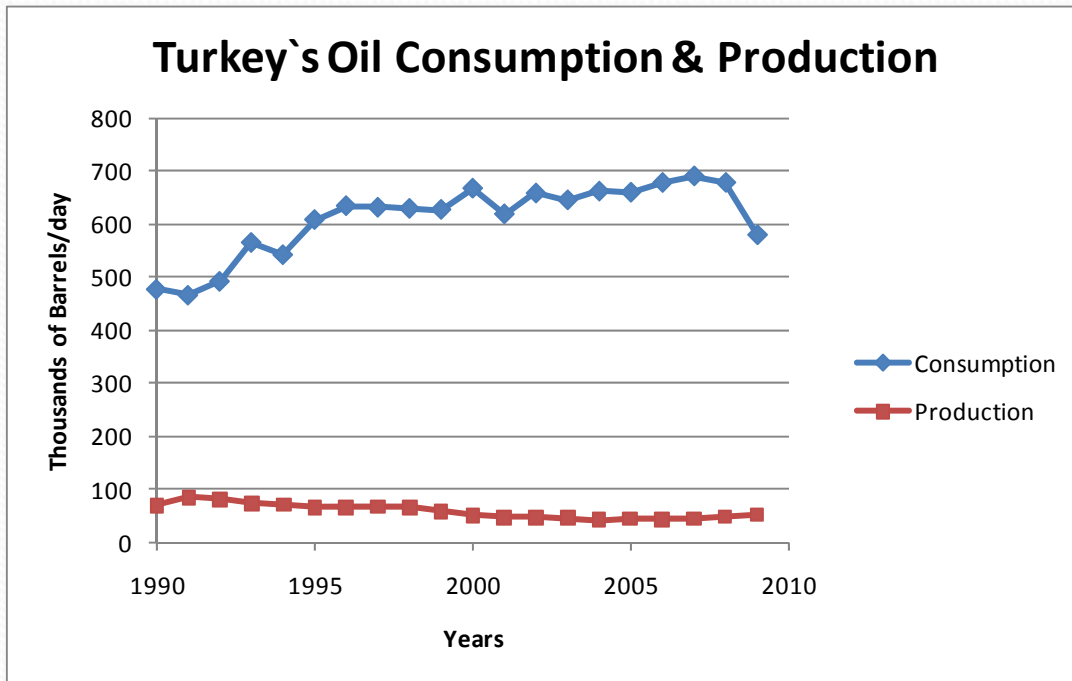


BIOETHANOL PRODUCTION POTENTIAL OF TURKEY AS AN ALTERNATIVE FUEL FROM AGRICULTURAL RESIDUES



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Motivation for a Bio-economy



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Biorenewable Resources

- Organic material of recent biological origin (commonly known as biomass)
- Biorenewable resources are by definition sustainable natural resources, which renew themselves so that they will be available for the next generations.



