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A Hybrid Approach to Generation 1.5 for High Volumes of Cellulosic Ethanol

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Team Lead, Principal Scientist

About ICM

ICM is a global company with small-business roots in a farming community.

•Headquartered in Colwich, Kansas

•Sales and services for ethanol facilities

•Research and development

•Technology development and process optimization

•Manufacturing

•Comprehensive service capabilities

•Engineering solutions, project management and support, and construction



SMT™ and FST™ are protected by US Patent Number 9012191. SMT V2™ and FST Next Gen™ are protected by US Patent Number 9376504. TS4™ is protected by US Patent Number 8986551 and is patent pending. ULTRAMAX™ is protected by US Patent Number 10093891. Screens, Flingers, and the MZSA are patent pending. © 2019 ICM, Inc



Cellulosic Ethanol from Corn Fiber

Gen 1.5: In-Situ vs Separate Process

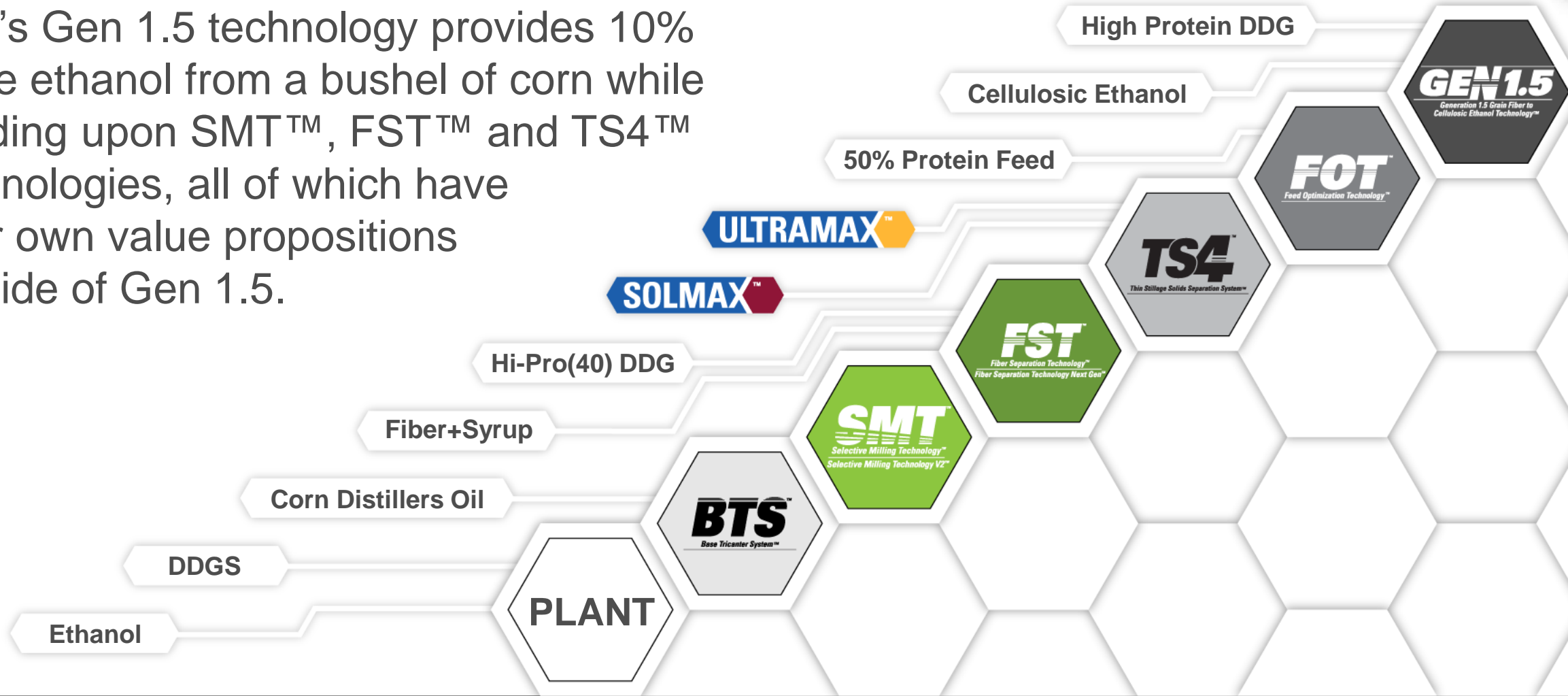
In-Situ	Separate
Reduced capital and operational costs	Dedicated fiber unit operations (Additional costs)
Catalytic processes may be compromised to optimize other parts of the process	Customized conversion conditions can be used for both fiber and starch
Potential for 10% yield gain per bushel	Up to 7% yield gain per bushel
Challenging assay quantification of cellulose in the presence of high levels of starch	Quantification is straightforward and can be accomplished online

