Example Application of the Feedstock Readiness Level Tool: Perennial Grasses in the Great Plains & Midwest

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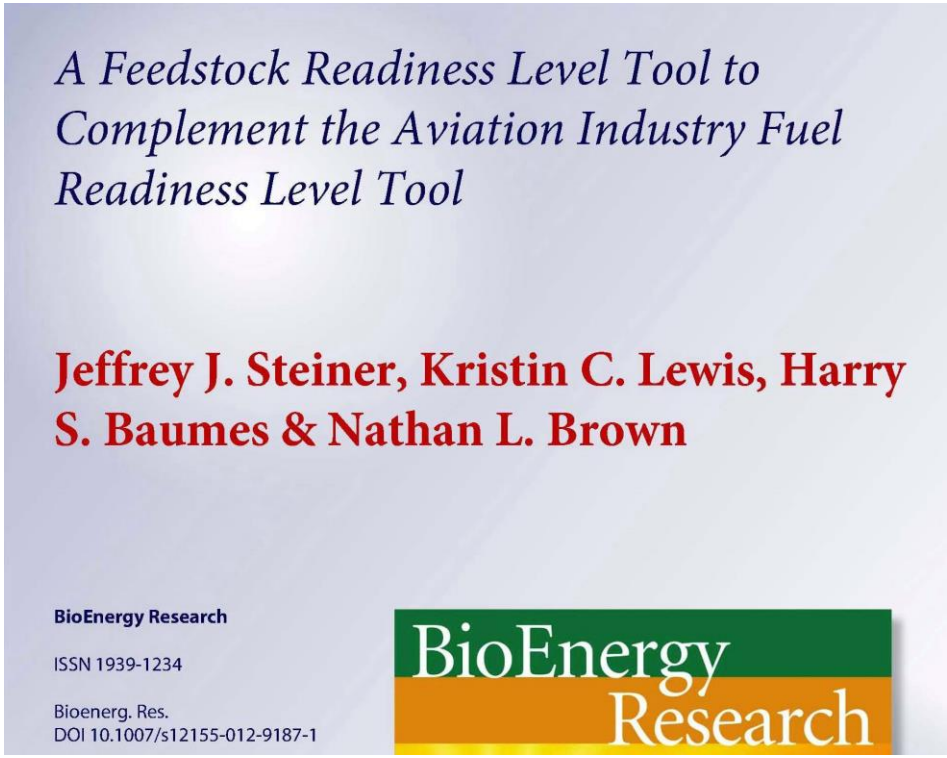
Feedstock Readiness Level Tool (FSRL)

- FSRL tool was developed by USDA, FAA, & Research and Innovative Technology Administration to describe the steps involved in bringing plant-based feedstocks to market for aviation biofuels production.
- Candidate feedstocks are assigned a FSRL level (1 to 9) indicating maturity towards commercialization.
- FSRL level communicates a feedstocks state of development concurrent with its readiness for use with a conversion process.


A Feedstock Readiness Level Tool to Complement the Aviation Industry Fuel Readiness Level Tool

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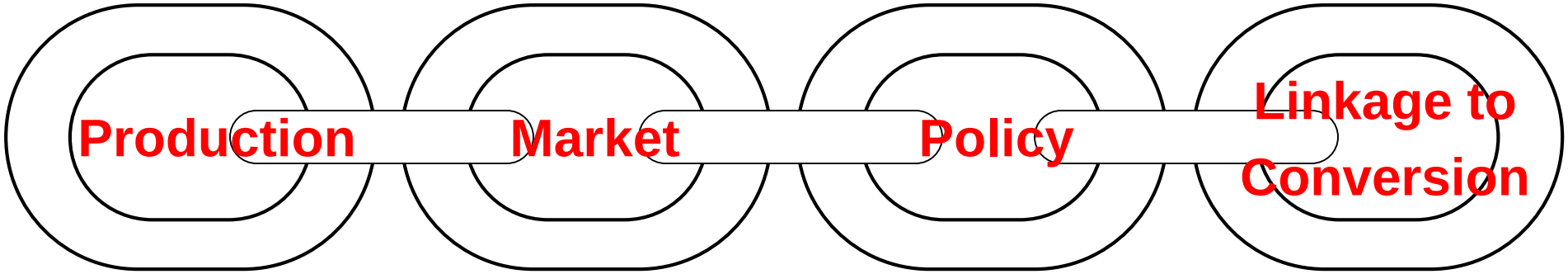
Feedstock Readiness Level Tool (FSRL)

