



**BOĞAZIÇI UNIVERSITY
SUSTAINABLE DEVELOPMENT AND CLEANER
PRODUCTION CENTER
INSTITUTE OF ENVIRONMENTAL SCIENCES**

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The Challenges Associated with Lignocellulosic Bioethanol Production and Consumption Considering Renewable Energy Policies in Turkey

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LAYOUT

- Current Energy Situation in the World
- Why Renewables?
- ✓ Why Bioethanol?
- ✓ Why Bioethanol from Lignocellulosics?
- World Bioethanol Production as Transportation Fuel
- Bioethanol Incentive Program and Policy Examples
- Lignocellulosic Feedstock and Second Generation Bioethanol Production Potential in Turkey
- Turkey's Renewable Energy Policies for Bioethanol
- Challenges in Turkey
- Recommendations





CURRENT ENERGY SITUATION IN THE WORLD

- ❑ Energy use per capita in World is 1802.57 kgoe per capita in 2009
(World Bank, 2010)

- ❑ The world's total proven reserves by the end of 2010 :
 - Oil : 188.8 billion tons
 - Natural gas : 187.1 trillion m³
 - Coal : 860.9 billion tons

- ❑ With current consumption trends, the reserves-to-production (R/P) ratio of world by 2010 :
 - Oil : 41.6 years
 - Natural gas : 60.3 years
 - Coal : 133 years



WHY RENEWABLES ?

- ❑ Global Primary Energy Demand → will increase by one-third between 2010 and 2035 (IEA, 2011)
 - 3.5°C increase in global temperature
 - Energy-related CO₂ emissions increase by 20%
- } **by 2035**

(International Energy Agency-World Energy Outlook, 2011)





WHY RENEWABLES ?

Transportation sector;

- ✓ 95% fossil fuel dependent

(BP Energy Outlook 2030, 2012)

- ✓ responsible for 61% of the world oil consumption

(IEA, 2009)

- ✓ Cause 23% of global CO₂ emissions.

(IEA Statistics Highlights)

EU targets;

- ✓ 10% share of renewable energy in the transport sector } **by 2020**

*Transport biofuels based on lignocellulose count as double
for the national target*

(Renewable Energy Directive, 2009)

Adverse effects of GHG emissions

Declining petroleum reserves

**BIOFUELS FROM
RENEWABLES**



WHY BIOETHANOL ?

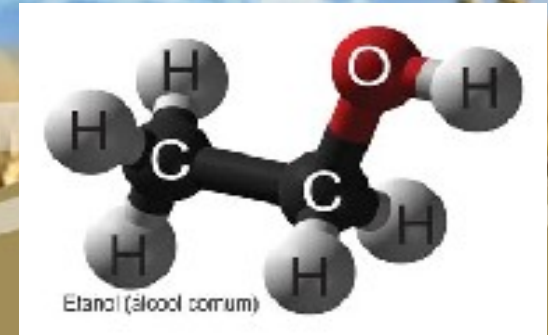


Table 1. Fuel properties of gasoline and bioethanol

Property	Ethanol	Gasoline
Chemical Formula	C_2H_5OH	C_4 to C_{12}
Molecular Weight	46.07	100–105
Carbon content, Weight %	52.2	85–88
Hydrogen content, Weight %	13.1	12–15
Oxygen content, Weight %	34.7	0
Density, g/cm^3 @ 15,5 ° C	0.79	0.72-0.75
Octane no.	108	90–100
Energy Density (MJ/L)	20.000	32.200
High heating value (MJ/kg)	29.8	47

☐ Renewable bioethanol fuel;

- ✓ Oxygenated fuel containing 35% oxygen
- ✓ More efficient combustion- Less HC and PM
- ✓ Higher octane number (prevent engine knocking problem) and flame speeds and than gasoline
- ✓ Improve regional development, enhance rural manufacturing jobs,



WHY BIOETHANOL FROM LIGNOCELLULOSICS?

