

# Geopolitics, Development, and the Energy Transition

Center For Science and Technology

February 6, 2019

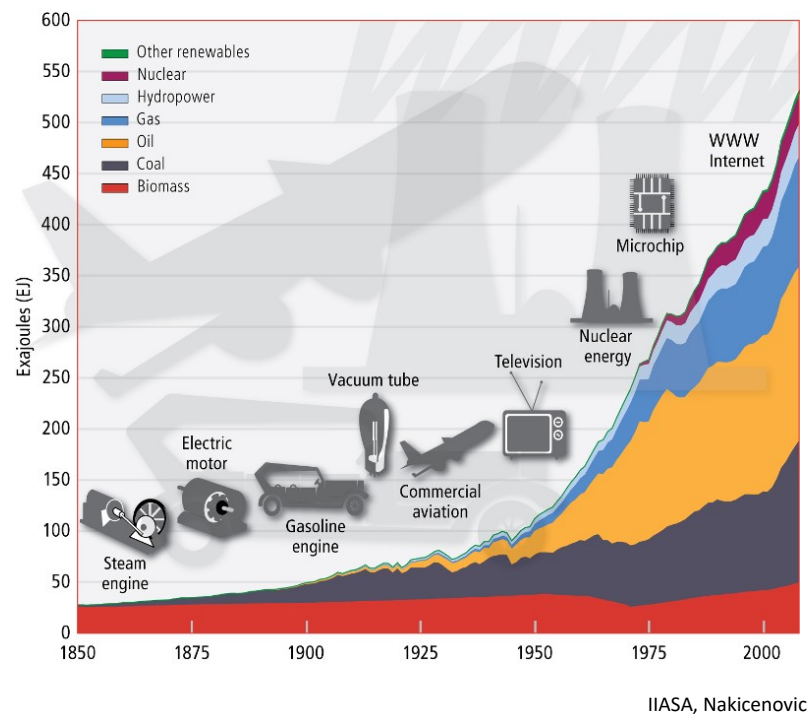
Morgan D. Bazilian, Ph.D.

Director, The Payne Institute, and Professor of Public Policy



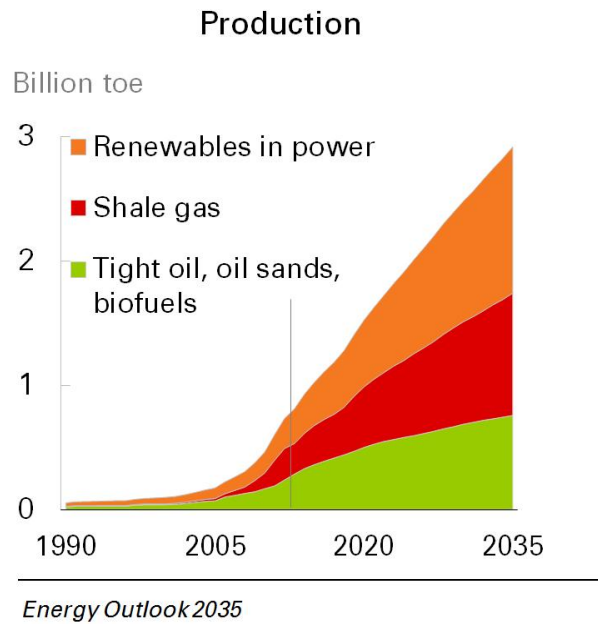
Of policy curves, triangles, and asymmetry