- There are four components to the FSRL
  1. Production
  2. Market
  3. Policy – Program support & regulatory compliance
  4. Linkage to conversion process
- Each component has one to four tollgate descriptions per readiness level.
- The FSRL tool was structured to complement the Fuel Readiness Level (FRL) tool used by the aviation industry as an internationally recognized best practice for communication.

Feedstock Readiness Level Tool (FSRL)

- The FSRL identifies gaps in any feedstock supply chain designed for any biofuel or conversion process that provides a market for feedstocks.
- Integrating feedstock and conversion technology can help plan & develop a viable biofuels industry.



How do you use the FSRL & Checklist?

- Farm 2 Fly 2.0 FSRL sub-team led by Kristen Lewis (DoT) & Bob Fireovid (ARS) was organized to implement the FSRL through the USDA/FS Regional Biomass Research Centers.
- FSRL Tool & checklist provides a mechanism for tracking the progress of feedstocks as they move towards commercialization.
- A complete supply chain system is implied.
- The FSRL Tool has four components: (1) Production, (2) Market, (3) Policy - Program Support and Regulatory Compliance, and (4) Linkage to Conversion Processes.
- The Production, Market, and Policy - Program Support and Regulatory Compliance components are static for all conversion technologies for a given feedstock.
- The Linkage to Conversion Processes component is where individual feedstocks are characterized for a specific conversion process.

How do you use the FSRL & Checklist?

- The checklist assists in rating the FSRL for individual feedstocks.
- In the Rating column beside each component, simply indicate (Yes or No) if the tollgate has been attained for the specific feedstock.
- If 'Yes', move to the next scale and evaluate.
- Continue this process from the top down until you reach a tollgate scale for which you answer 'No'.
- At that point, return to the last scale for which you answered 'Yes'. That is the current FSRL for that component.
- Repeat the process for each of the four components.
- Record the FSRL for each component in the Summary Table tab and record pertinent information for each step in the evaluation process.
- If the status of a specific tollgate is uncertain, place a ? after your 'Yes' or 'No' reply and discuss in the summary table.

Feedstock Readiness Level (FSRL)			FSRL Components with Tollgates			
Activity	**Scale**	**Description**	**(1) Production**	**(2) Market**	**(3) Policy - Program Support and Regulatory Compliance**	**(4) Linkage to Conversion Process**
Preliminary Feedstock Evaluation	1	Basic Principles	Identify potential feedstock for specific conversion			
	2.1	Concept Formulated				
	2.2					
	2.3					
	2.4					
Feedstock Experimental Testing	3.1	Proof of Concept				
	3.2					
	4.1	Preliminary Technical Evaluation				
	4.2					
	4.3					
Pre-commercial Feedstock Assessment	5.1	Production System Validation				
	5.2					
	5.3					
	5.4					
	6.1	Full-Scale Production Initiation				
	6.2					
Feedstock Commercial Deployment	7	Feedstock Availability				Sustainable full-scale production of biofuel and co-products
	8	Commercialization				
	9	Sustainable Feedstock Production Capacity Established				

Feedstock Readiness Level (FSRL)			FSRL Components with Tollgates			
Activity	**Scale**	**Description**	**(1) Production**	**(2) Market**	**(3) Policy - Program Support and Regulatory Compliance**	**(4) Linkage to Conversion Process**
Preliminary Feedstock Evaluation	1	Basic Principles	Identify potential feedstock for specific conversion			
	2.1	Concept Formulated				
	2.2					
	2.3					
	2.4					
Feedstock Experimental Testing	3.1	Proof of Concept				
	3.2					
	4.1	Preliminary Technical Evaluation				
	4.2					
	4.3					
Pre-commercial Feedstock Assessment	5.1	Production System Validation				
	5.2					
	5.3					
	5.4					
	6.1	Full-Scale Production Initiation				
	6.2					
Feedstock Commercial Deployment	7	Feedstock Availability				Sustainable full-scale production of biofuel and co-products
	8	Commercialization				
	9	Sustainable Feedstock Production Capacity Established				

