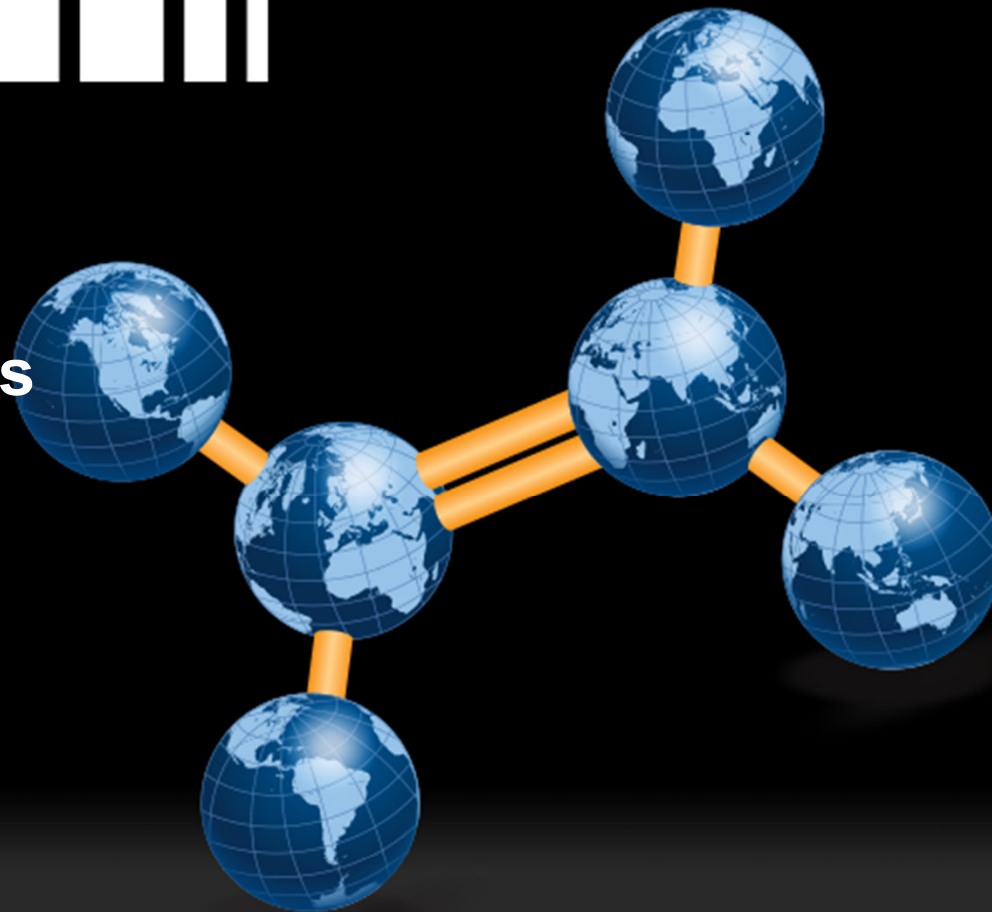


Shale Gas and Ethylene: Implications of Increased NGL Production

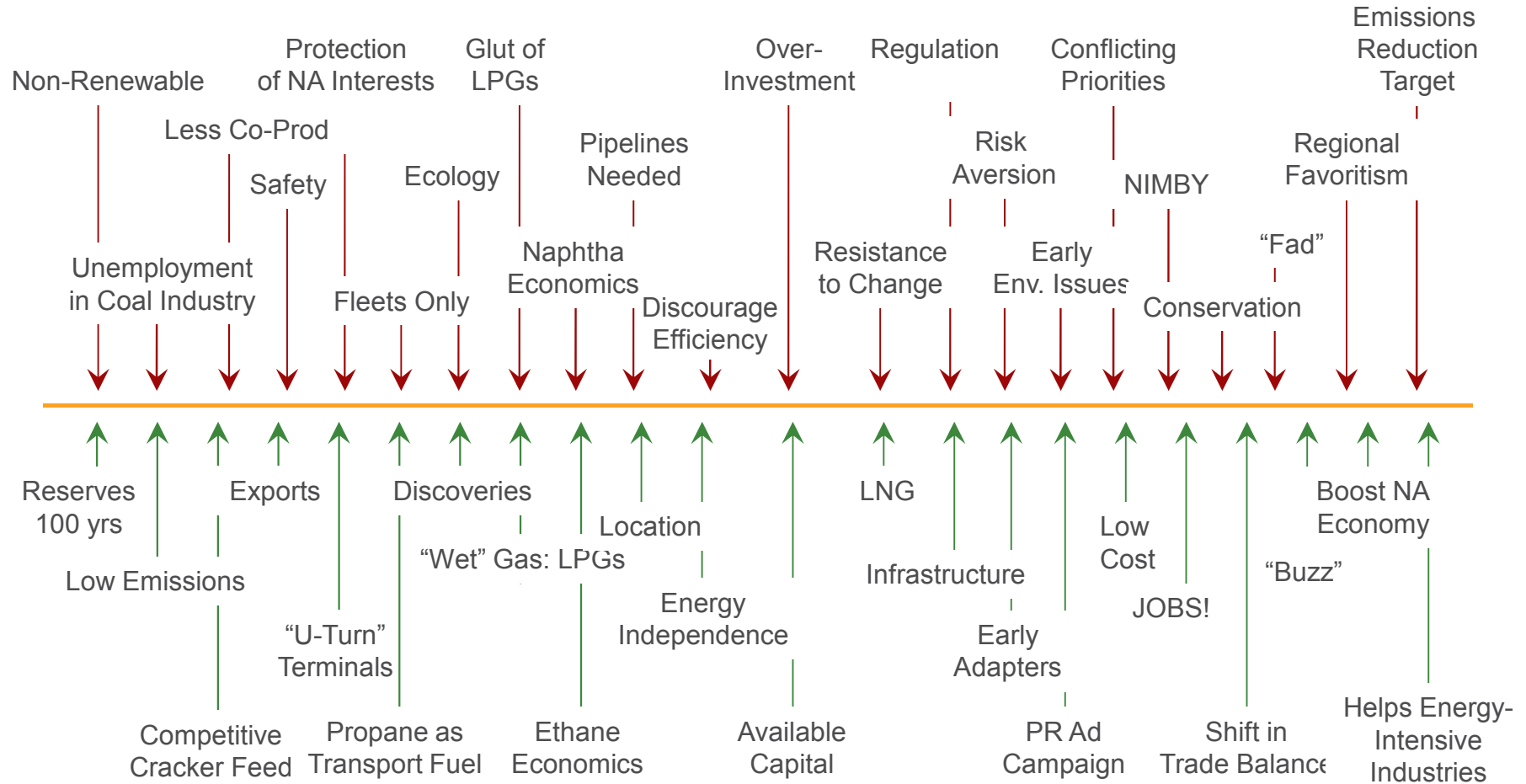
Claire L. Cagnolatti
VP, Chemicals Studies
Solomon Associates

Bill Gwozd,
Senior VP, Gas Services
Ziff Energy Group (a division of Solomon Associates)

