far Western**
Province name	Jhapa and Morang	Dhanusha and Sarlahi	Nawalparasa	Kailali and Kanchanpur
Plant capacity (MW)	29	29	24	27
Annual requirement ('000 tonnes)	Rice straw: 309 Wheat straw: 53	Rice straw: 310 Wheat straw: 125	Rice straw: 249 Wheat straw: 66	Rice straw: 283 Wheat straw: 127
Capital investment (USD Million)	25	25	20	23

Country-wise implementation plan (5/6)
Pakistan

Rice and wheat contribute ~30% of the total food crop production. Given the complementary nature of their production and harvesting, it is recommended to implement smaller size biomass gasifier plants that will run alternatively on rice and wheat residues. This will also ensure reduced capital costs, land requirement and storage space for the residue. Accordingly, the plant capacities have been optimized and will operate on a residue collection efficiency of 75%. With an increase in the collection efficiency additional plants may be installed in the future to meet the rise in supply.

Particular	Details			
Total Surplus Residue Potential for energy generation	13 Million MT			
Residue Collection Efficiency	75%			
Total Power Generation Potential	834 MW			
Region wise implementation				
Location	**North**	**East**	**West**	**South**
Province name	Khyber Pakhtunkhwa Province	Punjab Province	Baluchistan Province	Sindh Province
Plant capacity (MW)	131	155	131	155
Annual requirement (‘000 tonnes)	Wheat straw: 1608	Rice straw: 1625 Wheat straw: 1,608	Wheat straw: 1,608	Rice straw: 1,625 Wheat straw: 1,608
Capital investment (USD Million)	111	131	111	131

Country-wise implementation plan (6/6)
Sri Lanka

Rice production in the country account for over 90% of the total crops cultivated annually. Taking into consideration the high heating values (15-16 MJ/kg) of their residue, it is suggested to install rice residue-based gasifier plants in areas with high production and easy aggregation. The energy generation potential has been calculated for a residue collection efficiency of 75% on a conservative scale. With an increase in the collection efficiency additional plants may be installed in the future to meet the rise in supply.

Particular	Details			
Total Surplus Residue Potential for energy generation	1 Million MT			
Residue Collection Efficiency	75%			
Total Power Generation Potential	71 MW			
Region wise implementation				
Location	**North**	**East**	**West**	**South**
Province name	Anuradhapura and Mannar	Mahaweli and Ampara	Kurunegala and Gampaha	Hambantota
Plant capacity (MW)	11	38	17	6
Annual requirement (‘000 tonnes)	Rice straw: 113	Rice straw: 398	Rice straw: 180	Rice straw: 60
Capital investment (USD Million)	9	32	15	5

Power generation potential including husk residue

If husks and shells is also considered for energy generation purposes, the power generating potential of the Member States increases substantially

The table below illustrates the Gross residue, Surplus residue and power generation potential using all the residues of wheat and rice for each Member State.

Member State	Residue used	Total wheat and rice production (MT)	Gross Residue Production (MT)	Surplus Residue Production (MT)	Total Power Generation Potential (MW)
Afghanistan	Wheat straws & husks	4.2	7.7	1.7	69
Bangladesh	Rice and Wheat straws & husks	38.1	65.3	17.8	1,253
India	Rice and Wheat straws & husks	212.6	371.4	93.2	6,249
Nepal	Rice and Wheat straws & husks	7.7	13.3	3.5	160
Pakistan	Rice and Wheat straws & husks	36.3	64.3	15.2	980
Sri Lanka	Rice straws & husks	2.4	4.0	1.1	81
Total		**301**	**526**	**133**	**8,792**

Key recommendations (1/5)
Institutional and Organizational

Laws and policies to curb crop residue burning

- The government must formulate suitable laws, policies or orders for prevention of crop residue burning.
- The governments should identify or establish a regulatory body to formulate policies and ensure the implementation of such orders and policies, prevent and ban the practice of crop residue burning. This regulatory body may also set up a regional/ district/ state/ province level regulatory cell for close monitoring of the orders.
- The government should also incentivize the establishment of projects aiming at utilization of crop residue by entitling them fiscal benefits and grants.
- The government should also provide tax incentives to bioenergy projects, including reduced custom taxes for imported equipment and income tax holiday benefits.
- The government should pass a law forbidding the direct burning of crop residue in fields.
- The governments may also consider incentivizing the farmers directly for non-burning of residue which can be paid to the farmers via a local monitoring agency in the next harvesting season and shall be subject to confirmation by the monitoring agency.

Regulatory support

- It is suggested that the power utilities may be directed to procure a certain percentage of their power needs from biomass plants.
- Power generators could be mandated to procure a minimum percentage of fuel supply from crop residue with high energy content (in form of pellets/briquettes) to co-fire the boilers to generate electricity.
- It is recommended to remove the capacity limit for bioenergy plants in some countries such as India to encourage more players in the market.

