



Plumenergy

Small-scale LNG Value Chains
for
Non-traditional Markets

May 21, 2013



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Introduction

CEO of Plum Energy LLC

- Focused on development of small-scale LNG value chains to facilitate increased use of natural gas
- Founder and former CEO of Prometheus Energy
- Pioneered development of small-scale LNG for several industrial applications in the US and Poland, including mining and drilling sectors



Operating Partner for EverStream Energy Capital Management

- Focused on investments in natural gas supply chain
- Its wholly-owned subsidiary, **NewPath Energy Capital**, provides leases or other capital solutions for LNG and CNG equipment

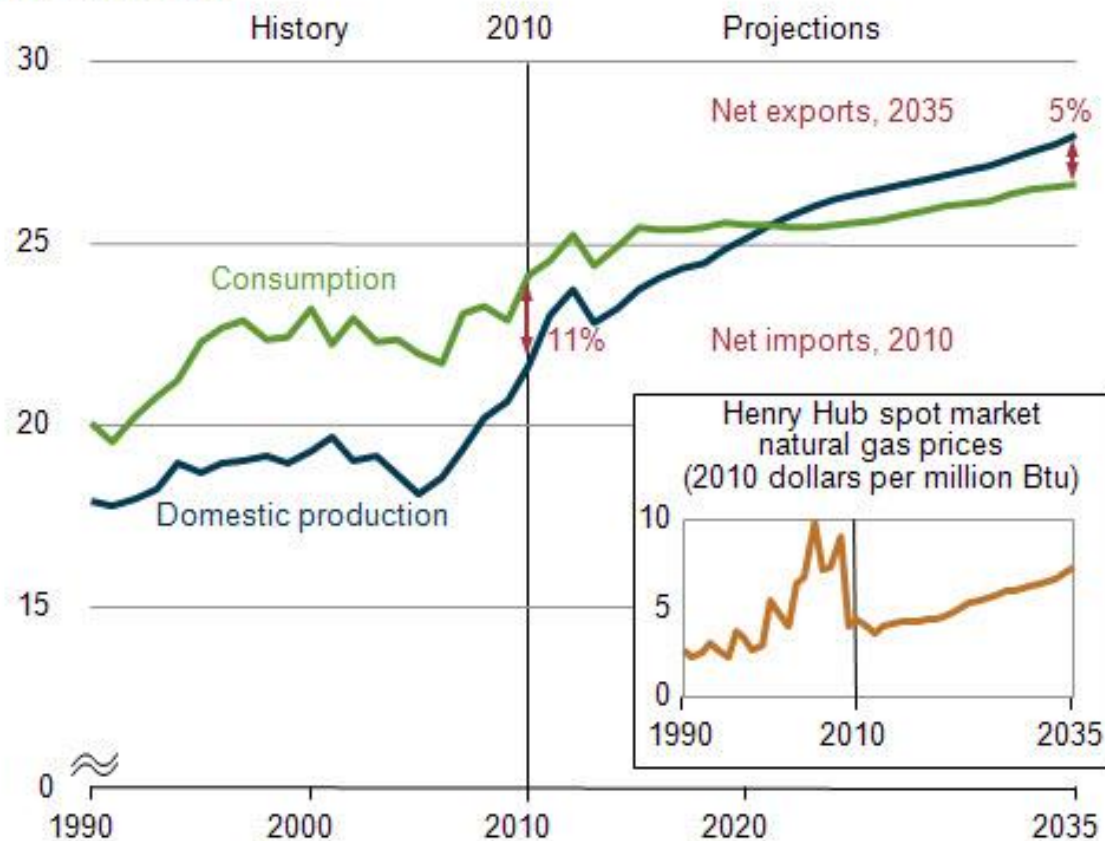


Fundamental Market Shift in Last 7 years

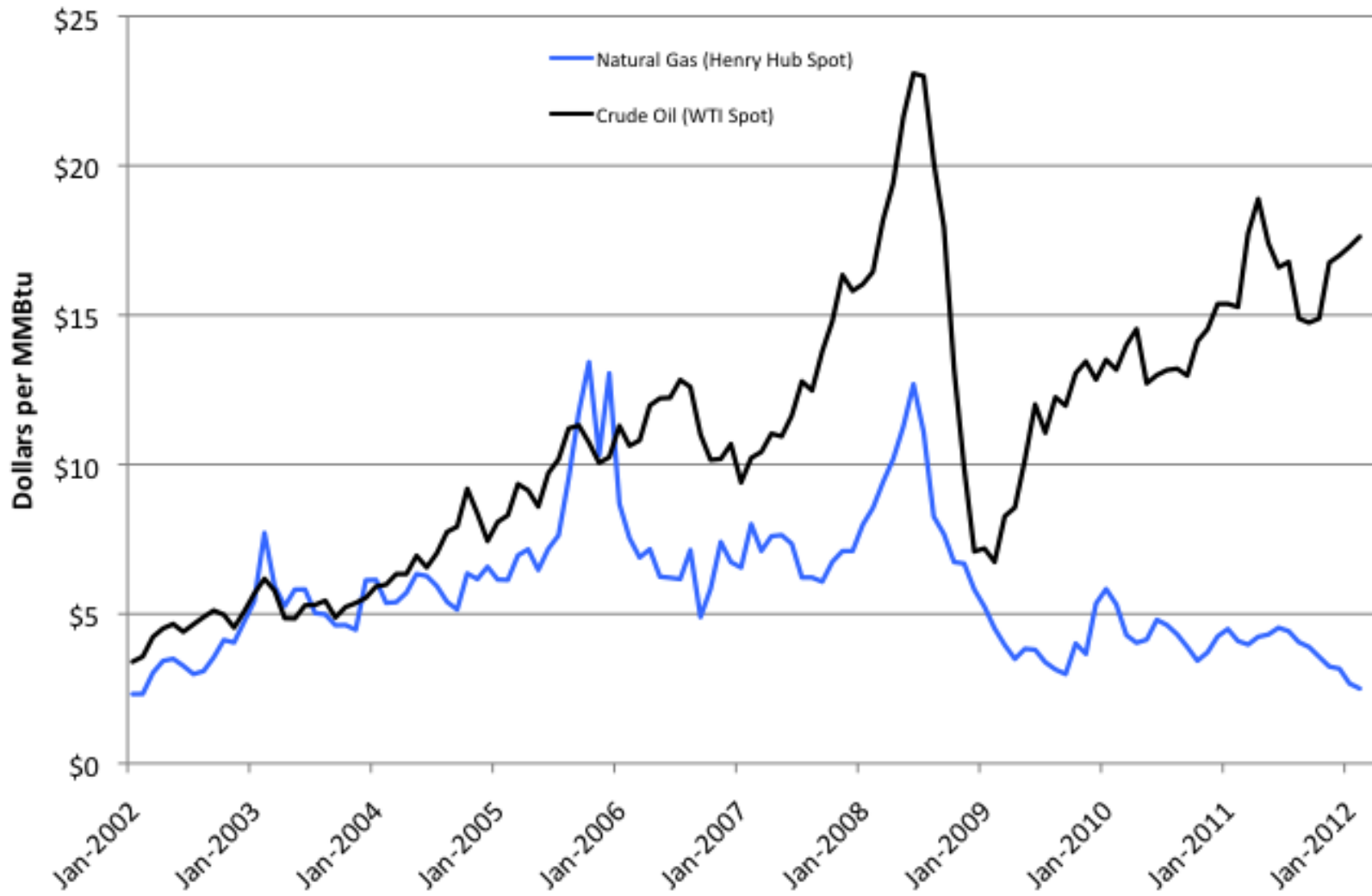
Gas production has peaked in North America.” (Lee Raymond, CEO—Exxon Mobile—June 2005)
President