The ICM Gen 1.5 process is a hybrid of both processes to leverage the advantages and minimize the disadvantages



ICM Technology Platform

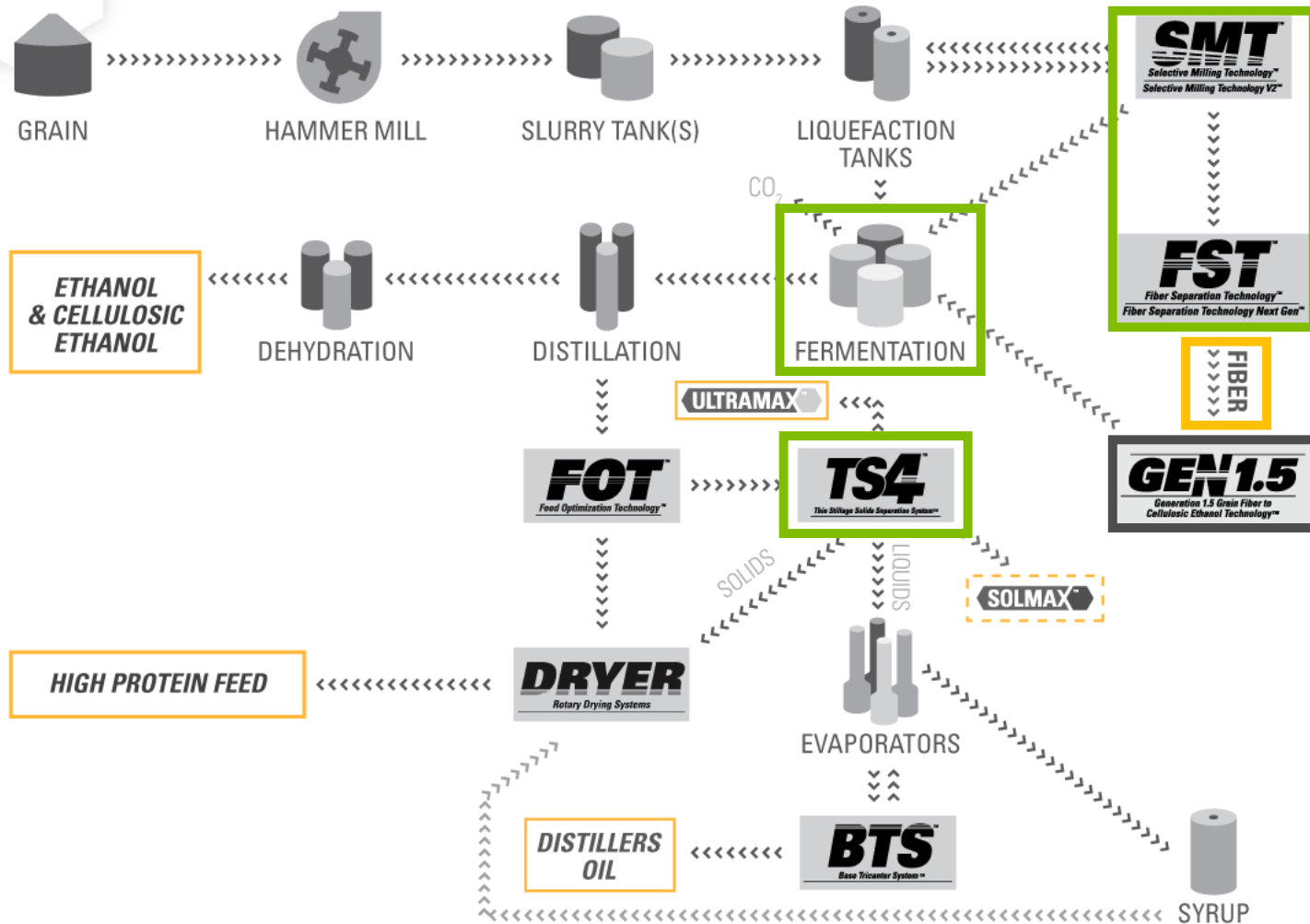
ICM's Gen 1.5 technology provides 10% more ethanol from a bushel of corn while building upon SMT™, FST™ and TS4™ technologies, all of which have their own value propositions outside of Gen 1.5.