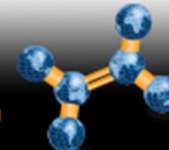


Shale Gas/LPG Production Forces

Resisting Forces (Cons)



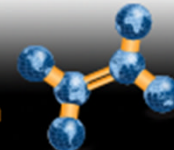
Driving Forces (Pros)





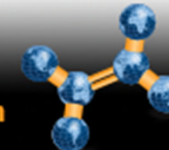
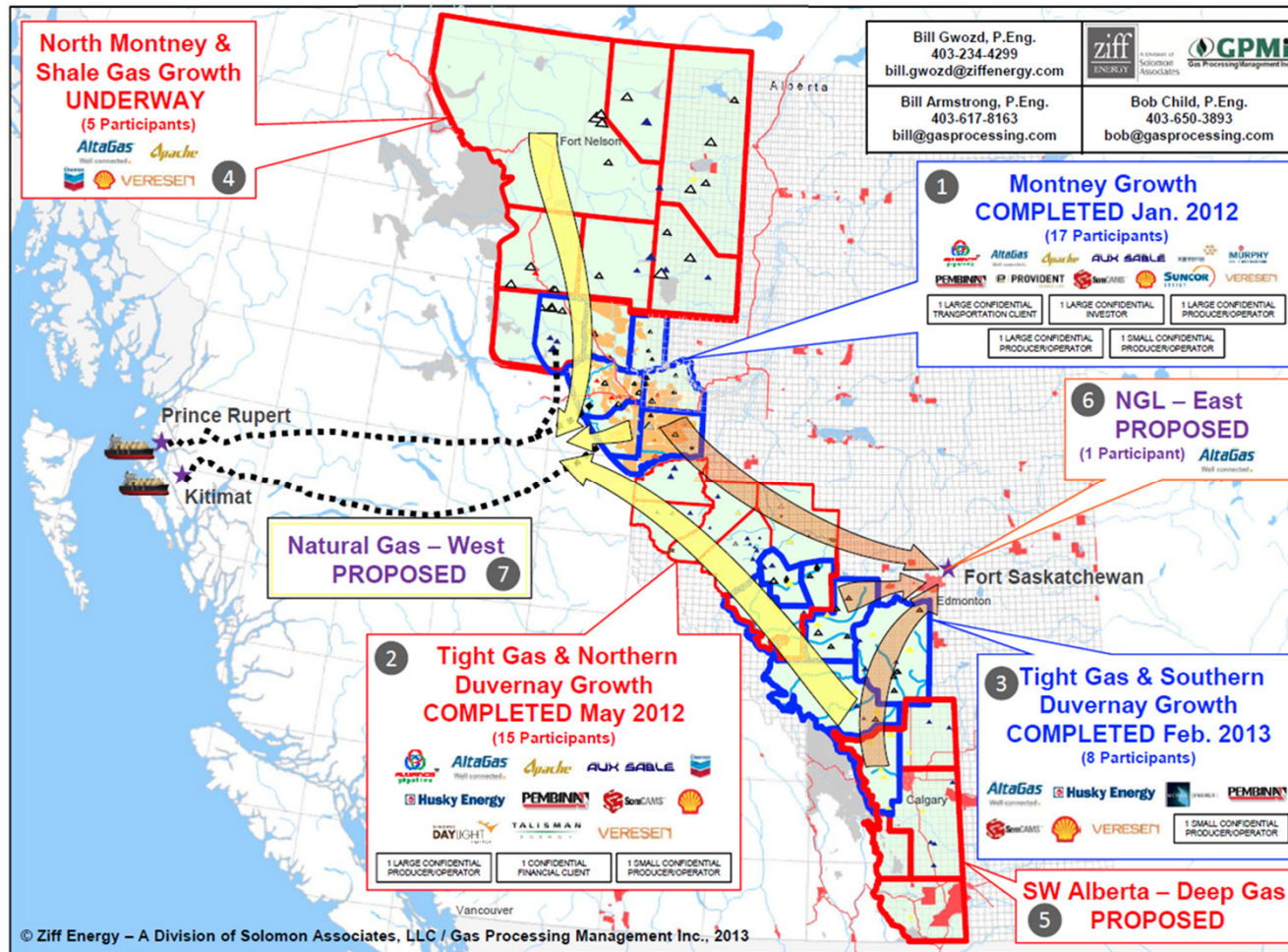
Ziff Energy Group Extends Solomon's Reach

- Solomon acquired Ziff Energy Group, July 2013
 - International Energy E&P benchmarking/consulting
 - North American NG forecasting/consulting
- Creates the #1 benchmarking service provider from wellhead to specialty chemicals
- Combines Ziff's shale gas E&P knowledge with Solomon's actual ethylene plant operating data