President Obama calls the US the “**Saudi Arabia of Natural Gas**. . . . *Because of new technologies, and because we can now access natural gas that we couldn't access before in an economic way, we've got a supply of natural gas under our feet that can last America nearly a hundred years.*” (US News, January 26, 2012)

Figure 4. Total U.S. natural gas production, consumption, and net imports, 1990-2035 (trillion cubic feet)



Economics--Increasing Commodity Spread



Pricing of LNG--Example

Item	Cost	Miles	Transport Cost/9,300 (gallons in typical transport)	LNG price (\$/Gallon)	DGE Price (X 1.68)
Feedstock for LNG	\$4.00/MMBTU			\$0.33	\$0.55
Liquefaction	\$4.50/MMBTU			\$0.37	\$0.62
Transport	\$3.00/Mile (Round Trip)	500	\$1,500/9,300	\$0.16	\$0.27
Overhead and Profit	\$4.00/MMBTU			\$0.33	\$0.55
Delivered Price	\$14.40/MMBTU			\$1.19	\$1.99

Strong Political Tailwinds

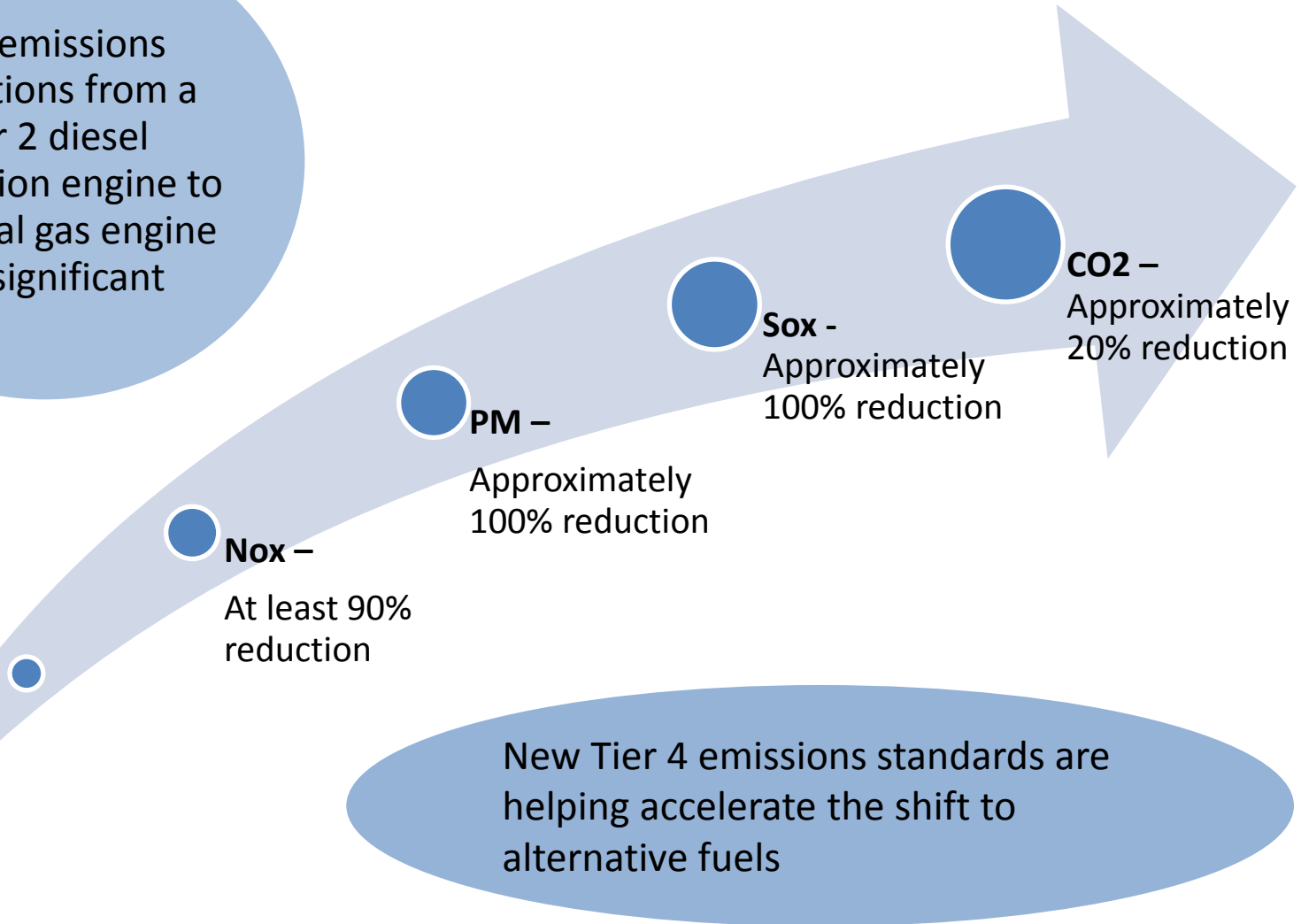
“We now have a supply of natural gas that can last America nearly one hundred years, and my Administration will take every possible action to safely develop this energy