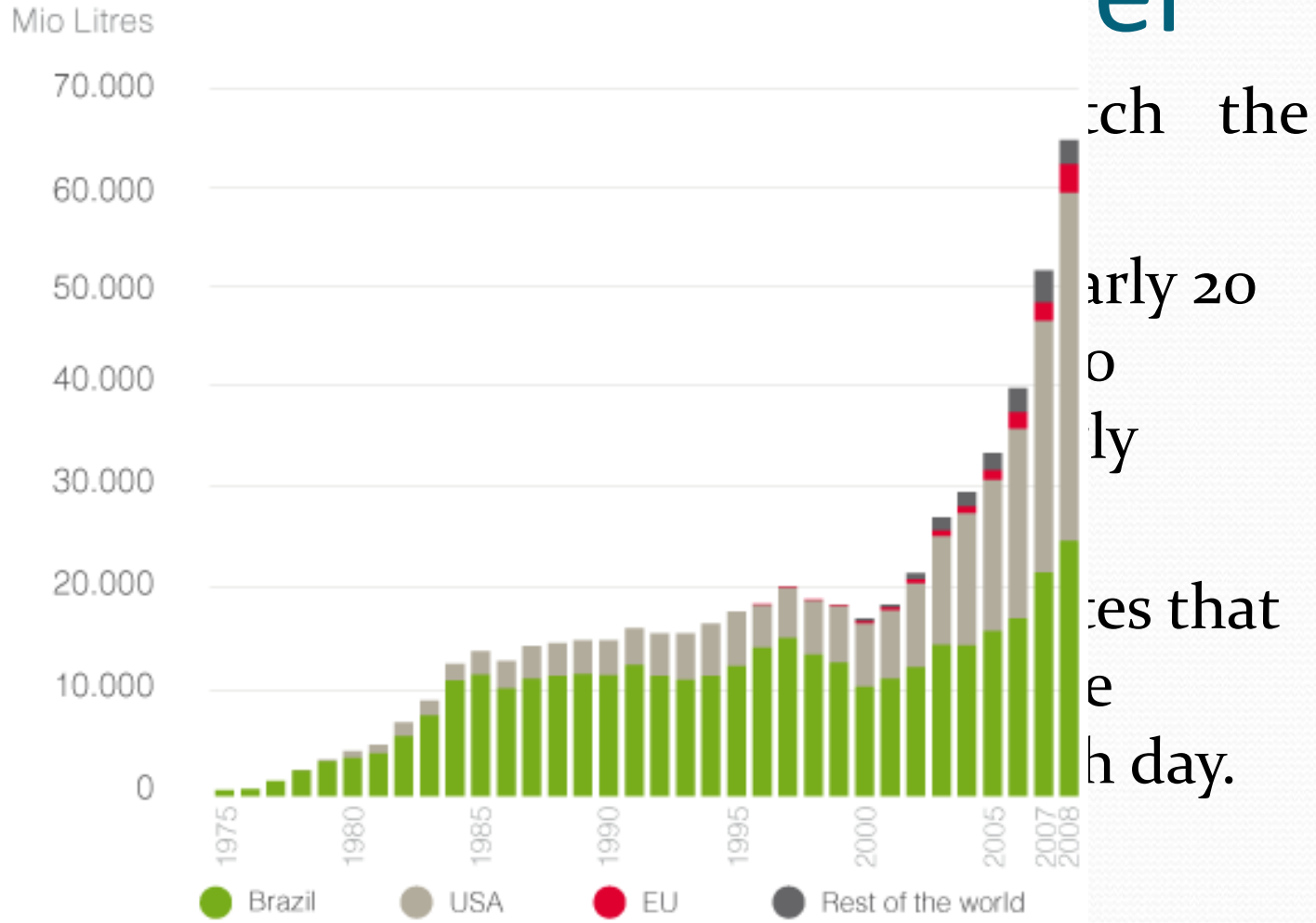
Defining the Resource Base

- Wastes
 - Agricultural residues (corn stover, wheat straw, bagasse)
 - Yard waste
 - Municipal solid waste
 - Food processing waste (grain hulls)
 - Manure
- Dedicated energy crops
 - Conventional crops (corn and soybeans)
 - Herbaceous crops (grasses)
 - Woody crops (hybrid poplar, eucalyptus)



Ethanol as an alternative fuel

- One of the most convenient
- In 2008, 15 billion gallons of ethanol were produced in the USA, 400% greater than in 1975
- The International Energy Agency estimates that ethanol will displace 10% of the world's oil by 2020



Sources: eBIO & F.O. Licht

Ethanol as an alternative

- Sugar crops (sugar cane in Brazil)
 - Starch crops (corn in the US)
 - Lignocellulosics (All cellulosic material-future process) → **2nd Generation Biofuels**
- 1st. Generation Biofuels**



Bio-ethanol in Turkey

- Bio-ethanol is being produced in Turkey only from molasses, corn, wheat & sugar beet (~150 Million L/y)
- Sugar and starch crops will support the development of bio-fuel production in the near future but utilizing lignocellulosic biomass has more advantages over edible feedstock in the long run.