- ❑ Bioethanol can be produced from:
 - ✓ Sucrose-containing feedstocks (e.g. sugar cane, sugar beet, sweet sorghum and fruits),
 - ✓ Starch materials (e.g. corn, wheat, rice, potatoes, cassava, sweet potatoes and barley)
 - ✓ Lignocellulosic materials (e.g. wood, straw and grasses)

- ❑ Mostly used feedstocks for bioethanol production (corn, sugarcane, etc)

- ❑ Current focus on → bioethanol from lignocellulosic biomass and agricultural residues
 - ✓ **Compete with food sector**
 - Feedstock availability (seasonal harvesting)
 - High feedstock prices



WHY BIOETHANOL FROM LIGNOCELLULOSICS?

Table 2. Estimated typical values for future biofuels that were not on the market or were on the market only in negligible quantities in January 2008, if produced with no net carbon emissions from land-use change

Biofuel Production Pathway	Typical GHG Emission Saving
Wheat ethanol (lignite as process fuel in CHP plant)	32 %
Wheat ethanol (straw as process fuel in CHP plant)	69 %
Wheat Straw Ethanol	87%
Waste Wood Ethanol	80%
Farmed Wood Ethanol	76%



WORLD BIOETHANOL PRODUCTION AS TRANSPORTATION FUEL

Country	Energy Crop	Bioethanol Yield (l/ha)
Brazil	Sugarcane, 100%	6641
USA	Corn, 98% Sweet sorghum, 2%	3370 1365
China	Corn, 70% Wheat, 30%	2011 1730
EU-27	Wheat, 48% Sugar beet, 29%	1702 5145
Canada	Corn, 70% Wheat, 30%	3460 1075





BIOETHANOL INCENTIVE PROGRAMS AND POLICIES IN THE WORLD

- ❑ Growing interest for biofuels around the world with bio-fuel programs to reduce :
 - ✓ GHG emissions
 - ✓ Dependence on petroleum-based fuels
- ❑ **ProAlcool in Brazil:**
 - ✓ Aim: To increase bioethanol production as a substitute for gasoline.
 - More incentives for private investment and reducing government intervention in allocations and pricing.
 - ✓ Started in 1975. Since 2007, the mandatory blend is 25% of anhydrous ethanol [(96 bio-ethanol + 4 water)/100]
 - ✓ More than 80% of current automobile production has flexible-fuel capability (30% in 2004)
 - ✓ Bioethanol fuel is available at almost all of Brazil's 32,000 gas stations





BIOETHANOL INCENTIVE PROGRAMS AND POLICIES IN THE WORLD

❑ **Clean Cities in US** (*US Department of Energy*):

- ✓ Aim: To provide informational, technical, and financial resources to EPA-Act-regulated fleets and voluntary adopters of alternative fuels and vehicles to reduce petroleum use.
- ✓ sponsored by the Vehicle Technologies Program.
- ✓ Has saved more than 3 billion gallons of petroleum since 1993.
- ✓ Current goal: To reduce petroleum use in the US by 2.5 billion gallons per year by 2020 with 3 strategies of “Replace, Reduce, Eliminate”.

(Clean Cities Overview, 2012)





BIOETHANOL INCENTIVE PROGRAMS AND POLICIES IN THE WORLD

□ US LEGISLATION:

- ✓ Energy Policy Act of 2005 (EPAct 2005) :
 - 10 cents per gallon incentive on the first 15 million of ethanol produced each year for small producer
 - 30% tax credit for installation of alternative fuel stations, up to \$30,000
- ✓ Energy Independence and Security Act of 2007 (EISA):
 - Aims 57.5 billion liters of bio-fuels (mainly bio ethanol) in 2012 and 136 billion liters in 2022.





BIOETHANOL INCENTIVE PROGRAMS AND POLICIES IN THE WORLD

□ US continue :

- ✓ Volumetric Ethanol Excise Tax Credit (VEETC), 2010 → policy to subsidize the ethanol production in US until 2016
 - 45-cent per a gallon tax credit for gasoline blenders
 - \$1.01 per a gallon credit to cellulosic ethanol producers
 - 10-cent per a gallon small-producer tax credit for ethanol in US.





BIOETHANOL INCENTIVE PROGRAMS AND POLICIES IN THE WORLD

□ EU LEGISLATION :

- ✓ The EC White Paper: European transport policy (COM/2001/0370) → to reduce oil dependency of transportation sector
- ✓ Renewable Energy Directive (Directive 2009/28/EC): 20% share of all renewable energy sources and 10% share of renewable energy in the transport sector by 2020.
- ✓ In 2007, Fuel Quality Directive (Directive 2009/30/EC) : To allow adequate levels of blending, 6% reduction in GHG intensity used in road transport by 2020
- ✓ Tax reductions for bio-ethanol in EU countries as high as US\$0.84 per liter.