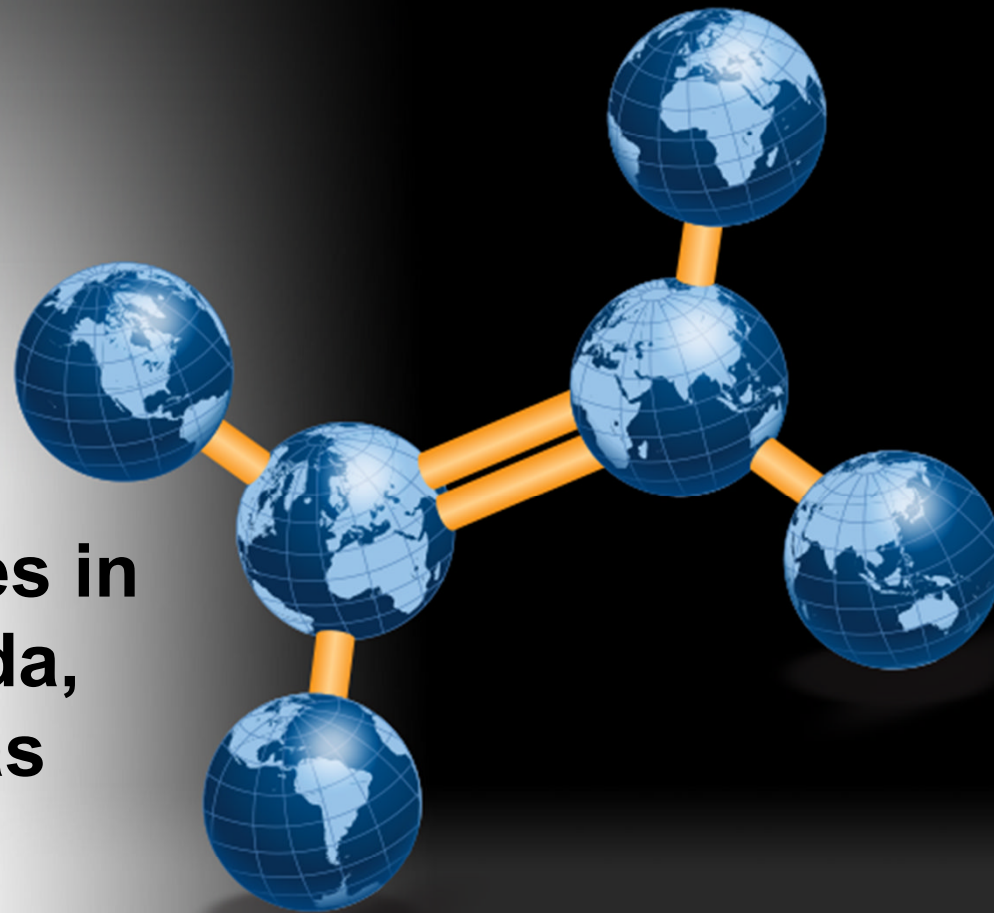


Ziff's NG & NGL Supply & Infrastructure Studies

46 Subscriptions with 24 Clients



Shale Gas Reserves in the U.S. and Canada, Wet Gas vs Dry Gas

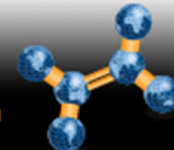




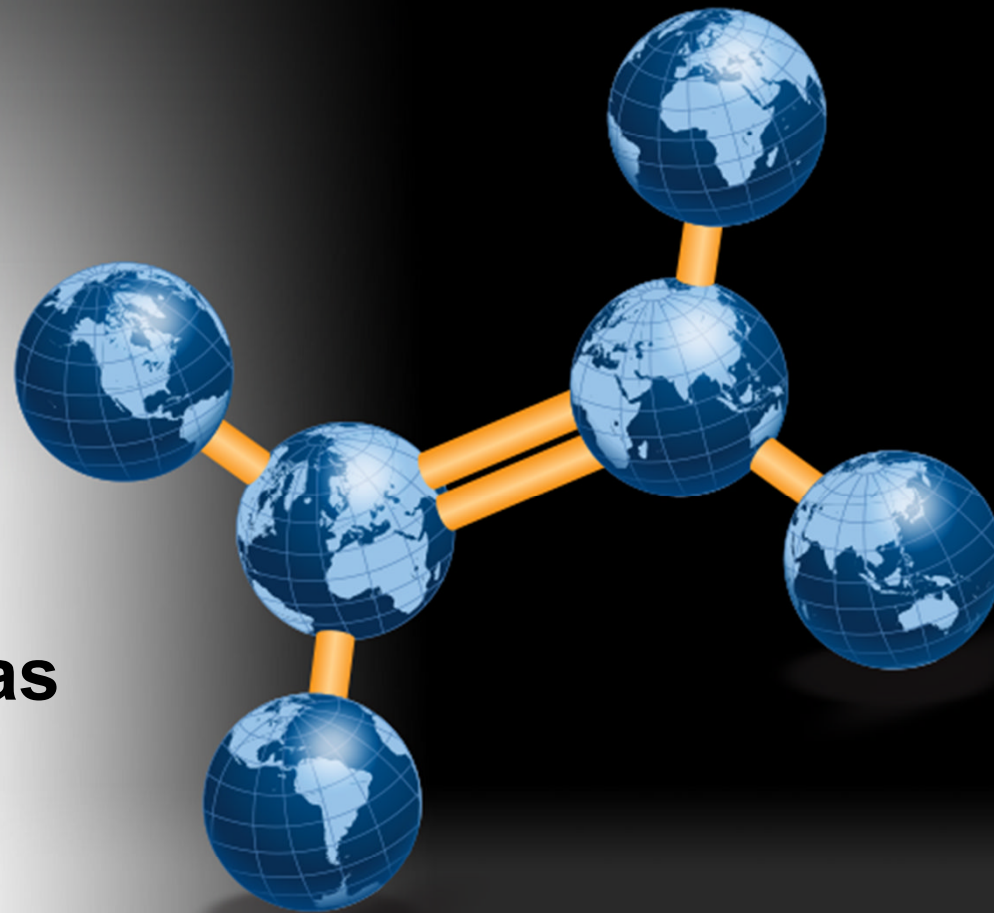
Added Value of Wet Gas vs Dry Gas

- Many shale gas wells produce significant quantity of NGLs (ethane, propane, butane, C₅s), referred to as “wet” gas wells
- If little or no NGLs, well is considered “dry gas”
- Separating NGLs adds to well cost, but increased revenue more than offsets cost
- In some cases, ability to sell NGLs limits well producing capacity of natural gas

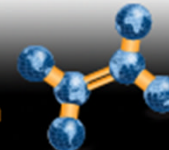
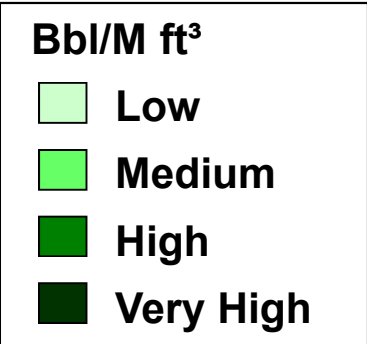
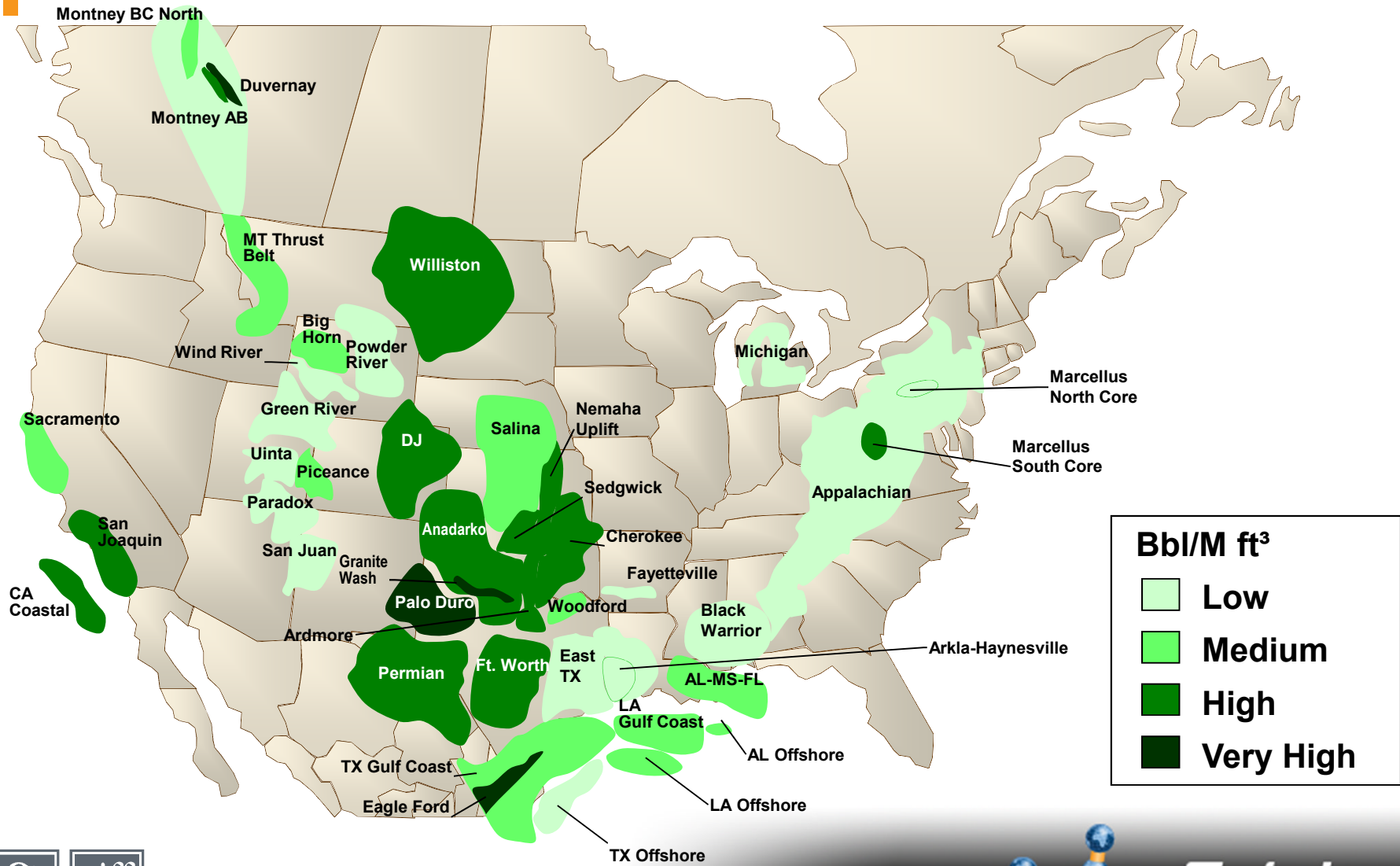
“Wet” gas wells produce more ethylene feedstock