TARKİM A.Ş. BURSA
MUSTAFAKEMALPAŞA

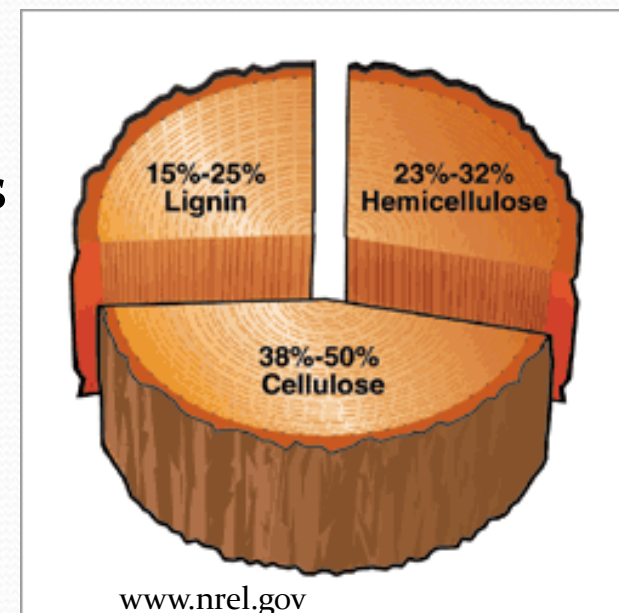


Why cellulosic ethanol better?

- Utilizing edible biomass may increase the demand and prices of these crops
- Cellulosic ethanol reduces GHG emission by 90% compared to gasoline (corn-based ethanol decreases emissions by only 10-20%)
- Cellulosic ethanol has a 3 times better net energy balance than corn-based ethanol