(Balat and Balat, 2009)



LIGNOCELLULOSIC FEEDSTOCK AND SECOND GENERATION BIOETHANOL PRODUCTION POTENTIAL IN TURKEY

Table 3. Crops production and residues in Turkey
(LIFE Programme, 2005)

Crops	Residues	Production (ton)	Area (ha)	Yield (kg/ha)	Available residues (ton)	Calorific value (MJ/kg)
Corn	Stalk	2,209,601	565,109	3,190	2,982,155	18.5
	Cob				1,144,384	18.4
Wheat	Straw	22,439,042	9,424,785	2,381	3,514,486	17.9
Rice	Straw	331,563	59,879	5,337	125,719	16.7
	Husk				62,198	12.98



LIGNOCELLULOSIC FEEDSTOCK AND SECOND GENERATION BIOETHANOL PRODUCTION POTENTIAL IN TURKEY

Table 4. Corn, Wheat and Rice Crops Production and Residues in Turkey
(LIFE Programme, 2005)

Region	Production (ton)	Area (ha)	Yield (kg/ha)	Available residue (ton)		Calorific Value (Mj/kg)	
				Stalk	Cob	Stalk	Cob
Mediterranean Region (Corn)	758,458	205,058	3.699	Stalk	Cob	Stalk	Cob
				1,379,988	577,846	18.5	18.4
Central Anatolian Region (Wheat)	6,269,294	3,124,326	2,007	1,022,608		17.9	
Marmara Region (Rice)	209,094	37,459	5.582	Straw	Husk	Straw	Husk
				78,185	36,116	16,7	12,98

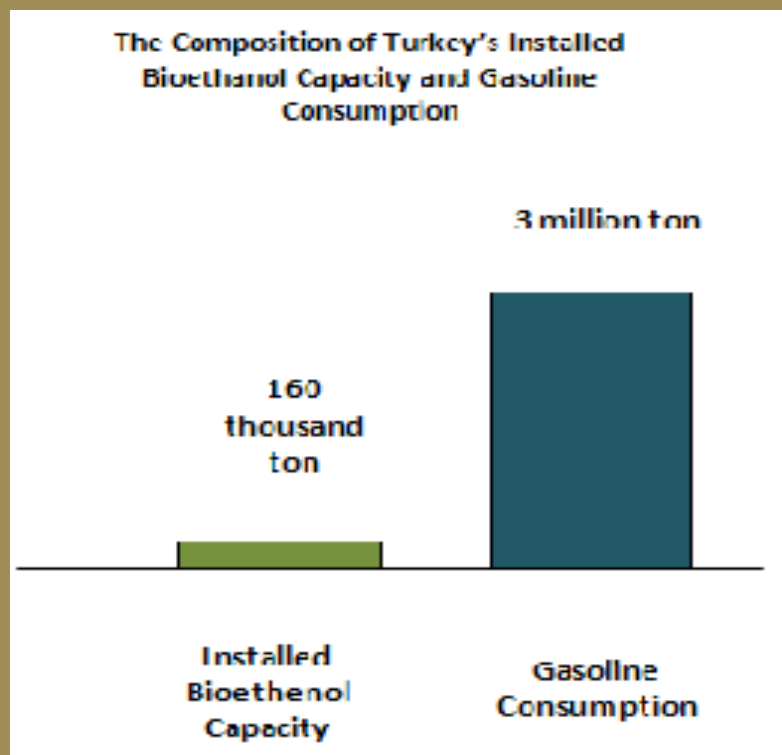
LIGNOCELLULOSIC FEEDSTOCK AND SECOND GENERATION BIOETHANOL PRODUCTION POTENTIAL IN TURKEY

Table 4, The maximum theoretical bioethanol yield (NREL, 2009)

Wheat straw	431 L/ton
Corn stover	427 L/ton
Rice straw	417 L/ton

- ✓ Wheat Straw:
 $431 * 1,022,608 = 440$ million L
- ✓ Corn Stover:
 $427 * (1,957,834) = 835$ million L
- ✓ Rice Straw:
 $417 * (114,301) = 32$ million L