The development of natural gas will create jobs and power trucks and factories that are cleaner and cheaper, proving that we don't have to choose between our environment and our economy.” (President Barack Obama - Jan. 24, 2012 State of the Union Address)

Stricter Emissions Standards

The emissions reductions from a Tier 2 diesel propulsion engine to a natural gas engine are significant



Nox –
At least 90%
reduction

PM –
Approximately
100% reduction

Sox -
Approximately
100% reduction

CO2 –
Approximately
20% reduction

New Tier 4 emissions standards are helping accelerate the shift to alternative fuels

Development of Non-traditional Markets

- Focus on displacing higher priced, higher carbon diesel, gasoline and other oil-based commodities
- Uses are often “off-grid” or require portability
- Must deliver gas in the form of Compressed Natural Gas (“CNG”) or Liquefied Natural Gas (“LNG”)



- Will require significant investments in infrastructure—storage tanks, re-fueling stations, production facilities, regasification units, etc.

Small-scale LNG Value Chain



Upstream

Midstream

Downstream

Consumption

- Exploration
- Production

- LNG Production
- LNG Transport

- LNG Storage
- Regasification

- Process Heat
- Power Generation



Small-Scale LNG Production

THE WALL STREET JOURNAL.

- **Shell to Build LNG Plants in Louisiana and Canada**
 - *“The LNG plants are among the latest efforts by energy companies to create great demand for what is now a “glut of Natural Gas in North America.”*
 - *“Will produce LNG for heavy trucks and large ships”*
- GE, Conoco Phillips, Noble Energy, Clean Energy and others have announced the development of small-scale LNG production facilities ranging from ~100,000 gpd to 250,000 gpd



Micro-Scale LNG Supply

- “Micro LNG” production plants produce ~10,000--60,000 LNG gpd
- GE, Dresser Rand, Black & Veatch, Chart and others have announced development of micro-LNG production facilities



LNG Transportation

- Transport currently is by heavy-duty truck and cryogenic trailer, each hauling ~9,300 gallons of LNG
- Rail transport likely within 1-2 years at ~30,000 gallons per rail car
- Marine transport options also increasing with barges, smaller LNG transport ships and specialized ISO delivery vessels



Stationary LNG Storage and Regasification

- Local storage options range from ~1,000 gallons to several hundred thousand gallons depending on applications
- Large users enable production and distribution channels to facilitate small applications, much like propane and heating oil is used in the US and abroad