FSRL Tool

FSRL Checklist

Feedstock Readiness Level (FSRL)			FSRL Components with Tollgates							
Activity	**Scale**	**Description**	**(1) Production**	**Rating**	**(2) Market**	**Rating**	**(3) Policy & Reg. Compliance**	**Rating**	**(4) Linkage to Conversion**	**Rating**
Preliminary Feedstock Evaluation	1	Basic Principles	Identify potential feedstock for a specific conversion technology		Identify current feedstock producers, feedstocks and coproduct users, and wastes		Identify regulatory requirements to producing a new feedstock		Identify potential conversion technology to utilize feedstock	
	2.1	Concept Formulated	Estimate likely range of production environments and competing land uses		Assess feedstock market alternatives		Evaluate feedstock for compliance with regulatory requirements for likely production environments		Test feedstock quality for specific conversion technology	
	2.2		Identify production system components		Identify potential coproducts		Estimate production impacts on multiple resources concerns			
	2.3		Develop enterprise budget for potential feedstock		Identify waste disposal requirements		Formulate a plan including best practices to address regulatory requirements			
	2.4		Identify possible consequences of expanded production, articulate responses to trade-off's		Identify harvest techniques, post-harvest collection, transportation, and storage logistic options		Comply with any feedstock pre-importation regulations			
Feedstock Experimental Testing	3.1	Proof of Concept	Screen candidate genetic resources for feedstock yield		Estimate feedstock production costs		Determine potential for societal resistance to use of the candidate feedstock		Test feedstock in conversion process at the experimental bench-scale	
	3.2		Screen candidate genetic resources for biofuel conversion potential		Evaluate current and alternative future scenarios for establishing a feedstock sector - feasibility study		Formulate a plan to address societal concerns			
	4.1	Preliminary Technical Evaluation	Perform coordinated regional feedstock trials to determine potential for yield improvement and dependability of feedstock supply		Identify biorefiners for targeted feedstock market development and link feedstock producers to feedstock brokers to supply biorefineries		Identify Federal, state, or other special incentive programs		Performance estimated for feedstock through a conversion process	
	4.2		Compare performance of candidate feedstock with alternative feedstock choices		Identify specific alternatives for reducing production and supply uncertainties (i.e., contracts and loan guarantees)		Develop conservation plan to address resource concerns for a feedstock production system		Determine conversion efficiency and unique effects on fuel properties	
	4.3		Implement agricultural extension and education programs to promote feedstock production		Implement education programs to establish interest in production and demand for feedstock purchase		Draft NEPA (EA or EIS) and other required permitting documents		Co-product production and utilization performance estimated	
Pre-commercial Feedstock Assessment	5.1	Production System Validation	Define range of adaptation for feedstock and identify production uncertainties		Develop and refine post-harvest logistics and storage		NEPA documents, conservation plan, and other required permit applications submitted		Pilot-scale testing	
	5.2		Conduct on-farm, field-scale production cost trials and assess production impacts on resource concerns		Assess maximum market potential for feedstock and coproducts		NEPA documents, conservation plan, and other required permit applications approved			
	5.3		Establish partial budget costs and returns		Evaluate waste disposal and other costs		Prepare and submit service program applications		Scaled-commercial testing	
	5.4		Establish price points for feedstock market competitiveness with competing land uses		Develop feedstock offtake options and pathways to realizing market potential		Service program applications approved and payments received			
	6.1	Full-Scale Production Initiation	Establish source material nurseries and begin feedstock production scale-up process		Ancillary service providers apply knowledge gained to advise producers and other supply chain participants		All regulatory compliance is complete		Performance confirmed for feedstock conversion and effects on fuel properties, engines, and components	
	6.2		Produce feedstock planting materials to meet demand		Determine feedstock production capacity when linked to market outlets - price and quantity					
Feedstock Commercial Deployment	7	Feedstock Availability	Commercial-scale production and feedstock delivery to conversion facility - payments made for feedstock		Utilize risk management tools to reduce uncertainty of feedstock production		Continue service program participation as needed		Sustainable full-scale production of biofuel and co-products	
	8	Commercialization	On-going monitoring and research to improve production system performance while managing multiple resource concerns		Market established - make necessary adjustments to the supply chain as the feedstock market evolves[d]		Maintain regulatory compliance and make adjustments as needed			
		Sustainable								