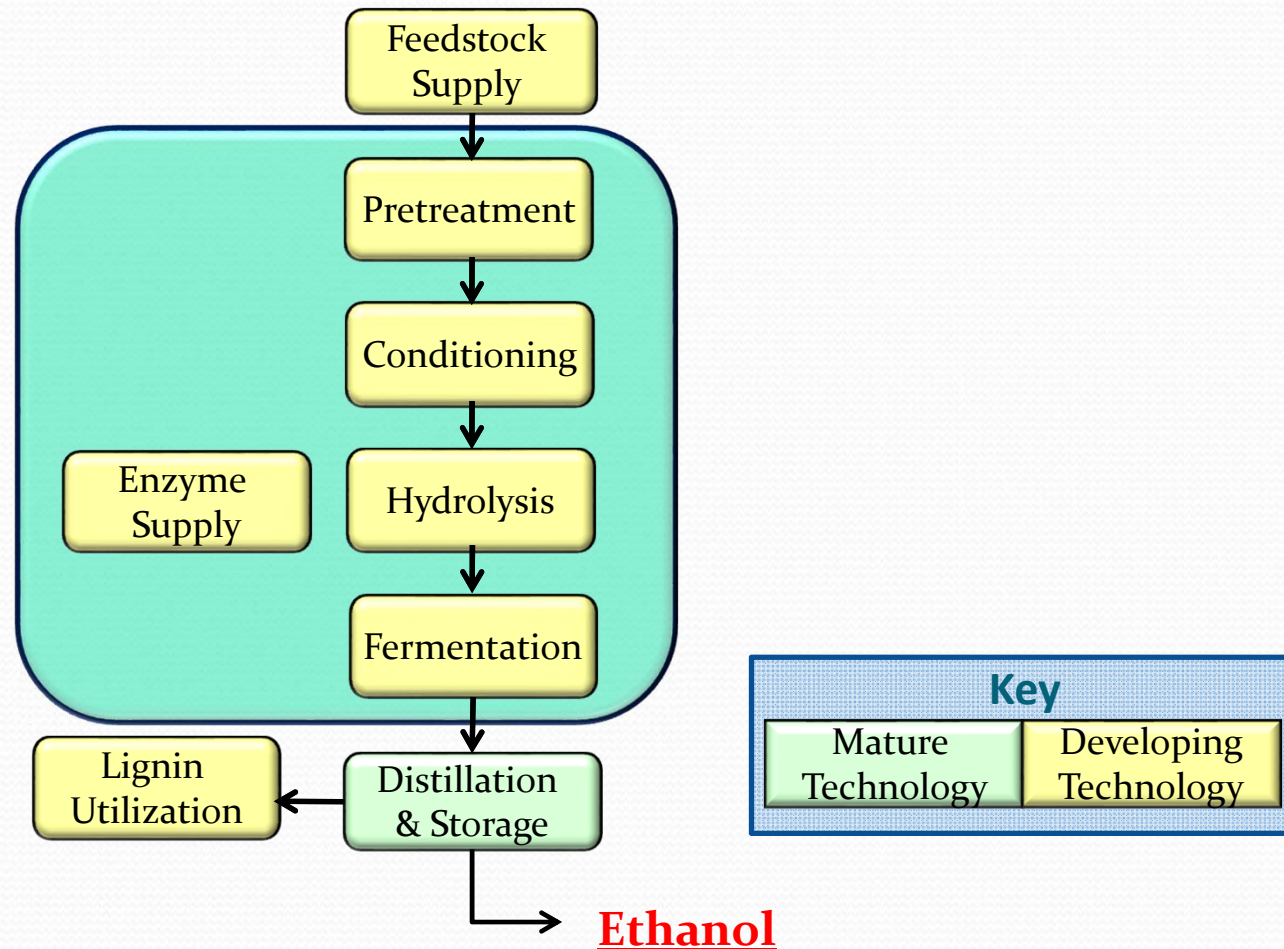
Lignocellulose

- *Lignocellulose*- composite of cellulose fibers embedded in a cross-linked lignin-hemicellulose matrix
 - Cellulose and hemicellulose are polymers of sugars and can be broken down to fermentable sugars
 - Strong, stable structural material



