

# Isobutanol in Marine Gasoline

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1B: Drivers for Emergence of Biofuels for Maritime Industry



# Gevo's Current Business System



## Gevo Production Facilities

### Isobutanol Production – Side-by-Side with Ethanol



Isobutanol



## Core Near Term Markets

### Drop-in Markets - Isobutanol

#### Specialty Chemicals & Solvents



#### Specialty Gasoline Blendstock (Marine/Off-Road)



### Hydrocarbon Biorefinery



Hydrocarbons



### Drop-in Markets - Hydrocarbons

#### Jet Fuel

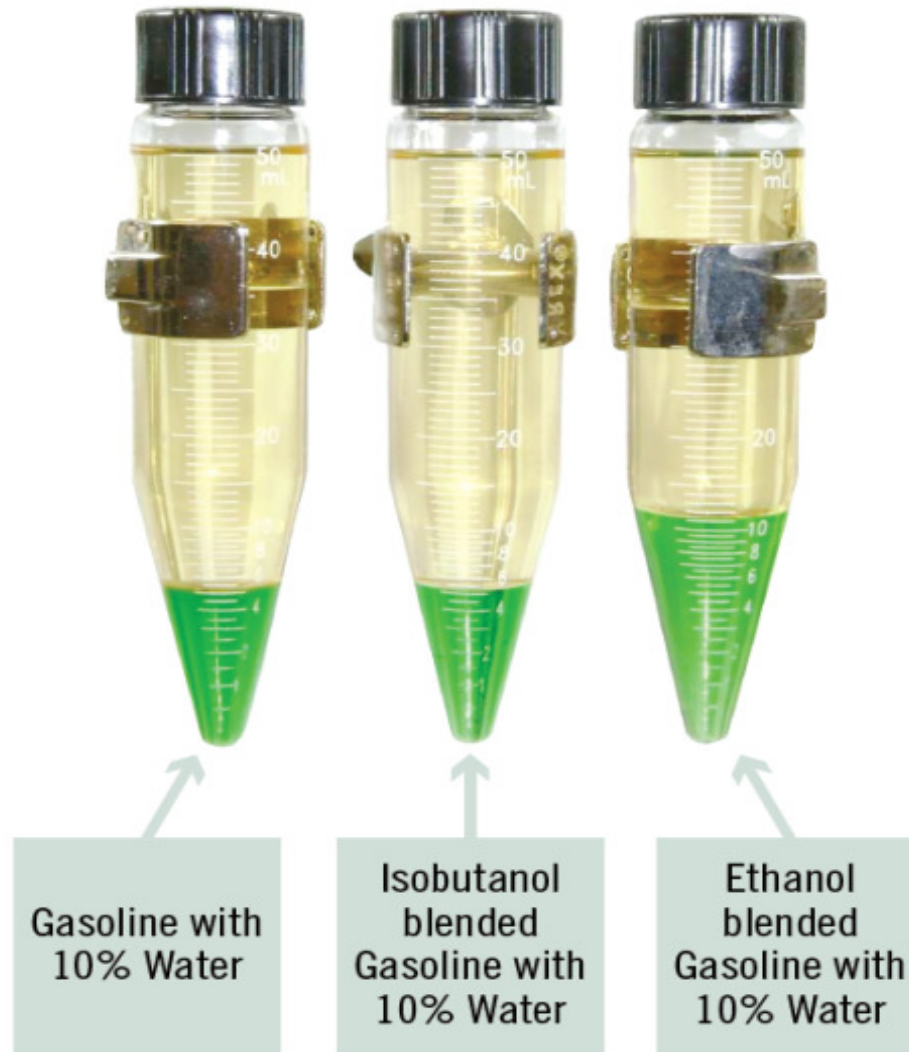


#### Isooctane (gasoline)





# Isobutanol Properties



# Gasoline blending value



	Gasoline	Ethanol	Isobutanol
RON	95	109	105
MON	85	90	91
Anti-knock Index	90	100	98
RVP (psi)	7-15	19	5.2
Density 20C [kg/m3]	720-775	794	801
Boiling Point (C)	32.2	21.1	26.6
% Heating Value of Gasoline	100	66	84
Oxygen (%w/w)	<2.7%	34.7	21.6

isobutanol has low RVP, enabling refiners to blend incremental volumes of butanes and pentanes