The Big Prize—On-Road Transportation

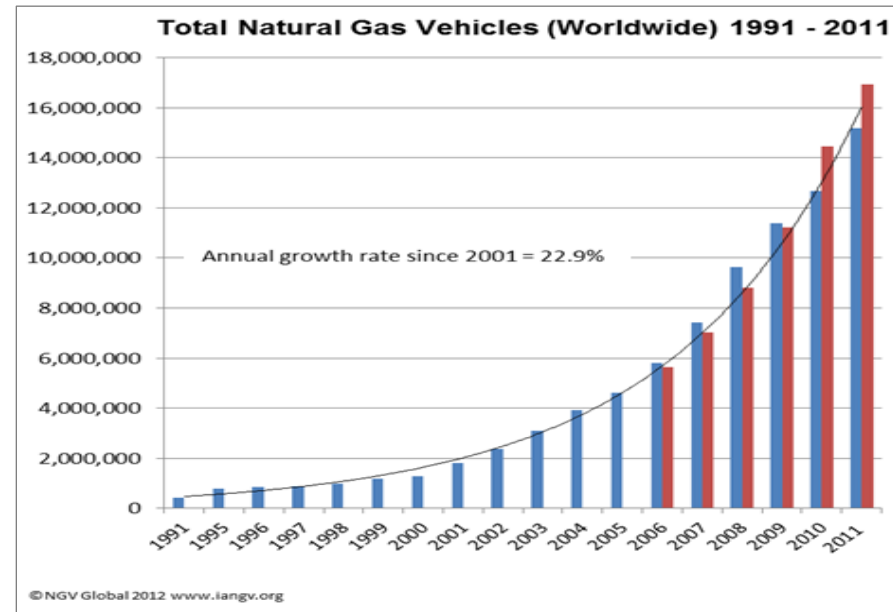
US has 120,000 NGVs on roads today. Over 14.8 million operating worldwide

~1,000 NGV fueling stations exist in the U.S., only about half of which are open to the public.

Transit buses account for about 66% of all vehicular natural gas use. Waste collection and transfer vehicles account for about 11 percent and are the fastest growing NGV segment.

EIA predicts the amount of natural gas consumed in the US for vehicle use more than doubled between 2000 and 2009, now displacing more than 300 million diesel gallon equivalents each year.

The International Association of Natural Gas Vehicles estimates that there will be more than 50 million natural gas vehicles worldwide within the next 10 years, or about 9% of the world's transportation fleets.



Blue bars represent total growth since 1991 (23% p.a.)
Red Bars denote projected growth from 2006



Natural Gas Vehicle Association (<http://www.ngvc.org>)
International Association of Natural Gas Vehicles

On-Road Transportation

- Transport companies and government agencies increasingly are looking at using gas to power fleet vehicles, such as garbage trucks and delivery trucks



- Several major engine and truck builders heavily engaged in engine development for heavy duty on-road trucks



- Other companies are engaged in the conversion of light and medium duty vehicles



Non-Traditional Market--Rail

- BNSF Railway Co. plans this year to test using natural gas to power its locomotives
- BNSF estimates it is the second-biggest user of diesel in the country after the US Navy
- **“This could be a transformation event for our railroad”** (BNSF Chief Executive Matt Rose)
- Shifting to natural gas would **“rank right up there”** with the industry’s historic transition away from steam engines last century (Matt Rose)

On the Rails

Use of diesel by railroads, in billions of gallons



Source: Energy Information Administration
The Wall Street Journal



Non-Traditional Market--Rail

- New LNG powered locomotives are being developed by units of [General Electric](#) Co. and [Caterpillar](#) Inc.
- Retrofitting a diesel locomotive and adding the tanker car could add 50% to a locomotive's roughly \$2 million price tag
- CAT estimates savings on fuel costs could be >50%



Non-Traditional Market--Rail

- [Canadian National Railway](#) Co. retrofitted two locomotives last September to run on a mixture of 90% LNG and 10% diesel
- Requires a significant rebuild of engines as compared to less invasive bi-fuel systems that target displacement rates of ~50%



Non-Traditional Market--Marine

- According to the U.S. Coast Guard, there are currently approximately
 - 1,000 U.S.-flagged tugs larger than 100 tons
 - 65 ferries larger than 500 tons
 - 43 Great Lakes bulk carriers.
- Natural gas delivered for LNG is now estimated to be at least 70% to 85% less expensive on an energy equivalent basis than marine residual fuel and marine distillate fuel, respectively.
 - Relative price advantage projected to continue, and even increase, through 2035.
- Annual marine fuel consumption is significant
 - 150-ton tug can burn more than 400,000 gallons
 - 1,000-ton ferry can burn almost 700,000 gallons
 - Great Lakes bulk carrier can burn 2 million gallons