Integrating Gen 1.5: Operational Impact

Full Plant Efficiency Provides Basis for Gen 1.5



SMT V2™ and FST Next Gen™:

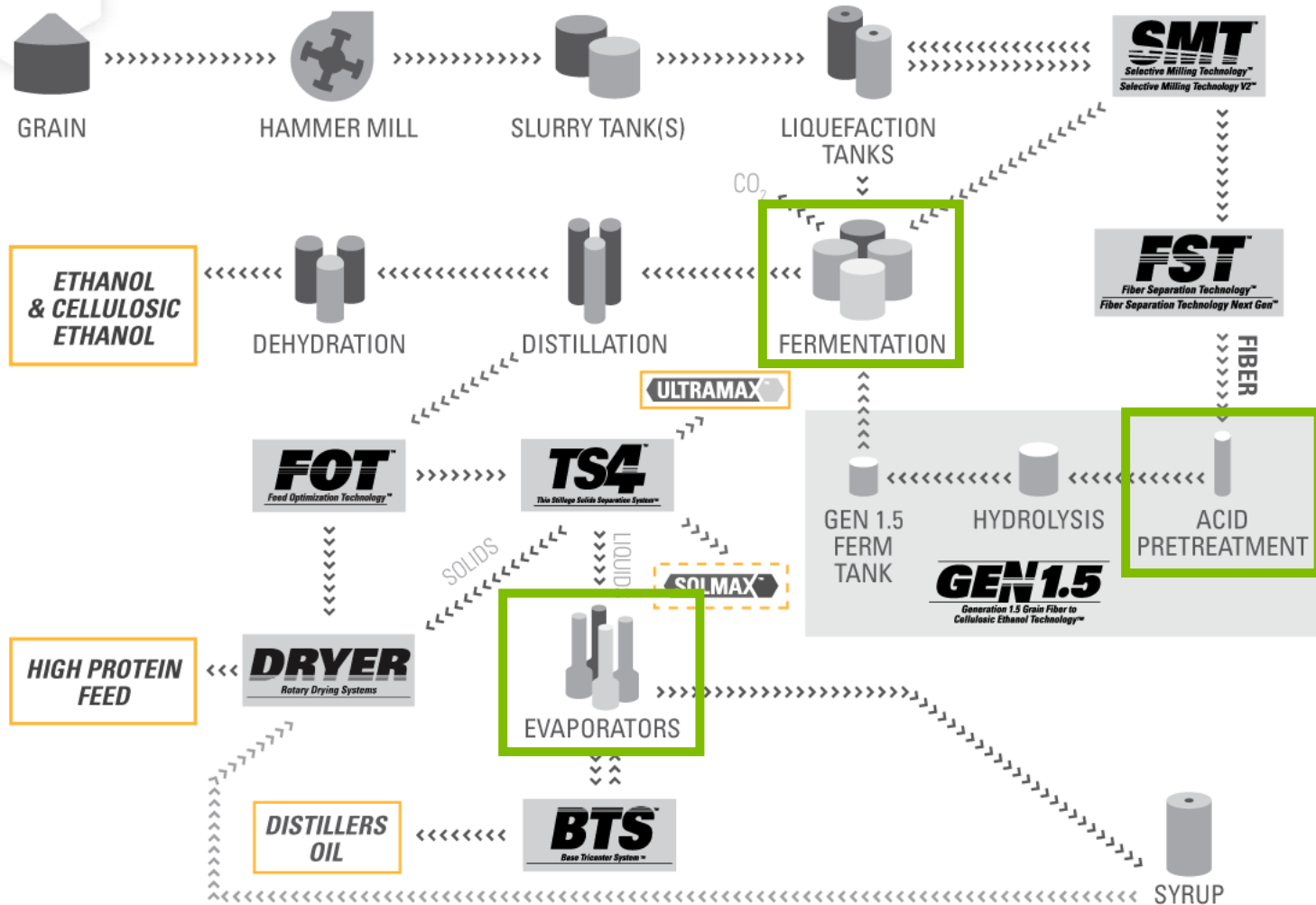
- Use less connected horsepower than other offerings
- Separate fiber at the front end of the plant
- Front-end removal of fiber allows for increased fermentation capacity (beneficial to regular starch fermentation as well as Gen 1.5)