Feedstock Readiness Level Checklist		
Activity	**Scale**	**Description**
Preliminary Feedstock Evaluation	1	Basic Principles
	2.1	Concept Formulated
	2.2	
	2.3	
	2.4	
Feedstock Experimental Testing	3.1	Proof of Concept
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Pre-commercial Feedstock Assessment	5.1	Production System Validation
	5.2	
	5.3	
	5.4	
	6.1	Full-Scale Production Initiation
	6.2	
Feedstock Commercial Deployment	7	Feedstock Availability
	8	Commercialization
	9	Sustainable Feedstock Production Capacity Established

The FSRL Checklist implements the FSRL Tool to evaluate a feedstock with a specific conversion process.

Example: Switchgrass in the Great Plains & Midwest for cellulosic ethanol

Feedstock Readiness Level Checklist			FSRL Components with Tollgates	
Activity	**Scale**	**Description**	**(1) Production**	**Rating**
Preliminary Feedstock Evaluation	1	Basic Principles	Feedstock potential for specific conversion technology	Yes
	2.1	Concept Formulated	Estimate likely range of production environments and competing land uses	Yes
	2.2		Identify production system components	Yes
	2.3		Develop enterprise budget for potential feedstock	Yes
	2.4		Identify possible consequences of expanded production, articulate responses to trade-off's	Yes
Feedstock Experimental Testing	3.1	Proof of Concept	Screen candidate resources for feedstock yield	Yes
	3.2		Screen candidate resources for conversion potential	Yes
	4.1	Preliminary Technical Evaluation	Perform regional feedstock trials to determine yield improvement potential & feedstock supply dependability	Yes
	4.2		Compare performance of candidate feedstock with alternative feedstock choices	Yes
	4.3		Implement agricultural extension and education programs to promote feedstock production	Yes
Pre-commercial Feedstock Assessment	5.1	Production System Validation	Define range of adaptation for feedstock and identify production uncertainties	Yes
	5.2		Conduct on-farm, field-scale production cost trials and assess production impacts on resource concerns	Yes
	5.3		Establish partial budget costs and returns	Yes
	5.4		Establish price points for feedstock market competitiveness with competing land uses	Yes
	6.1	Full-Scale Production Initiation	Establish material sources & begin feedstock scale-up	Yes
	6.2		Produce feedstock materials to meet demand	Yes
Feedstock Commercial Deployment	7	Feedstock Availability	Commercial-scale production and feedstock delivery to conversion facility - payments made for feedstock	No
	8	Commercialization	On-going monitoring and research to improve production system performance while managing multiple resource concerns	
	9	Sustainable Feedstock Production Capacity Established	Full array of private services support feedstock production sector - understanding of feedstock sector evolves - make adjustments as commercial-scale biofuel production expands	