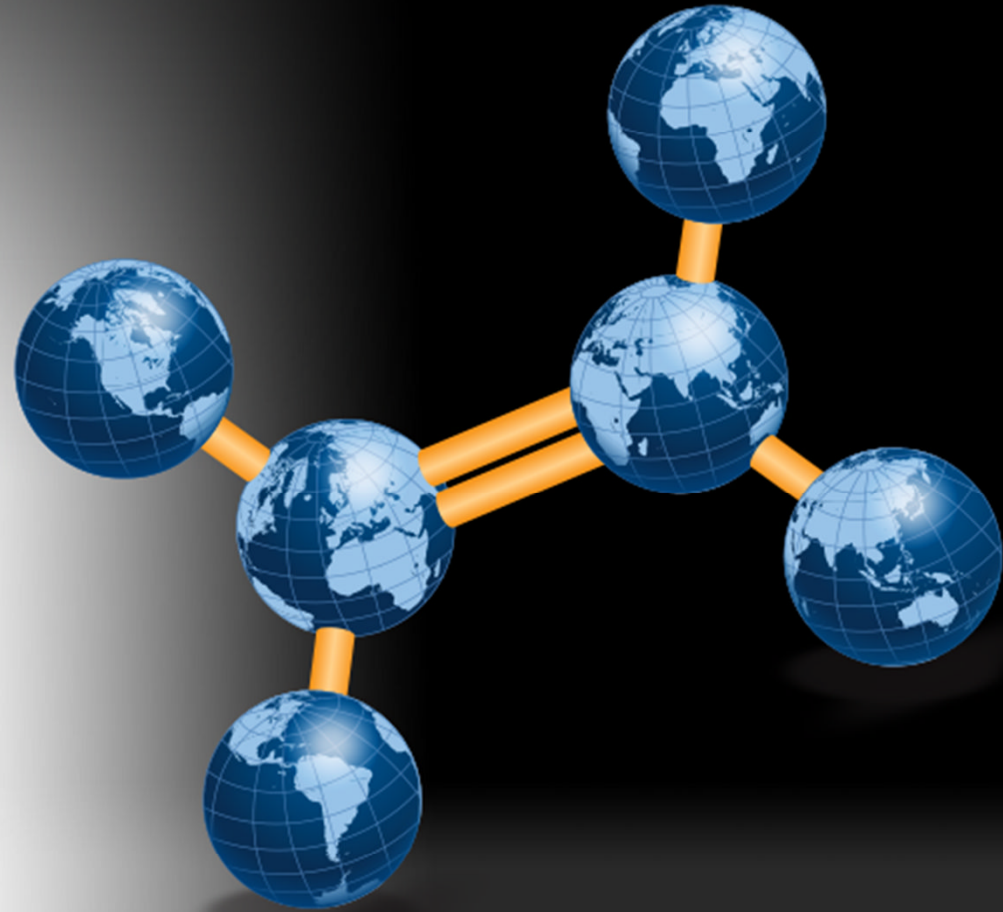
Which North American Shale Gas Wells Have More NGLs?



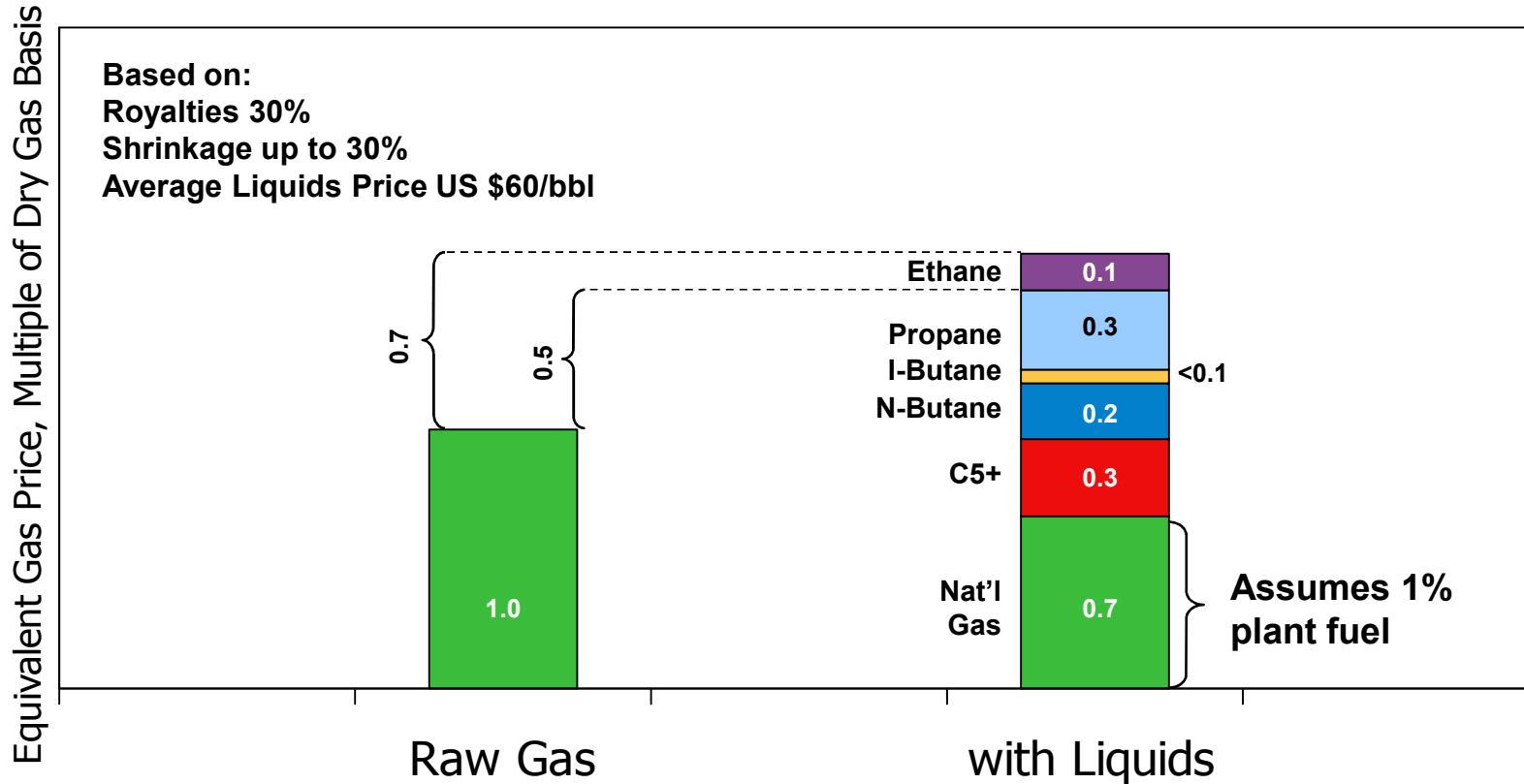
NGL Content of Gas Wells (Bbl NGL/M ft³ Dry Gas)