TS4™:

- Removes suspended solids
- Allows evaporation up to 75% total solids (normally 35%)
- Water is recycled from evaporators vs going through the dryer
- Less water in dryer reduces natural gas usage



Integrating Flows with Gen 1.5 Saves Raw Materials

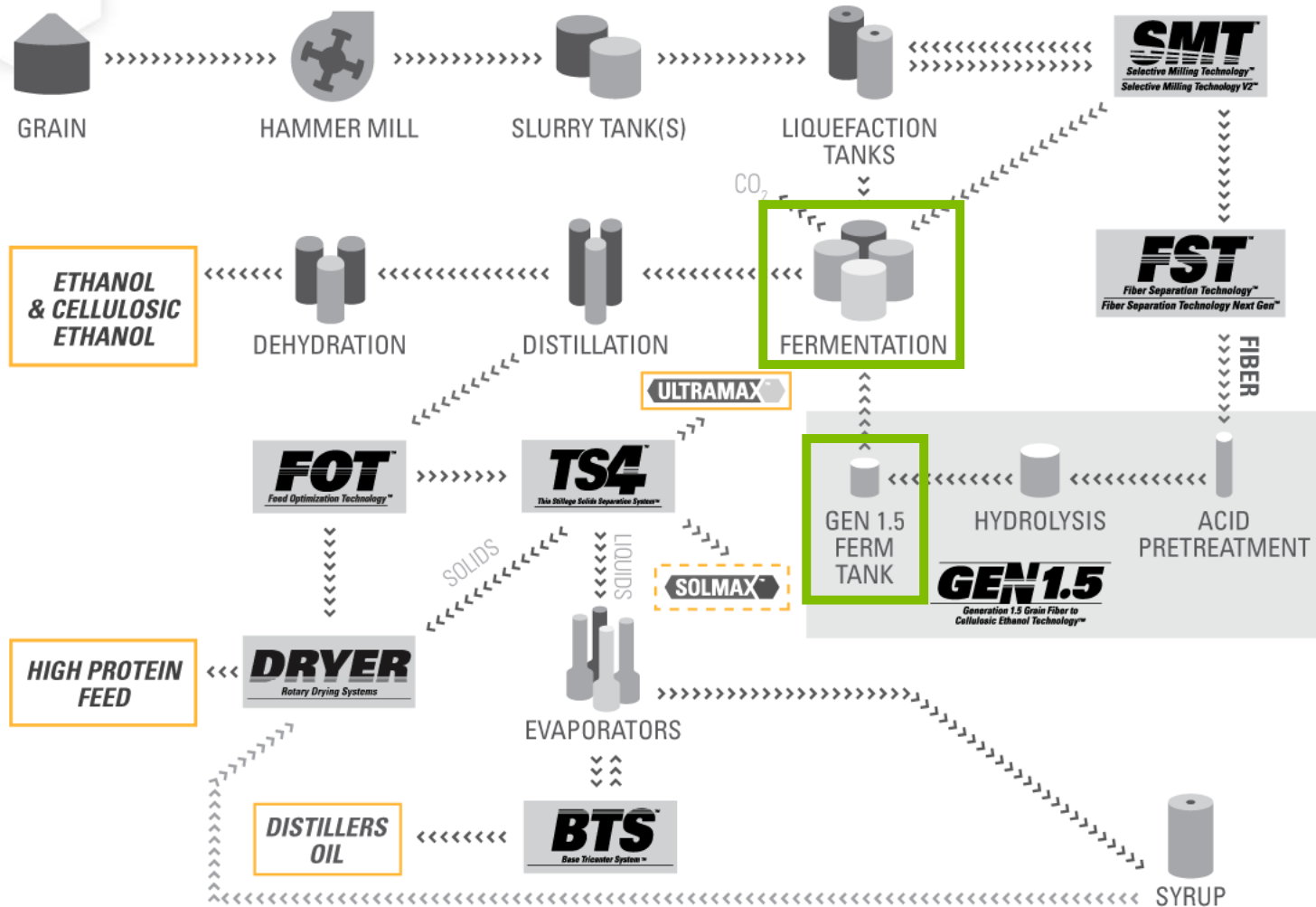