Feedstock Readiness Level Checklist			FSRL Components with Tollgates	
Activity	**Scale**	**Description**	**(2) Market**	**Rating**
Preliminary Feedstock Evaluation	1	Basic Principles	Identify feedstocks, producers, coproduct users, & waste	Yes
	2.1	Concept Formulated	Assess feedstock market alternatives	Yes
	2.2		Identify potential coproducts	Yes
	2.3		Identify waste disposal requirements	Yes
	2.4		ID harvest, collection, transportation, & storage logistics	Yes
Feedstock Experimental Testing	3.1	Proof of Concept	Estimate feedstock production costs	Yes
	3.2		Evaluate current and alternative future scenarios for establishing a feedstock sector - feasibility study	Yes
	4.1	Preliminary Technical Evaluation	ID biorefiners for targeted feedstock markets & link feedstock producers to brokers to supply biorefineries	Yes
	4.2		Identify specific alternatives for reducing production and supply uncertainties (i.e., contracts and loan guarantees)	Yes
	4.3		Implement education programs to establish interest in production and demand for feedstock purchase	Yes
Pre-commercial Feedstock Assessment	5.1	Production System Validation	Develop and refine post-harvest logistics and storage	Yes
	5.2		Assess max market potential for feedstock & coproducts	Yes
	5.3		Evaluate waste disposal and other costs	Yes
	5.4		Develop feedstock offtake options and pathways to realizing market potential	Yes
	6.1	Full-Scale Production Initiation	Ancillary service providers apply knowledge gained to advise producers and other supply chain participants	Yes
	6.2		Determine feedstock production capacity when linked to market outlets - price and quantity	Yes
Feedstock Commercial Deployment	7	Feedstock Availability	Use risk mgt tools to reduce feedstock production uncertainty	No
	8	Commercialization	Market established - make necessary adjustments to the supply chain as the feedstock market evolves[d]	
	9	Sustainable Feedstock Production Capacity Established	Market functions to support sustainable feedstock production	

Feedstock Readiness Level Checklist			FSRL Components with Tollgates	
Activity	**Scale**	**Description**	**(3) Policy/Program Support & Regulatory Compliance**	**Rating**
Preliminary Feedstock Evaluation	1	Basic Principles	Identify regulatory requirements to grow new feedstocks	Yes
	2.1	Concept Formulated	Evaluate feedstock for compliance with regulatory requirements for likely production environments	Yes
	2.2		Est. production impacts on multiple resources concerns	Yes
	2.3		Formulate a plan including best practices to address regulatory requirements	Yes
	2.4		Comply with any feedstock pre-importation regulations	Yes
Feedstock Experimental Testing	3.1	Proof of Concept	Determine potential societal resistance to the feedstock	Yes
	3.2		Formulate a plan to address societal concerns	Yes
	4.1	Preliminary Technical Evaluation	Identify Federal, state, or other special incentive programs	Yes
	4.2		Develop conservation plan to address resource concerns for a feedstock production system	Yes
	4.3		Draft NEPA (EA or EIS) and other required permitting documents	Yes
Pre-commercial Feedstock Assessment	5.1	Production System Validation	NEPA documents, conservation plan, and other required permit applications submitted	Yes
	5.2		NEPA documents, conservation plan, and other required permit applications approved	Yes
	5.3		Prepare and submit service program applications	Yes
	5.4		Service program applications approved & payments rec'd	Yes
	6.1	Full-Scale Production Initiation	All regulatory compliance is complete	Yes
	6.2			
Feedstock Commercial Deployment	7	Feedstock Availability	Continue service program participation as needed	No?
	8	Commercialization	Maintain regulatory compliance and make adjustments as needed	
	9	Sustainable Feedstock Production Capacity Established	Federal, state, and private programs function with minimal disruption from unintended economic, environmental or social consequences	

Feedstock Readiness Level Checklist			FSRL Components with Tollgates	
Activity	**Scale**	**Description**	**(4) Linkage to Conversion Process**	**Rating**
Preliminary Feedstock Evaluation	1	Basic Principles	Identify potential conversion technology to utilize feedstock	Yes
	2.1	Concept Formulated	Test feedstock quality for specific conversion technology	Yes
	2.2			
	2.3			
	2.4			
Feedstock Experimental Testing	3.1	Proof of Concept	Test feedstock in conversion process at the experimental bench-scale	Yes
	3.2			
	4.1	Preliminary Technical Evaluation	Performance estimated for feedstock through a conversion process	Yes
	4.2		Determine conversion efficiency and unique effects on fuel properties	Yes
	4.3		Co-product production and utilization performance estimated	Yes
Pre-commercial Feedstock Assessment	5.1	Production System Validation	Pilot-scale testing	Yes
	5.2			
	5.3		Scaled-commercial testing	Yes
	5.4			
	6.1	Full-Scale Production Initiation	Performance confirmed for feedstock conversion and effects on fuel properties, engines, and components	No?
	6.2			
Feedstock Commercial Deployment	7	Feedstock Availability	Sustainable full-scale production of biofuel and co-products	
	8	Commercialization		
	9	Sustainable Feedstock Production Capacity Established		