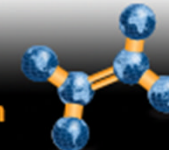
How do NGLs add Revenue to Gas Wells?



Impact of Liquid Content on Revenue

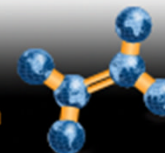
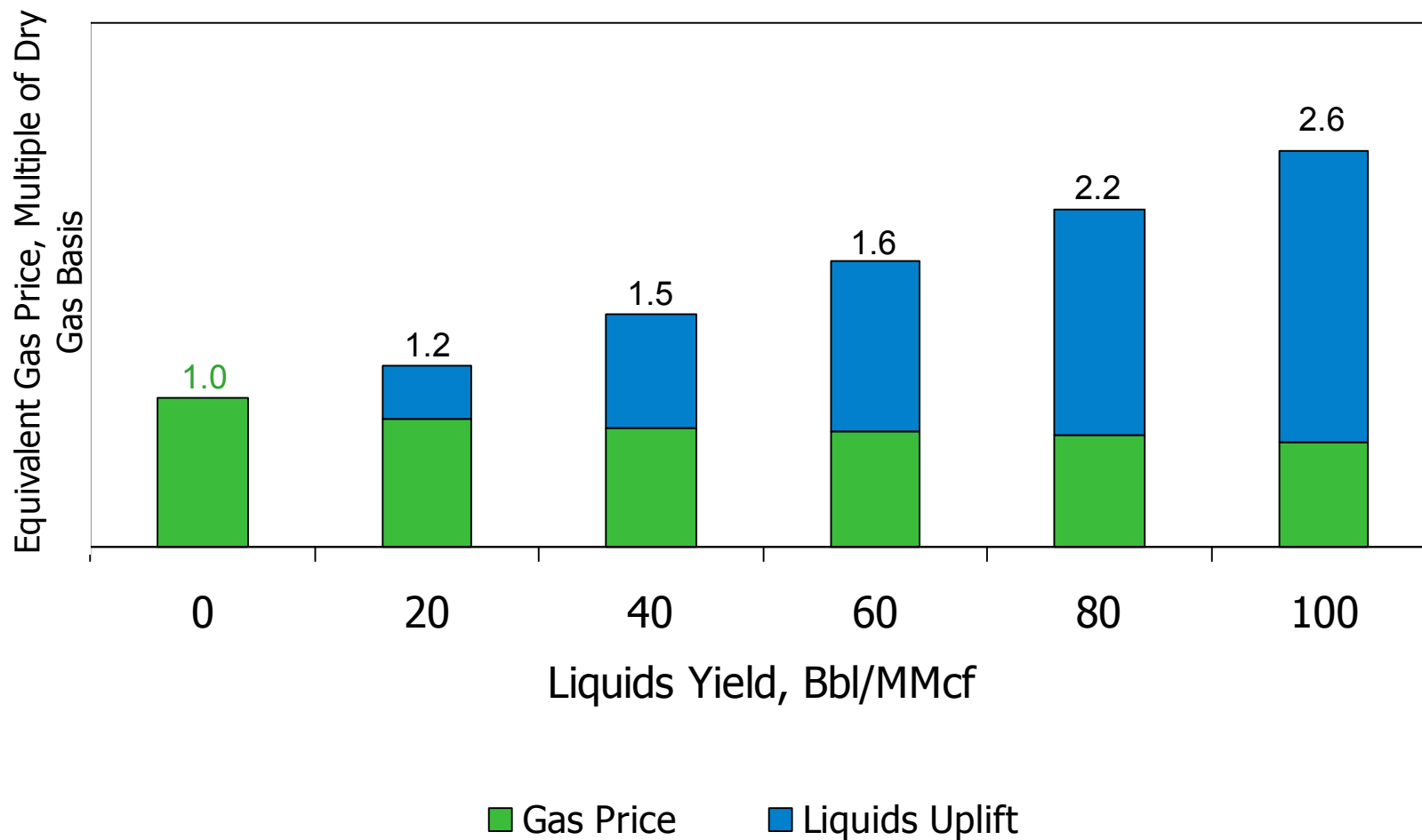