Sulfuric Acid and Ammonia get multiple uses:

- Catalysts in Gen 1.5 pretreatment
- Nitrogen source in fermentation
- Acidifier in evaporation (reduces ash waste)



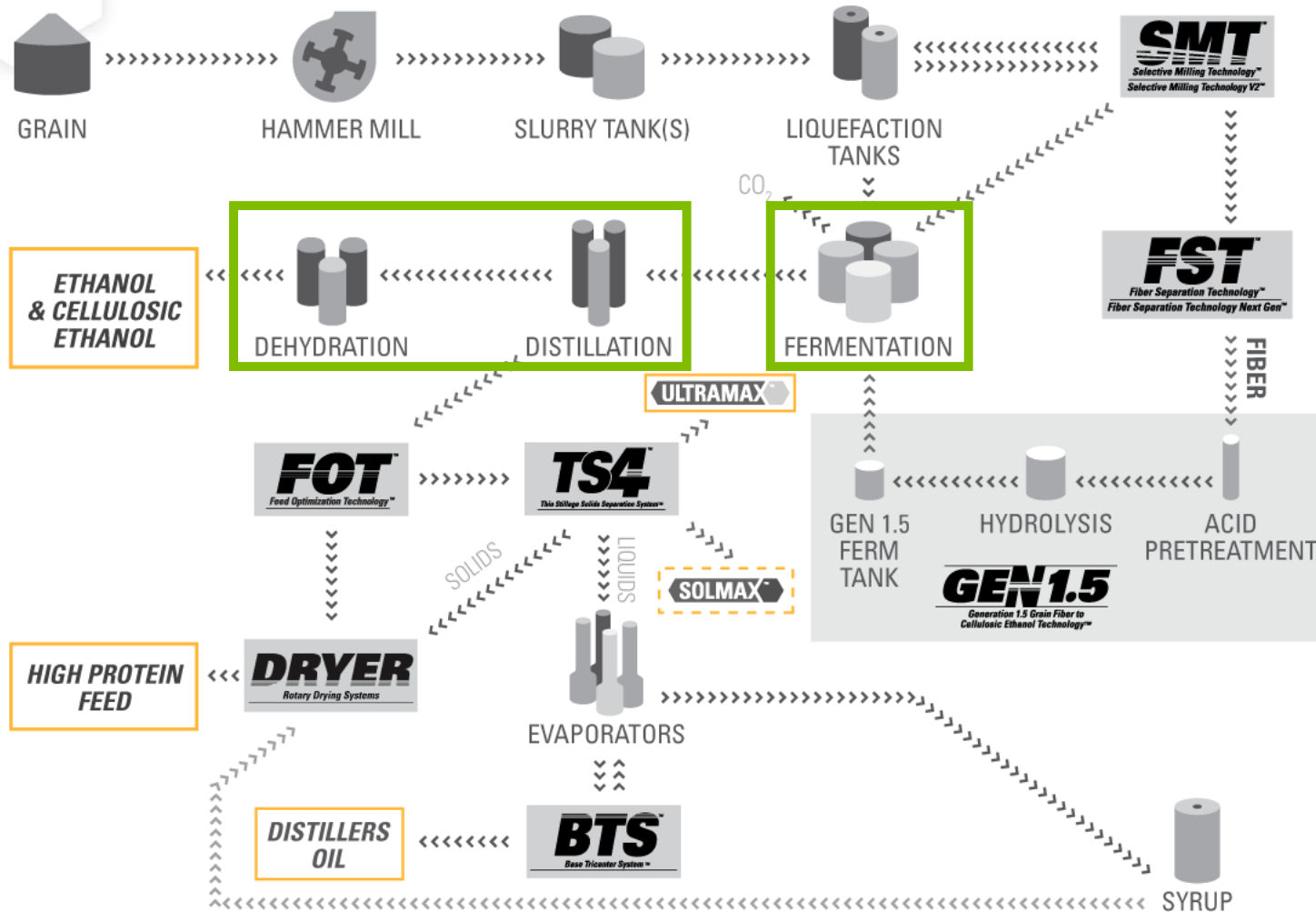
Integrating Flows with Gen 1.5 Gives Higher Yields