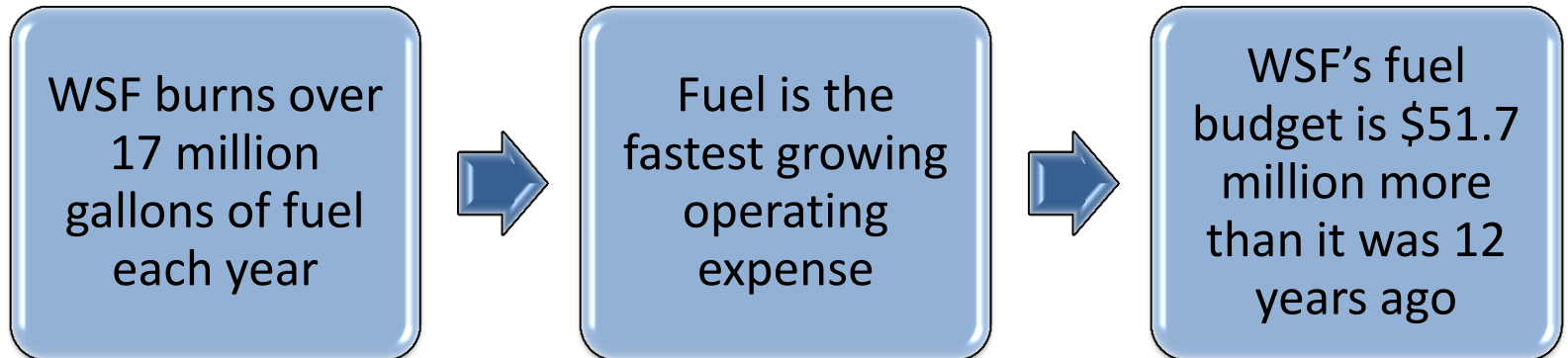
Non-traditional Market-- Marine

- **Totem Ocean Transport Express** has announced conversion of ships to LNG
- [Wärtsilä](#) signed contracts to send China the world's first tugboats operating on diesel-LNG engines
- **Rolls Royce** provides dedicated natural gas engines for marine transport using LNG



Washington State Ferry System

- Largest ferry system in the United States
- Fourth largest carrier of passengers and largest carrier of vehicles in the world
- WSF has proposed to the U.S. Coast Guard to retrofit the propulsion system with new engines on the six Issaquah Class vessels



Non-Traditional Markets—Off Grid Industrial

Industrial Boilers



Power Generation Equipment



Asphalt Plants



Off-grid Communities (West Yellowstone)