# Marine Research Overview



**NMMA**™ National Marine  
Manufacturers Association



18' Mako boat with 175 HP  
Evinrude GDI Outboard



24' SeaDoo Challenger boat  
with 215 HP Rotax engine



Volvo-Penta 5.7 Closed-loop  
catalyst – Almar Boat



1999 OMC Johnson  
Conventional Carbureted 2-  
stroke Intruder Boat



Indmar 6.0L Closed-loop  
catalyst – Malibu Ski Boat



150 HP Yamaha on Century Boat

Marine Engine Tested – BRP Evinrude and SeaDoo, Mercury, Volvo-Penta, Yamaha, Tohatsu, Indmar, OMC-Johnson, Honda.

# Marine Biobutanol over 5 years of research



- Alternative Fuel Butanol: Preliminary Investigation on Performance and Emissions of a Marine Two-Stroke Direct Fuel Injection Engine
- Impact of Blending Gasoline with Isobutanol Compared to Ethanol on Efficiency, Performance and Emissions of a Recreational Marine 4-Stroke Engine
- Gaseous and Particulate Emissions Using Isobutanol-Extended Fuel in Recreational Marine Two-Stroke and Four-Stroke Engines
- In-Use Performance Testing of Butanol-Extended Fuel in Recreational Marine Engines and Vessels
- Effect of Fuel Contamination of Lubrication with Marine Engine Oil
- Isobutanol Testing Update – International Boat Builders Exposition 2014
- Effect of Fuel Weathering on RVP, Distillation and Oxygen Content of Ethanol and iso-Butanol Blends
- Compatibility Study for Plastic, Elastomeric, and Metallic Fueling Infrastructure Materials Exposed to Aggressive Formulations of Isobutanol-Blended Gasoline
- Butanol Mercury Marine CRADA Report - US Coast Guard
- Butanol Honda CRADA Report - US Coast Guard

<https://sites.google.com/site/marinebiobutanolfuel/research>



# NMMA Board of Director Resolution



NMMA Board approved an Engine Manufacturer Division (EMD) resolution to support encourage the use of isobutanol 16% as the preferred renewable fuel for recreational marine engines and boats

## NMMA EMD Membership-

AB Volvo Penta  
American Honda Motor Co Inc  
BRP U.S. Inc.  
BRP U.S. Inc.  
BRP/Evinrude  
Caterpillar Inc. Global Marine Division  
Caterpillar Marine Division  
Caudwell Marine (Pty) Ltd.  
Clean eMarine Americas LLC  
Crusader Engines Pleasurecraft Engine Group  
Cummins Inc.  
Cummins MerCruiser Diesel  
Elco Motor Yachts, LLC  
Flagship Marine Engine Co., Inc.  
FPT Powertrain Technologies  
GM Powertrain, General Motors  
Honda Canada, Inc.  
Honda Marine American Honda Motor Co.  
Ilmor High Performance Marine  
Ilmor Marine LLC  
Indmar Products Co., Inc.  
John Deere Power Systems  
Kawasaki Motors Corp., U.S.A.  
Keith Eickert Performance Products  
LEHR  
MAN Engines & Components  
Marine Power, Inc.  
Megatech Marine LLC

Mercury Marine A Division of Brunswick  
Mercury Marine Latin America & Caribbean  
Mercury Marine, Ltd. (Canada)  
Nissan Marine & Power Products  
Northern Lights  
Pleasurecraft Marine Engines  
Power-Tec Trading CV  
ReGen Nautic Inc.  
Rhodan Marine Systems  
Seven Marine, LLC  
Sterling Performance, Inc.  
Steyr Motors North America  
Suzuki Canada, Inc.  
Suzuki Motor of America, Inc.  
Teague Custom Marine, Inc.  
Textron Motors  
Tohatsu America Corp.  
Tohatsu America Corp.  
Torqeedo Inc.  
Volvo Group/Volvo Penta  
Volvo Penta Canada, Inc.  
Volvo Penta of the Americas  
Westerbeke Corp.  
Yamaha Marine Group  
Yamaha Motor Canada Ltd.  
Yamaha Motor Corporation, U.S.A.  
Yamaha Motor Corporation  
Yanmar Marine International B.V.



# Reality





Thank you

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