- Cellulosic fermentation begins in its own tank
- The Gen 1.5 beer is then added back to the starch slurry as a dilution to save water
- A typical Gen 1.5 process can only make 7% additional ethanol from the fiber; ICM's integration realizes an additional 3% yield in the starch fermentation



Integrating Flows with Gen 1.5 Saves Capital



- Removing fiber up front reduces the volume load to the fermentation and backend of the process, freeing up capacity
- Cellulosic fermentation finishes fermenting with the starch slurry
- Cellulosic ethanol is processed with the rest of the ethanol in the existing back end of the plant





**ICM's Gen 1.5
Technology Being
Commissioned at
ELEMENT™**





May 2019



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Analytical Methods

Current Analytics

- Quantifying cellulose within large quantities of starch can be difficult:
 - Solubilized starch can mimic the form of cellulose if not analyzed properly (addressed in draft ASTM)
 - Starch must often be quantified before cellulose, causing other issues
 - Current publicly available cellulose and starch methods can require 32 tests per validation of batch/lot to determine statistically relevant yields (numerous tests can impact profitability), so proprietary methods are most practical but add complexity



Opportunity for Improved Analytics

- Online systems with continuous analysis can streamline reporting and provide continuous feedback for yield optimization
 - FT-NIR, et al. methods are not currently available but could be beneficial
- The most preferable system would be direct cellulose quantification, so prior separation of starch is not needed for accuracy
 - This method is not publically available



Conclusions

- Using corn fiber for cellulosic ethanol is a logical first step in cellulosic ethanol production for the existing biofuels industry
- ICM's Gen 1.5 is a hybrid of in-situ and a separate process to maximize benefits and minimize issues
 - ICM's Gen 1.5 builds upon other ICM technologies to minimize cost, energy consumption, water consumption and waste
- The development of ICM's Gen 1.5 technology is complete
 - ICM's Gen 1.5 technology is currently being commissioned at the ELEMENT™ plant in Colwich, KS
 - Version two of ICM's Gen 1.5 is already in development
- Online analytics have the potential to streamline the process and allow for better optimization





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THANK YOU

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