Non-traditional Market—Mining



Additional Equipment for Mine Truck Conversion

Mobile Refueler



NEW PATH
ENERGY CAPITAL

40' ISO for On-site Storage



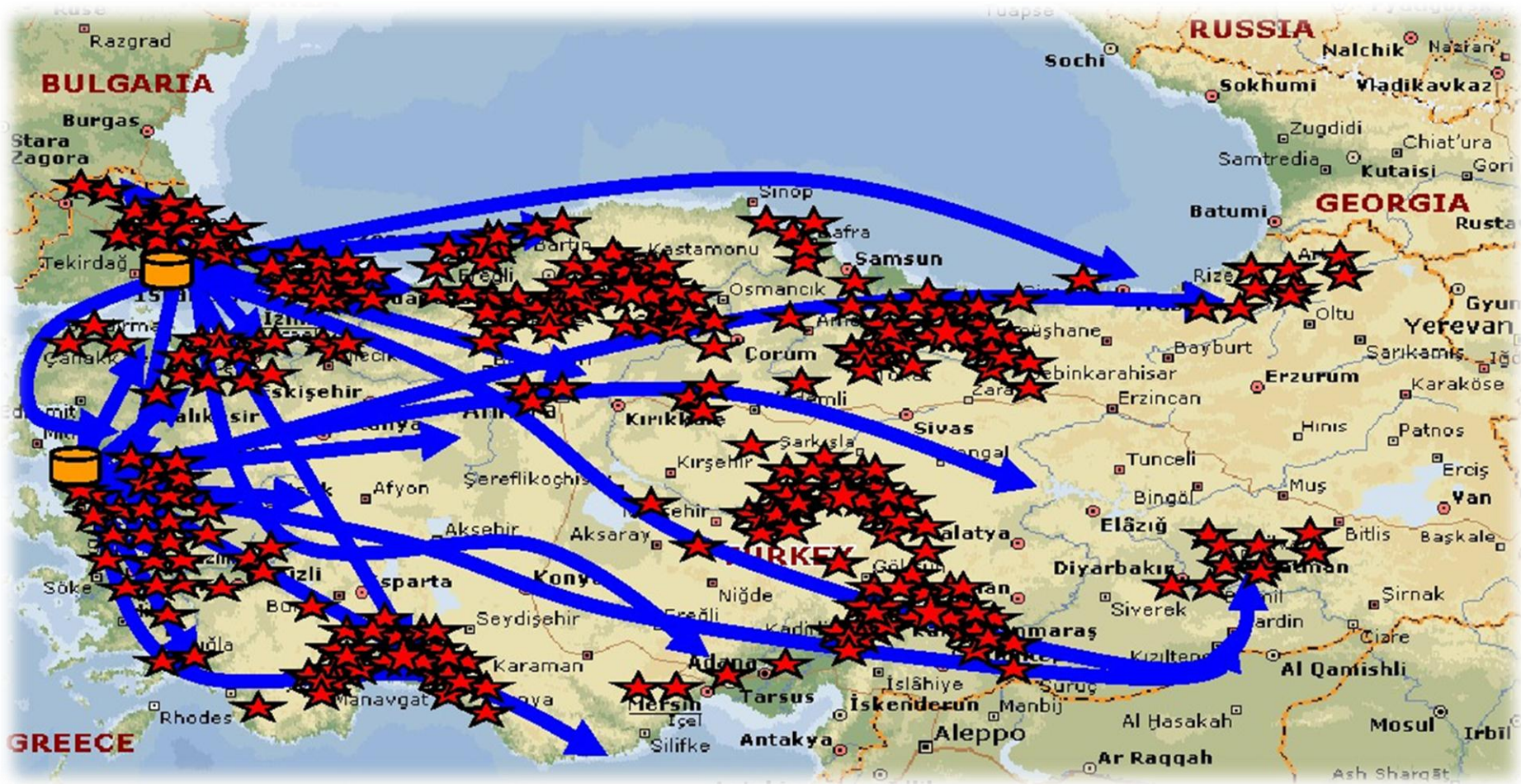
NEW PATH
ENERGY CAPITAL



Case Study--Turkey



Turkey—Over 2,000 Satellite Stations in ~ Seven Years



Satellite Station with LNG Delivery



Large-scale LNG Satellite Facility



Large-scale Satellite LNG Facility



Medium-scale Satellite LNG Facilities



Small-scale Satellite LNG Facilities



Summary—Why LNG?

Cheaper Fuel

- Nat gas prices held low by abundant supply created from advances in shale gas drilling
- Oil prices remain high from middle east turmoil and increasing global demand
- No government subsidies required

Cleaner Fuel

- Lower NOx, SOx, CO2, particulate matter
- Increased government regulations (transport, shipping) drive market to comply
- Lower carbon footprint good for business / marketing

Domestic Fuel

- Broad domestic supply of natural gas in US , Australia etc.... Shale in Europe, China?
- Energy security and trade balances provide motivation
- Local economic development and job creation creates further incentives



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