TOTAL= 1.307 million L potential bioethanol production capacity in TURKEY



(The Turkish Ministry of a Energy and Natural Sources, 2010)



TURKEY' S RENEWABLE ENERGY POLICIES FOR BIOETHANOL

- ❑ In 2006, the Amendment Regarding the Communication of Technical Regulation of Gasoline Types was published;
 - ✓ the denaturalization of bioethanol to the gasoline before the market supply must be at least 1% as volumetric ratio.
- ❑ In 2011, this regulation was revised:
 - ✓ the blending ratio of bioethanol produced from agricultural products to the petroleum products :
 - by the 1th of January 2013, will be minimum 2%
 - by the 1th of January 2014, will be minimum 3%.





CHALLENGES in TURKEY

❑ Storage and Distribution

- ✓ Ethanol is relatively corrosive → special vehicles for transportation and containers for storage against corrosiveness
- ✓ Water is immiscible in gasoline and fully miscible in ethanol → ethanol can easily be affected by moisture in storage and distribution systems;
 - Dry systems to be provided, equipped with automatic moisture control





CHALLENGES in TURKEY

□ Taxes :

In Turkey,

- ✓ About 180 million liter bioethanol capacity \approx 8% of gasoline demand \rightarrow but fuel bioethanol use is LOW
- ✓ Tax exemption for just 2% bioethanol-gasoline blend
(The Turkish Private Consumption Tax Bulletin, 2005)
- ✓ There is no financial supports or incentives for investments for installation of fuel stations for ethanol
(World Energy Council Turkish National Committee Energy Report 2010)





CHALLENGES in TURKEY

❑ Legislation:

- ✓ According to the Amendment Regarding the Communication of Technical Regulation of Gasoline Types (2011)→ obligation of minimum 2% blending ratio for bioethanol-gasoline by 2013 and 3% by 2014.
 - BUT still tax exemption just for 2%!
- ✓ This regulation has been released late compare to similar laws of EU member countries
- ✓ The goals set by the regulation are lower compared to other OECD countries
- ✓ 2% addition of bioethanol to gasoline with regarding to the exemption formulation in the Private Consumption Tax Bulletin by only Petrol Ofisi.





RECOMMENDATIONS

In order to successfully implement the renewable energy schemes in Turkey, the following measures need to be taken:

Political

- ✓ Should provide strong political support through adoption of policies in favour of bioethanol use
 - Specific targets with well defined deadlines must be set for share of renewables in the fuel market and CO₂ emission levels





RECOMMENDATIONS

❑ Legislative

- ✓ The proposed legislations should ensure;
- ✓ the energy market is accessible to independent bioethanol producers
 - By providing support for a guaranteed market, tax intensives/exclusives, subventions and incentives for bioethanol producers, and obligation of higher blends for vehicle fuel users.
- ✓ The blending and sale of bioethanol blends should be performed by private fuel distribution companies *like in the Petrol Ofisi case*





RECOMMENDATIONS

Legislative *continue*

- ✓ Although the allowed blend ratio without any engine modification is 10% by the regulations, the minimum obligated blending ratio is 2% by 2013 and 3% by 2014 by the legislation.
 - This lower ratio requirement prevents the extensive usage of fuel ethanol.
- ✓ Increasing this legal limit ratio will enhance the new tax applications in the sectors such as agriculture, industry, transportation and banking





RECOMMENDATIONS

Financial

- ✓ Tax exemption applied for 2% blends should be raised to 5% blends since, the installed bioethanol capacity is sufficient for meeting the current demand.
- ✓ Bioethanol production projects should have an easy access to financial support for facilitating investments, grants, loans, subsidies, etc.
- ✓ Provided financial support must cover all costs associated with bioethanol in order to keep the prices competitive with fossil based fuels, *particularly through the use of energy taxation*





RECOMMENDATIONS

- ❑ Role of public authorities
 - ✓ Should provide active support in the set up and implementation of bioethanol projects, including awareness raising and information dissemination campaigns, targeted towards promotion of the benefits of bioethanol use to the community such as:
 - New sector→job opportunity for rural community which could prevent the immigration
 - New market →improving several sectors (agriculture, industry, transportation and banking) and increasing employment
 - Cleaner fuel for cleaner environment





**THANK YOU FOR YOUR
ATTENTION...**

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