Adaptation of forage handling systems for collecting biomass feedstock

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Recent increased emphasis on renewable energy and environmental sustainability has focused research interest on the conversion of biomass to transportation fuel, electricity, and industrial products. The biomass may originate from forages, woody plants, crop residues, or a variety of other sources (eg: process waste streams). This paper focuses on biomass from agricultural crops.

While machinery systems for harvest and handling of forages are well developed, systems for crop residue and woody crops have yet to be perfected. The low value of residues has hampered the development of efficient machinery for their harvest and utilization. Only recently, the national bioenergy programs in the U.S. and elsewhere have propelled the issue of bio-feedstock supply systems to the forefront.

Numerous specialized pieces of equipment have been developed to carry out specific harvesting and handling tasks for forage crops. In this report, the most popular machinery used in harvest and post harvest operations of forage crops are reviewed. The characteristics and deficiencies of this equipment for biomass handling are identified. Forage machinery are widely used for crop residue harvesting, and thus the operational characteristics of these equipment are analyzed in detail. A section is devoted to crop residues, identifying challenges associated with their collection and handling. This report focuses on technical issues. It does not deal with in-depth economic considerations.

The discussion section begins with identifying the relevant quality attributes for biomass feedstock as it arrives at the gate of a typical conversion facility (table 1):

?? Maximum moisture content, Uniform species - not a mixture
?? Maximum allowable impurities, dirt, unwanted plants, oil, and twine, and other foreign materials
?? Not spoiled - moldy, badly weathered

Table 1. Proposed specifications for a a biomass feedstock (corn stover)

	Moisture content (%)	Dirt content (%)	Plants other than feedstock	Twine, oil (ppm)
Grade 1	12	0.5	1	10
Grade 2	17	5	5	50
Grade 3	25	10	10	100
Grade 4	>25	15	15	1000

Although there are a few farmers that are innovators and risk takers, the majority of farmers must be satisfied with the economic viability of the enterprise before committing to it. Collection and utilization of crop residues is no exception. The producer's expectations can be summarized as follows:

?? A fair price for the crop residue
?? Resources (soil) conserved
?? Existing infrastructure utilized
?? Does not interfere with the principal functions of the enterprise
?? Secure marketing channel
??

Handling, storage, and transportation of crop residue require awareness of the existing regulatory issues that are related to these operations.

?? Transportation, weight and dimensions
?? Fire codes
?? Building codes
?? Safety and health of workers
?? Dangerous goods status
?? Environmental regulations

Further developments in feedstock supply should proceed along three fronts simultaneously (Figure 1): research, development, and demonstration. Universities will provide the research infrastructure. Equipment manufacturers will engage in equipment development and testing. Entrepreneurs, farmer cooperatives, and processing companies will engage in demonstration ventures. A matrix showing the degree of involvement of university, manufacturer, and processor in research, development, and demonstration activities is developed. The elements of the matrix are shaded to highlight the focus as well as the collaborative nature of the activities.

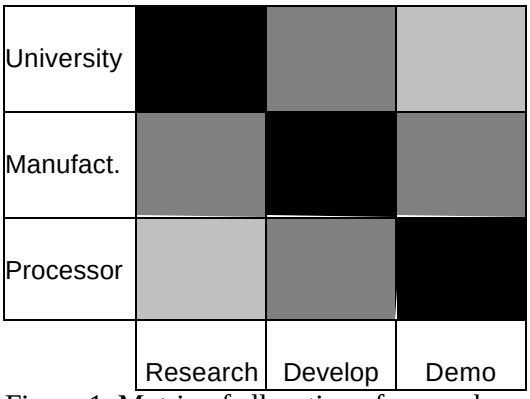

Figure 1. Matrix of allocation of research, development, and demonstration to university, manufacturer, and processor. Darker shade = heavier involvement

A close collaboration among entrepreneurs, equipment suppliers, and researchers is essential for the demonstration phase. All of the innovative ideas must be analyzed and evaluated before putting them into full scale application.

The conclusion identifies several areas of research and development for the development of biomass supply systems. These include modifications to balers for efficient crop pick up, on-farm and off-farm drying of crop residue, safe storage moisture and temperature, densification of crop residue using cubing process, whole crop harvesting, fire prevention technologies, ensiling wet crop residues, physical properties of crop residue for handling and machine design.