Example of Liquids Uplift Calculation

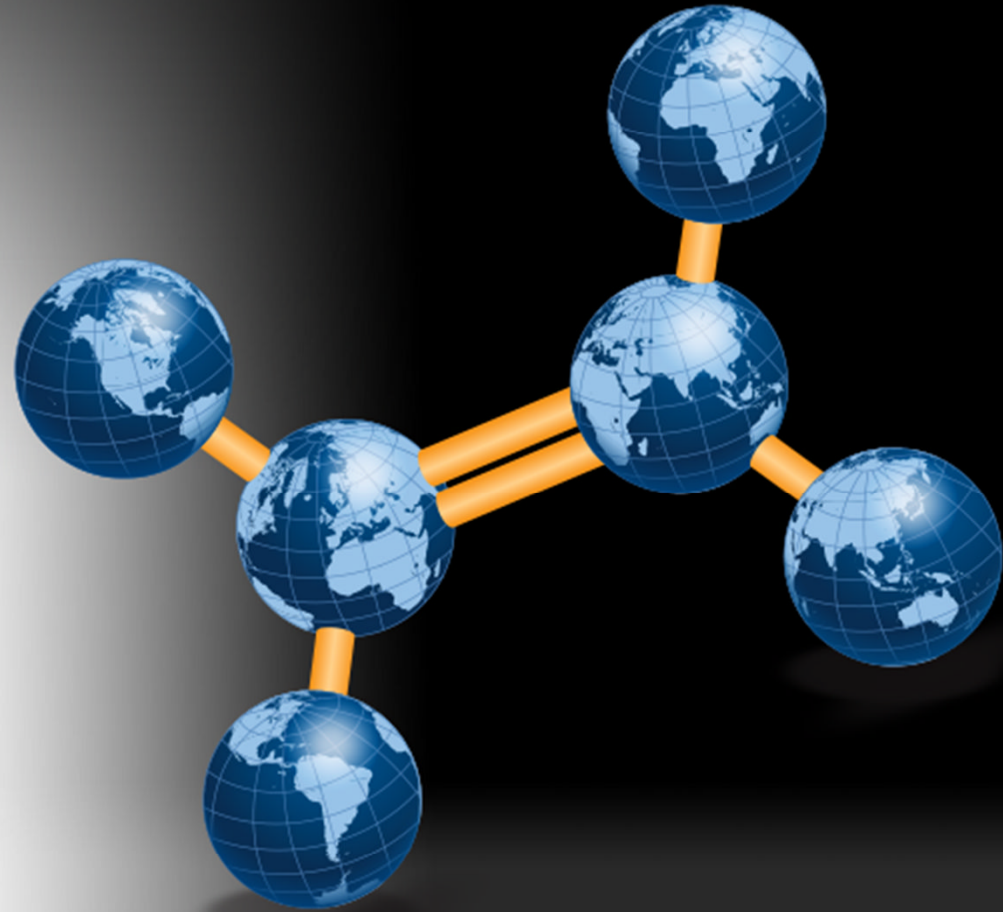




Impact of Liquid Content on Revenue



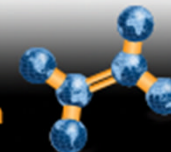
What do Solomon Olefin Study Results Say?



Feedstock Changes for Ethylene Production in North America

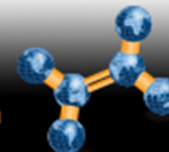
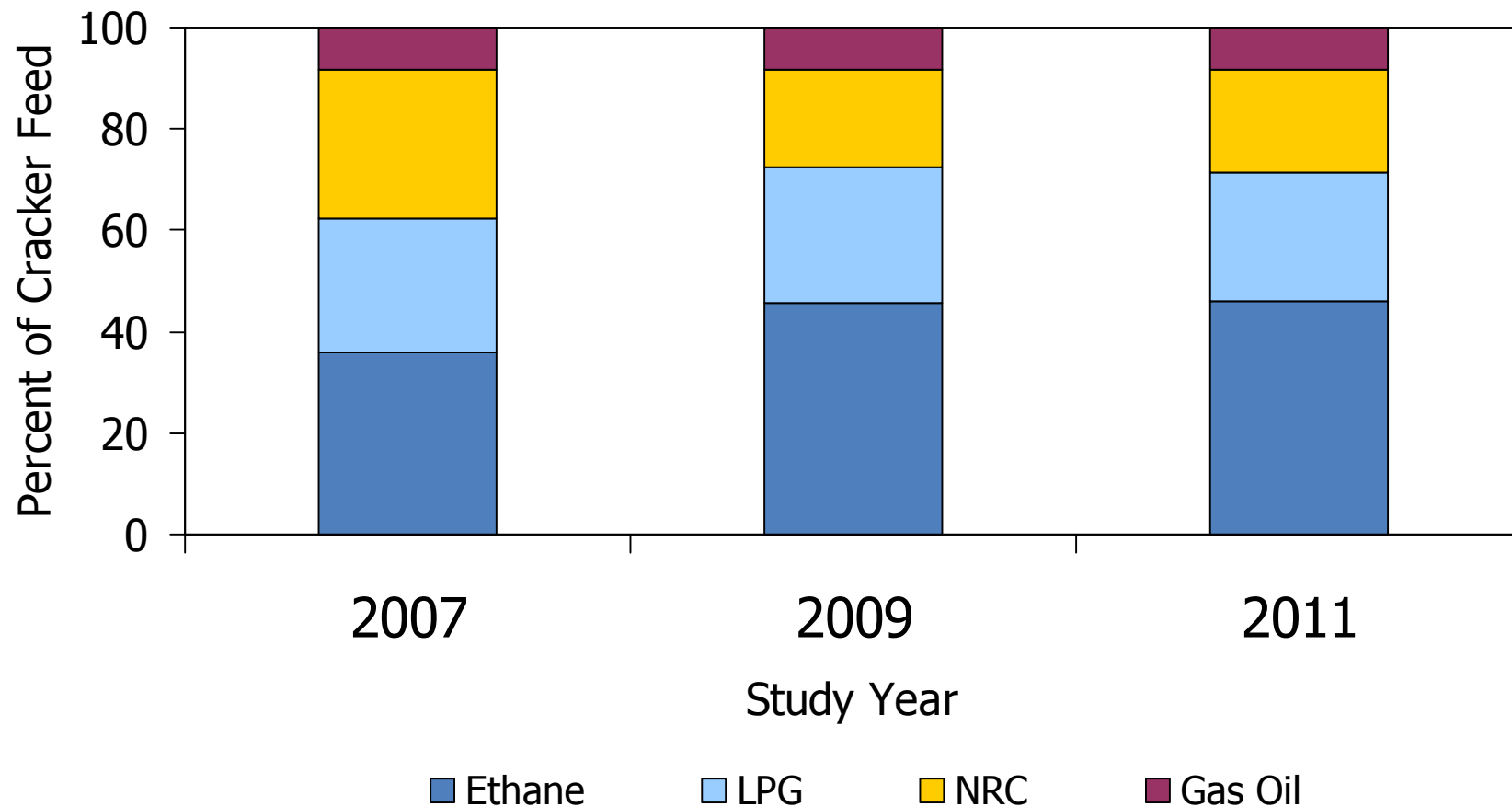
- Region with the most feedstock changes
- Olefin Study North American Trend Group
 - Approx 50% of ethylene production capacity
 - Trends over three study cycles on same-plant basis
- More feed-flexible plants than other regions
- Some plants making permanent changes to allow more light feed cracking

North America plants taking advantage of ethane economics





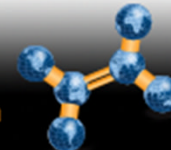
North American Feedstock Trends 2007–2011



What Happened to Co-Product Propylene & Butadiene?