Feedstock readiness level summary table for switchgrass for cellulosic ethanol in the Central-East Region

Feedstock	Production	Market	Policy	Linkage to Conversion
	---------- FSRL Scale ----------			
Switchgrass	6.2	6.2	6.2?	5.4?

Feedstock readiness level Production summary for switchgrass for cellulosic ethanol in the Central-East Region

(note the feedstock, region, & conversion platform specificity)

Production (6.2) – Switchgrass production is fully mature, is commercialized, and sustainable production capacity has been determined for many regions. Switchgrass is used by the livestock industry and for conservation purposes. Research is on going to improve sustainability and private services support the feedstock production sector. Switchgrass production can meet biofuel feedstock delivery demands in two years in the Central-East Region.

Feedstock readiness level Market summary for switchgrass for cellulosic ethanol in the Central-East Region

Market (6.2) – The switchgrass market is fully established for the livestock industry, but not the biofuel industry. Necessary adjustments are being considered to meet market demand for biofuels. The current market is dominated by the livestock industry and functions to support sustainable feedstock production. Although ancillary service providers like independent crop consultants and corporate agronomists (i.e., Servi-tech or regional Coops) are not used commonly on switchgrass, extension educators and the NRCS provide ancillary services. I expect crop consultants and corporate agronomists to have an increased presence when switchgrass becomes commercialized.

Feedstock readiness level Policy summary for switchgrass for cellulosic ethanol in the Central-East Region

Policy (6.2?) – Switchgrass policies for bioenergy are limited. However, if other perennial grass policies such as the Conservation Reserve Program (CRP) are considered a surrogate for switchgrass for biofuels, the FRL will increase. NRCS policies for CRP have been in practice for almost 30 years and have been applied to over 30 million acres. Bioenergy specific policy information is limited, but overlap in policies between CRP and biofuels likely will be similar. Crop insurance is one lacking policy area for switchgrass. Programs are being evaluated to prevent unintended economic, environmental, or social consequences for many regions.

Feedstock readiness level Linkage to Conversion summary for switchgrass for cellulosic ethanol in the Central-East Region

Linkage to Conversion (5.4?) – Switchgrass has been evaluated through scaled commercial testing and several small-scale plants have produced biofuel. Production performance has been confirmed for switchgrass biofuel production, but effects on fuel properties, engines, and components is lacking. The FRL changes significantly (to 6.2) if generalized ethanol data meets the fuel properties, engines, and component requirements.

Feedstock readiness level Final Assessment for switchgrass for cellulosic ethanol in the Central-East Region

Based on feedstock Production, Market, Policy, and Linkage to Conversion parameters, switchgrass for cellulosic ethanol has completed all activities in the Pre-commercial Assessment Phase and is ready to begin the Commercial Deployment Phase as determined by the Feedstock Readiness Level Tool. Switchgrass is the most advanced herbaceous perennial biofuel feedstock.

Summary

- The FSRL Tool & Checklist:
  - identifies gaps for a specific feedstock & conversion platform within a region.
  - is being evaluated by the USDA Regional Biomass Research Centers for herbaceous feedstocks.
  - is being expanded to woody feedstocks.
  - help assess barriers & timeframe to commercialization.
  - is under preliminary evaluation (give us feedback).
- NIFA-CAP grants have applied the FSRL Tool.

Questions?

Sunburst switchgrass

Liberty switchgrass