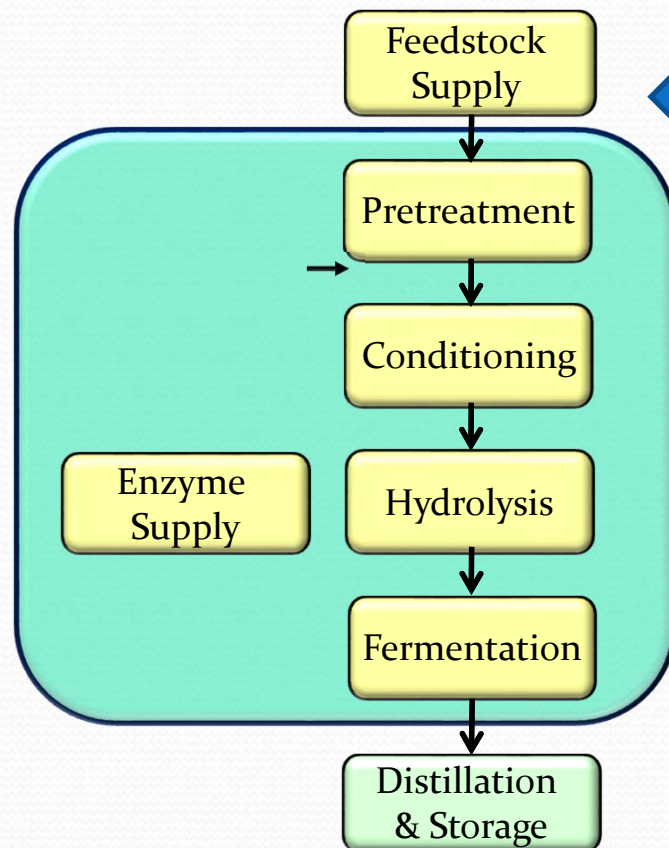
Cellulosic Ethanol

Traditionally Proposed Approach

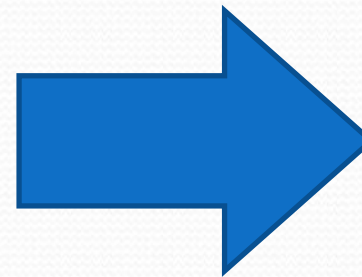
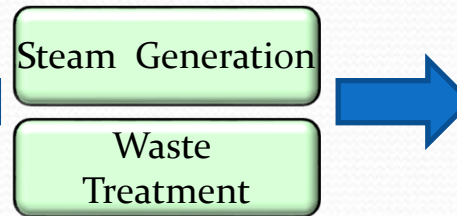
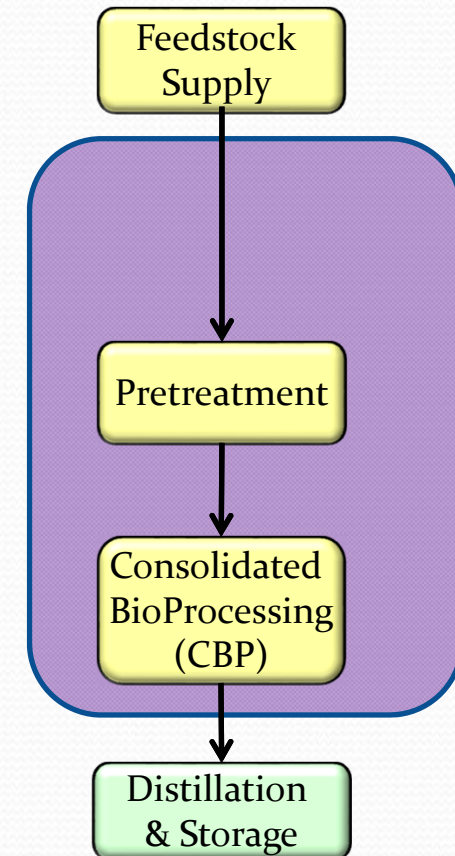


Consolidated Bio-Processing

Traditionally Proposed Approach



Advanced Approach



Key

Mature Technology

Developing Technology

Turkey has a large potential

- Agricultural residues can be an important renewable energy source.
- With its 25 million hectares arable land, Turkey, has a vast agricultural potential.
- Cereals and oil seeds are important biomass crops which are cultivated in considerable amounts, therefore, they are the major source of agricultural residues in Turkey.
- Turkey is a top 10 producer of wheat in the world and wheat straw is the major agricultural residue in Turkey.

Production and estimated amount of residues for major agricultural crops in Turkey

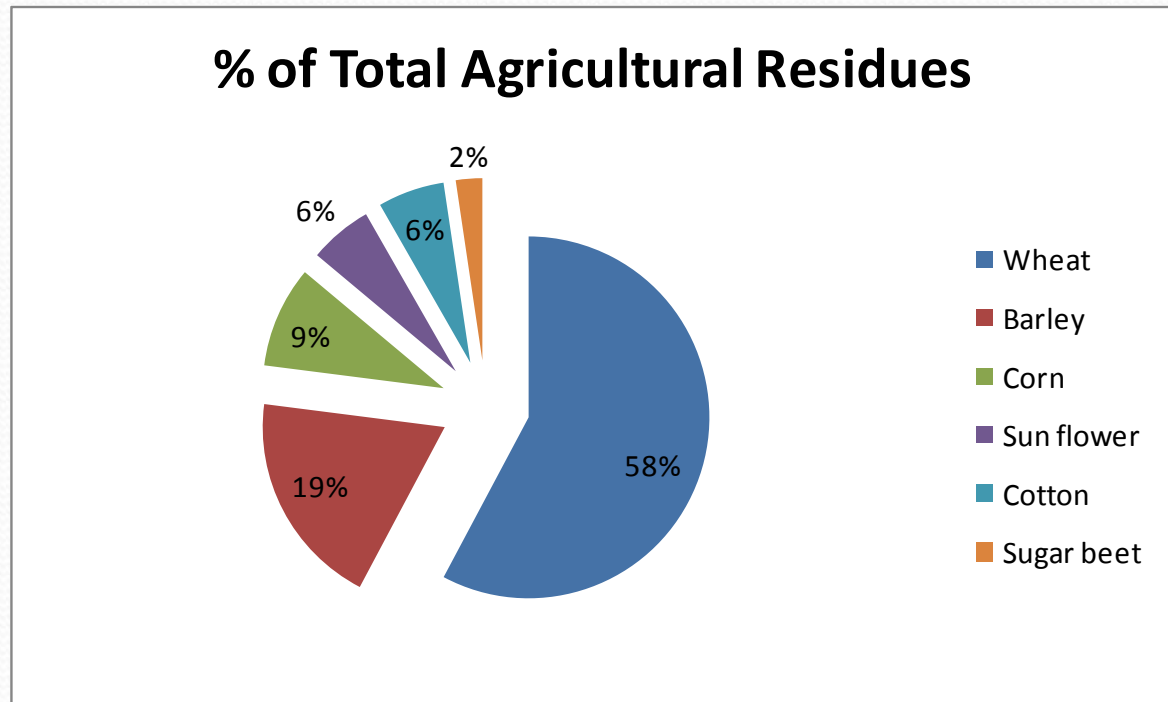
Crop	Residue type	Production (X1000 ton) ^a	Estimated Amount of Residue (X1000ton) ^b	Estimated Amount of Waste (X1000ton)-excluding the amount to prevent erosion and animal feed
Wheat	straw	17782	26673	10669
Barley	straw	5923	8885	3554
Corn	stalks	4185	4185	1674
Sun flower	stalks	992	2610	1044
Cotton	stalks	1820	2730	1092
Sugar beet	bagasse	15488	1084	434
Total		46190	46167	18467