- Switch to more ethane feed in North America
- Less propylene and butadiene produced in North America
- Prices rose worldwide, peaking in 2011
 - Both had higher value per ton than ethylene
- High prices improved alternate (non-cracker) production economics

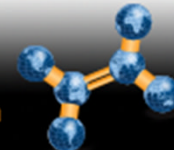
Severe propylene shortages were short term, prices moderating as alternative production increases





Alternative Production of Propylene

- Alternate (non-cracker) production to increase
 - Polymer-grade propylene from refineries
 - Must invest in mercury, arsine removal, and C3 splitter
 - Propylene from propane dehydrogenation (PDH)
 - Eight announced PDH units for USA
 - NA PDH economics could turn on export plans
 - PDH also being pursued in ME, E. Europe, Asia
 - Other On-Purpose Propylene (OPP) via catalytic methods (metathesis), methanol (MTP), biomass

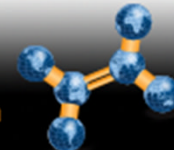




Alternative Production of Butadiene

- Metathesis
- Butane Dehydrogenation
- Biomass

Economic feasibility depends on product price relative to raw materials, investment cost

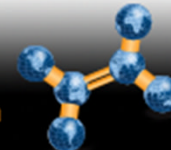




Other Uses for LNG, LPGs from Shale Gas

- Transportation Fuel
 - Currently fleet vehicles such as buses
 - Need infrastructure to use in personal vehicles
- Exports to Europe, South America, Asia
 - LPGs for cracker feedstock, transportation
 - LNG for fuel
- Syngas, Gas-to-Liquid (GTL) Fuel
- Power Generation – half the emissions of coal

Price, especially for LPGs, will depend on pipeline logistics, and on how quickly these other uses are put into practice.



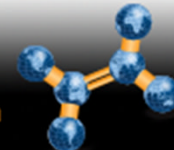


How Much Shale Gas is Out There?

- North American reserves: 100+ years¹
- Today, limit to North America natural gas production in some areas is disposal of ethane & propane²
- New ethane crackers coming online in North America
 - More “room” to produce natural gas
 - More supply can lead to lower natural gas prices
- Shale gas also in Middle East, China, South America, Australia, East Europe