Key recommendations (2/5)
Monitoring mechanism

Monitoring cell

- It is recommended to establish a regional level monitoring cell in each country to identify various interventions, formulate a work plan and monitor its implementation at village levels.
- At the national level, the apex monitoring and regulatory cell should monitor the residue burning at regular intervals after each harvesting season in target areas to ensure effective implementation of laws and measures to curb residue burning

Satellite-based monitoring

- It is recommended to used satellite-based remote sensing technologies to monitor and report crop residue burning practices. This will ensure prompt response from the regional regulatory cell and levy of penalties.

Key recommendations (3/5)
Financial

Government financial support for equipment and plant

- The funds required for successful crop residue management should be effectively mobilized through different regional/ state/ provincial governments. Such funds can be provided to farmers or project developers through the various on-going schemes/ programs introduced to curb crop residue burning.
- The government must provide central subsidies for purchase of harvesting equipment and machineries (combine harvesters, super SMS, happy seeders, rotovators) to the farmers to facilitate in-situ management of crop residue and retaining the straw for mulching.
- Some governments provide financial support to plant developers via Viability Gap Funding. Other SAARC countries may also consider providing such funding for viable projects. A clear application process should be designed for availing such supports, followed by a transparent process of transfer and monitoring of funds/support.

Access to funds

- It is recommended to increase the private sector participation in funding of viable and socially benefitting bioenergy projects.
- Loans/ Grants from multilateral agencies: SAARC Member States could reach out to such agencies requesting support for implementation of energy generation programme through funding of various initiatives covering pilot projects and setting up of necessary infrastructure. Some of the multilateral agencies are ADB, The UK- DfID, The World Bank, Asian Infrastructure Investment Bank etc.

SAARC Development Fund

- SAARC Member States should mutually agree upon joint investment into development of bioenergy projects and form an association to share technology and provide support in implementation along with faster adoption of bioenergy programs across the nations.
- The SAARC Energy Centre may also act as the Nodal Agency for the development of bioenergy programs, their implementation and funds disbursement in the interested Member States.

Key recommendations (4/5)
Technical and Implementation

Infrastructure assessment

- A detailed resource assessment, for different crops and regions, along with their quantum of production and timeline of availability should be conducted by the Nodal Agriculture Agency of respective Member State. This information will help developers and researchers in estimating the scale and type of bioenergy program most suitable for each region and crop based on availability.
- The electricity demand estimation of a certain region should be used to locate the end-users for the energy generated. Additionally, this data can be mapped with the grid infrastructure availability reports to analyze the ability to supply power from a given site.

Awareness campaigns

- As a first step, the government or regulatory body should organize training campaigns for farmers to create awareness about the effects of crop residue burning, methods of residue conservation for better use and technologies available through ongoing programs and schemes.
- The local regulatory cell may also implement self-certification by farmers to not resort to residue burning as an added security measure while availing loans from Financial Institutions.

Skill Development Programmes

- Along with awareness campaigns, skill development programmes should be organized to train people across targeted regions with necessary expertise to operate machinery for harvesting/sowing, set-up and operate bio-mass power plants and ensure proper storage and transportation methods.

Equipment and machinery

- The government should promote modern technologies that enable faster and more efficient harvesting by promoting capital subsidies on purchase of machinery/equipment.
- The government should also prioritize the key technologies to be eligible for subsidy based on primary surveys and needs of farmers

Key recommendations (5/5)
Market factors

Aggregating terminals

- It is recommended to set up regional level collection centers that are easily accessible by farmers using bullock carts, small tempos or in some cases, tractors to ensure maximum participation by farmers.
- Collection centers with a minimum storage capacity of 5,000- 10,000 tons of residue can be constructed in easily accessible locations to reduce the cost of procuring large land parcels for residue storage.

Price realization

- It is recommended that the regulatory body aids in discovering a fixed price for different types of residue depending on the harvesting season and region, which can then be displayed on the national portal for farmers and developers to reduce instances of cheating by the aggregators or developers.
- On the demand side the government may also devise a fixed price mechanism for purchase of the power generated by the plant developers. The factors determining the price per unit can be type of residue used, type of technology, capacity and region of installation.

Reward schemes

- A reward scheme can be designed for the villages that do not burn crop residue and become a role model for other villages. The proposed use of the funds can also be a determinant in the grant approval.

Support service-based shared infrastructure

- Governments can introduce a support mechanism for local entrepreneurs or farmer co-operatives interested in owning such equipment and providing services to farmers at reasonable rates.
- The government can provide capita subsidy for purchase of such equipment and provide additional incentives to such entrepreneurs based on their performance.
- It is also recommended that accelerated depreciation be provided on farm machinery and equipment to make purchases more attractive to local entrepreneurs under the shared service-infrastructure model.

Q&A

Thank you

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