^a TUGEM (Turkey General Directorate of Agricultural Production and Development)

^b Residue to grain ratio are taken Brown R. BioRenewable Resources (2003). Iowa State Press, Iowa.

Agricultural Residues

- Approximately, 18.5 million ton dry lignocellulosic biomass residue (excluding the amount to prevent soil erosion and animal feed) from these crops is available per year for conversion to bio-ethanol.



- Wheat and barley straw accounts for 58% and 19% of the total crop residue, respectively.

Total Bio-ethanol Potential

- A total of **5.4 GL of bio-ethanol/year** can be generated.

Crop	Residue type	Residue (X1000ton)	Total ethanol potential (L)	Gasoline equivalent (L)
Wheat	straw	10669	3094068000	2227728960
Barley	straw	3554	1101678000	793208160
Corn	stalks	1674	485460000	349531200
Sun flower	stalks	1044	302760000	217987200
Cotton	stalks	1092	316680000	228009600
Sugar beet	bagasse	434	125762560	90549043
Total		18467	5426408560	3907014163



Turkey's Bio-ethanol Potential

- One hundred-km driven by a conventional gasoline-fueled midsize passenger car requires 11 L of gasoline. For E85 fuel, 100-km driven consumes 2.2 L of gasoline and 12 L of bio-ethanol. Therefore, 1 L of bio-ethanol could replace 0.72 liters of gasoline.
- 5.4 GL of bio-ethanol/year could **replace 3.9 GL of gasoline/ year** when bio-ethanol is used in E85 fuel for a midsize passenger vehicle.
- The calculations suggested that bio-ethanol production from only wheat and barley straw can **replace 96% of annual gasoline consumption** in Turkey.
- Furthermore, Turkey can **export** approximately 0.77 GL gasoline equivalent of bio-ethanol per year.

Conclusion

- These findings indicate that Turkey has a huge potential to be an **energy independent** country.
- However there are still too many unknowns regarding cellulosic ethanol yet to be determined.
 - Material handling
 - Better pretreatment techniques
 - Cheaper and more effective enzymes
 - Better utilizing organisms (genetic engineering)
- Though cellulosic ethanol has potential, it will not be the only solution to our energy problem. There will be other sustainable approaches and ethanol will be a part of it.

References

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- Kim S & Dale B. Global potential bio-ethanol production from wasted crops and crop residues. (2004). 26:361-365.
- Renewable Fuels Association(RFA's Ethanol Industry Outlook 2010)
- TARKİM (<http://www.tarimsalkimya.com.tr>)
- TUGEM (General Directorate of Agricultural Production and Development)
- US. Department of Energy
- US Energy Information Administration
- US Environmental Protection Agency
- US National Renewable Energy Laboratory

The image features a solid blue background with a subtle gradient. At the top, there are several overlapping, wavy lines in various shades of blue, creating a dynamic, flowing effect. The text "Thank you" is centered in the middle of the frame in a clean, white, sans-serif font.

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