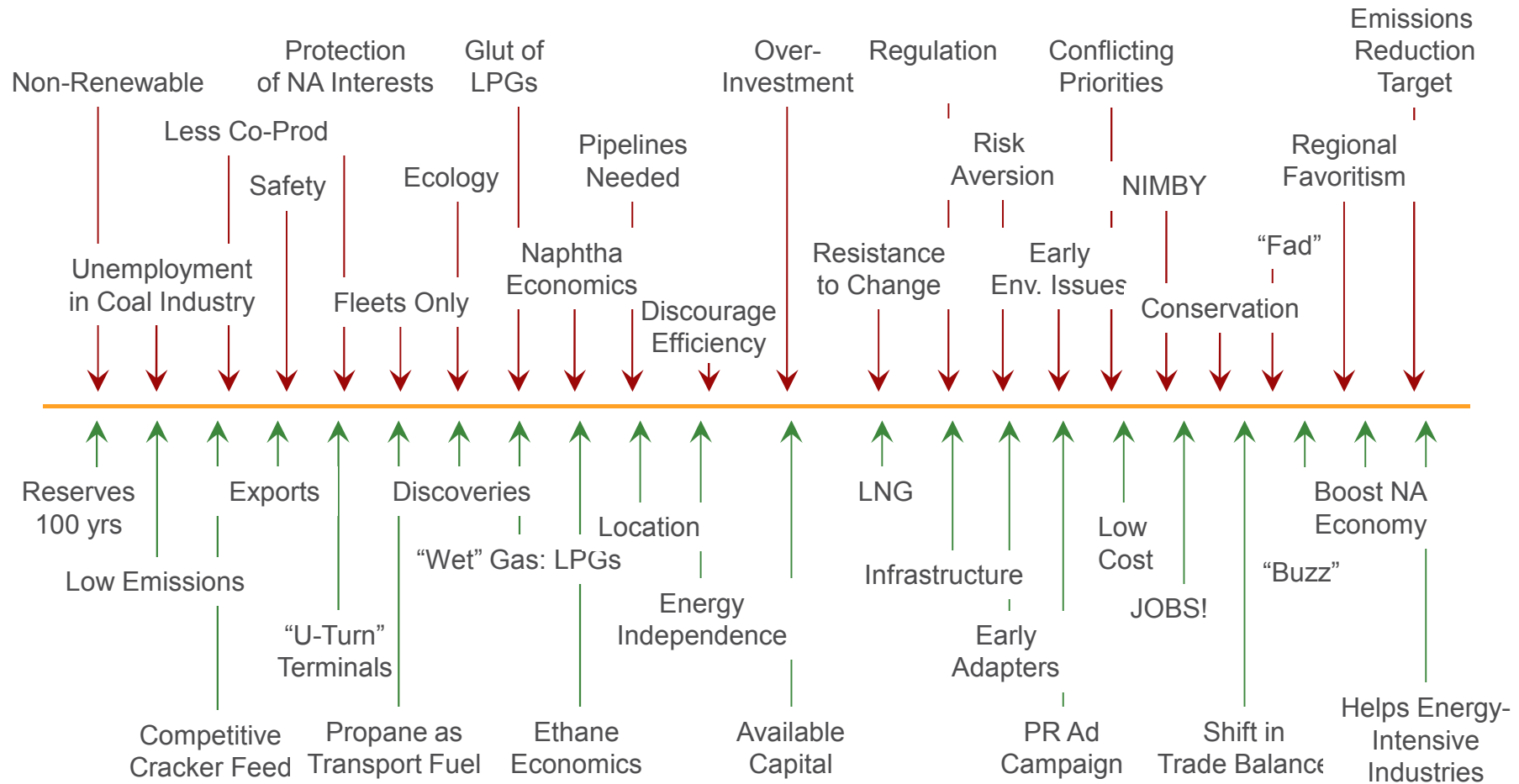
¹ Chemplants.com, 30 June 2013

² Platts.com, 30 Aug 2013

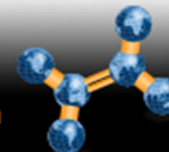


Shale Gas/LPG Production Forces

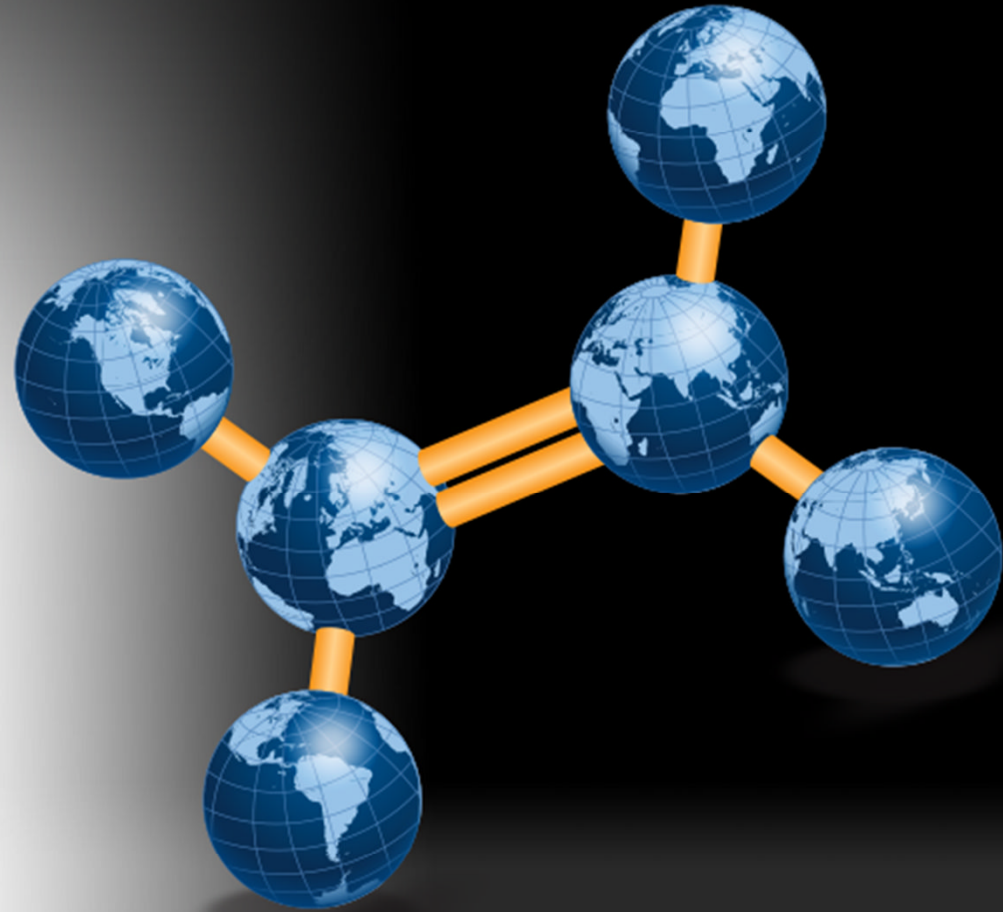
Resisting Forces (Cons)



Driving Forces (Pros)

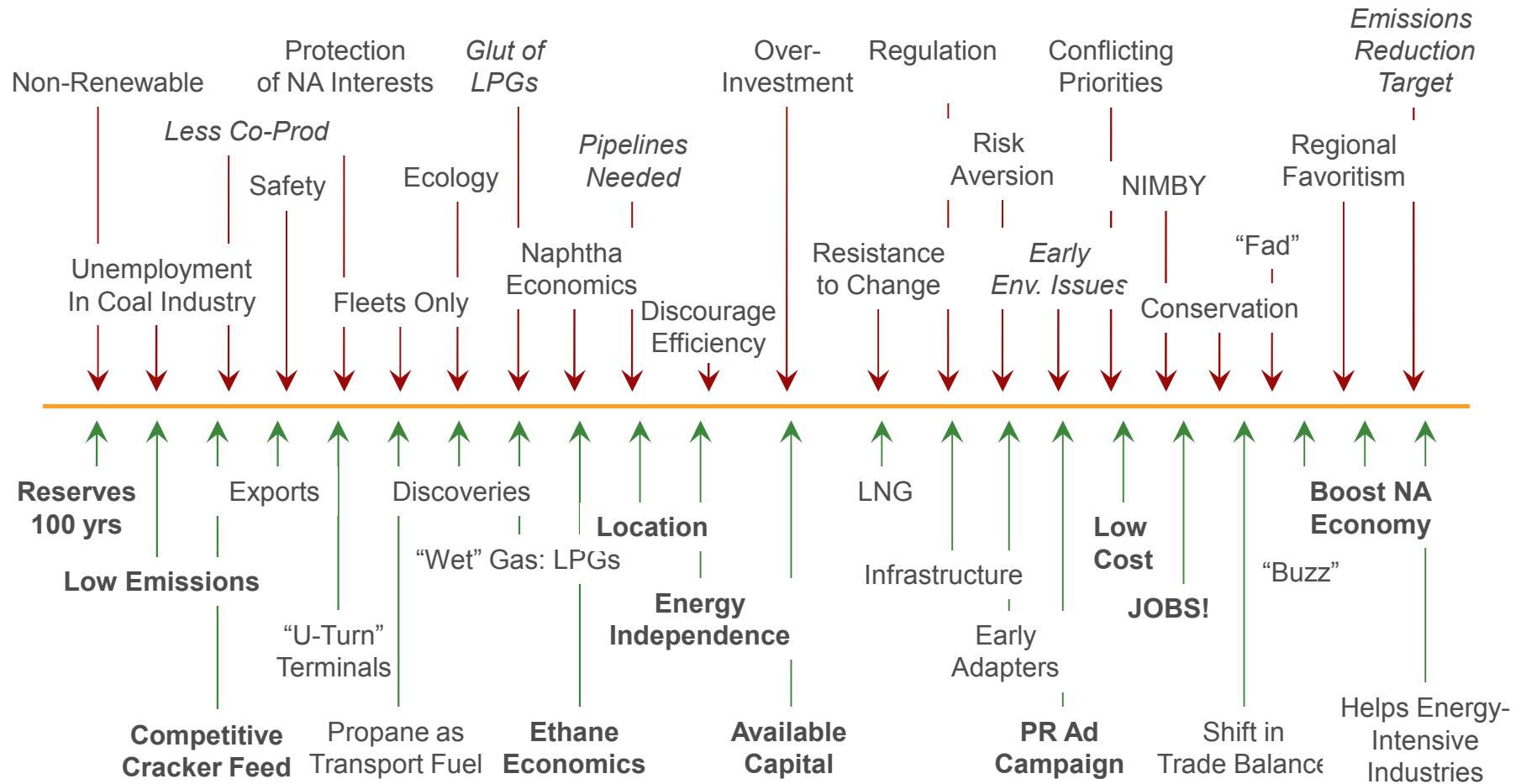


Which Forces are Stronger?

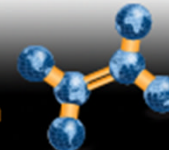


Shale Gas/LPG Production Forces

Resisting Forces (Cons)



Driving Forces (Pros)



Inaugural Ethylene Forum

Thank you!

Claire L. Cagnolatti
VP, Chemicals Studies
Solomon Associates

Bill Gwozd, Senior VP, Gas Services
Ziff Energy Group (a division of Solomon
Associates)

The material appearing in this presentation is for general information purposes only. Technip S.A. and its affiliated companies ("Technip") assume no responsibility for any errors or omissions in these materials. TECHNIP MAKES NO, AND EXPRESSLY DISCLAIMS ANY, REPRESENTATIONS OR WARRANTIES, EXPRESS OR IMPLIED, REGARDING THE MATERIALS CONTAINED IN THE PRESENTATION, INCLUDING ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. Under no circumstances shall Technip, the other sponsors, presenters and any of their respective partners, officers, directors, employees, agents or representatives be liable for any damages, whether direct, indirect, special or consequential, arising from or in connection with the use of materials and information contained in the presentation. The materials contained in this presentation may not be reproduced, republished, distributed, or otherwise exploited in any manner without the express prior written permission of Technip.