## Of non-linearity

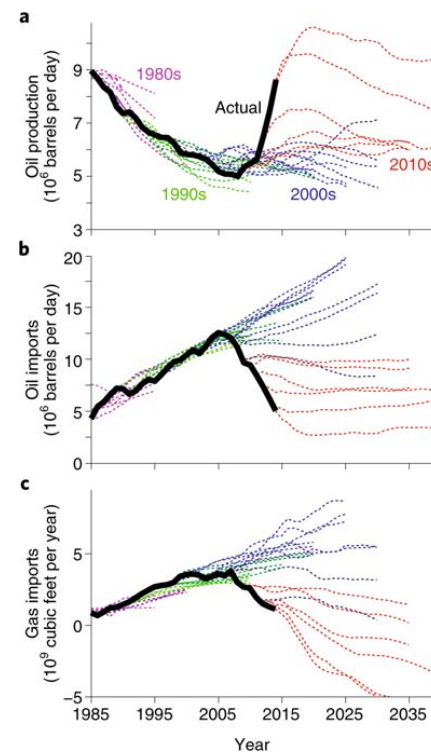


Tough for policy and regulations to keep up with curves like this

### New sources of energy supply

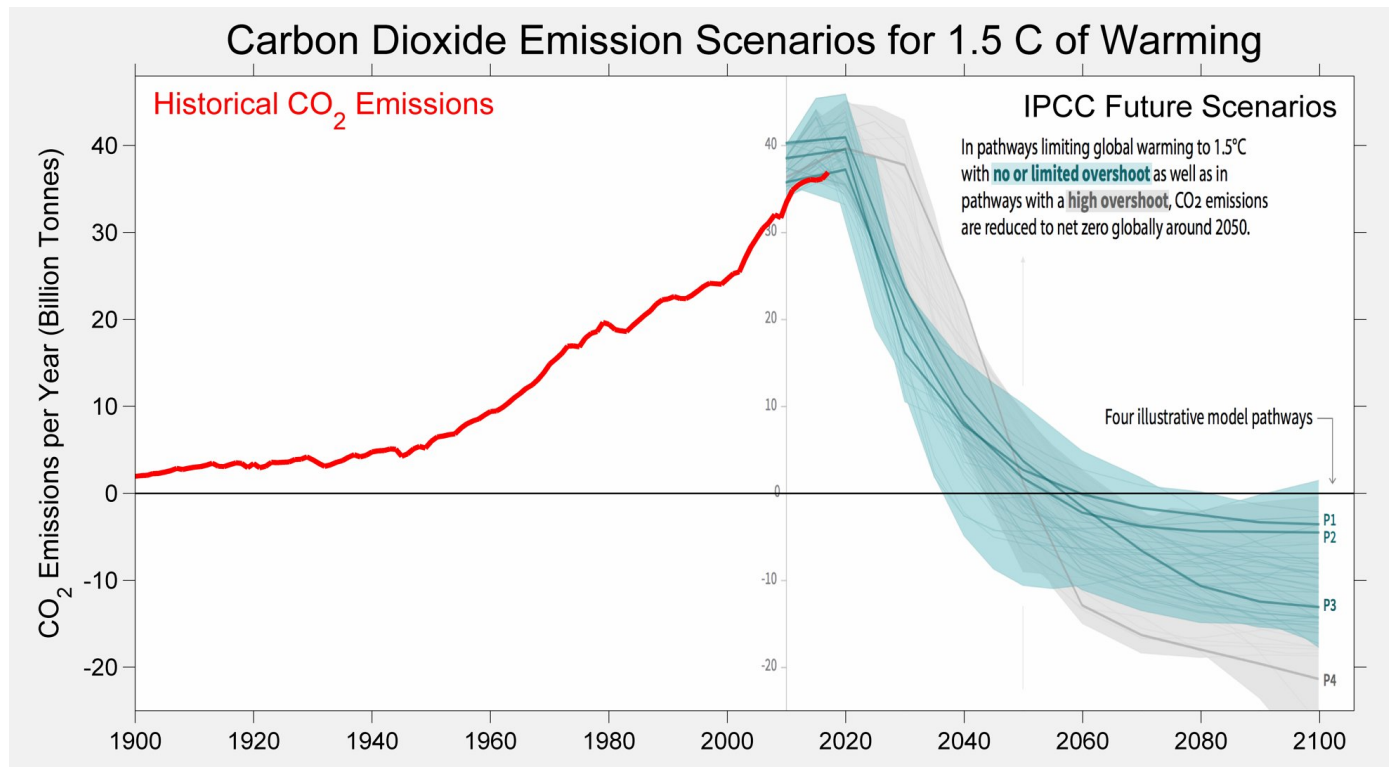


BP, Davis, S. Nature, 2018





# Curves



# Policy making is more than analysis



CASE BY CASE

## Teaching Public Policy

FRANCIS FUKUYAMA

*Local context is all too often lacking in the prevailing economics-centered approach to public policy education.*

**I**n my [previous post](#), I noted how public policy education needs to shift its focus from training policy analysts to training leaders who are capable of actually

Among the many problems with the current economics-centered approach to public policy education is the lack of appreciation for local context. Modern economics aspires to be context-free: it seeks universal rules of human behavior that can be mathematized in abstract models.

## (At least) seven contours

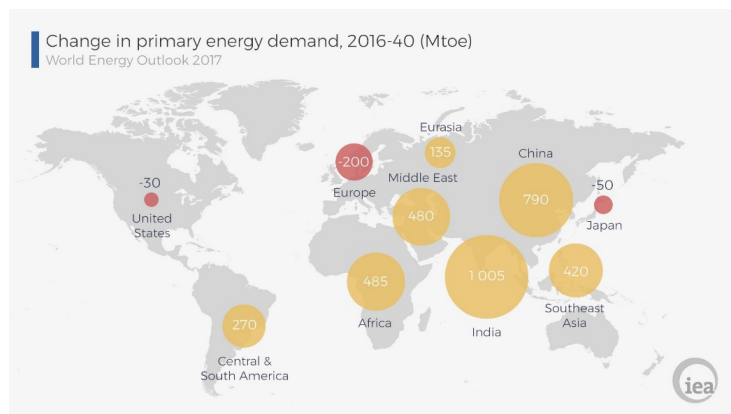
While the climate change impacts of the transition are being well-monitored, less so are other energy-related considerations.

- (1) [institutional shifts](#) in the influence and membership of multilateral organizations like the Organization of Petroleum Exporting Countries (OPEC) and the International Energy Agency (IEA);
- (2) the accelerating [growth of trade in natural gas](#) either through new international pipelines or via a rapidly expanding market for liquefied natural gas (LNG);
- (3) the supply chain of [cutting-edge clean edge technologies](#) and their trade;
- (4) [issues of cybersecurity](#) that are growing in importance with the rise of interconnected systems and new forms of metering and system operations;
- (5) the changing [landscape for conflict and other minerals](#) due to these changes in technologies and their deployment in large numbers;
- (6) the growing [regional power interconnection](#) in electricity grids from the Belt and Road to East Africa; and
- (7) [Lingering energy poverty](#) and the demand for provision of quality and affordable energy services to billions of people and businesses. It is clear that these areas go well beyond technology.

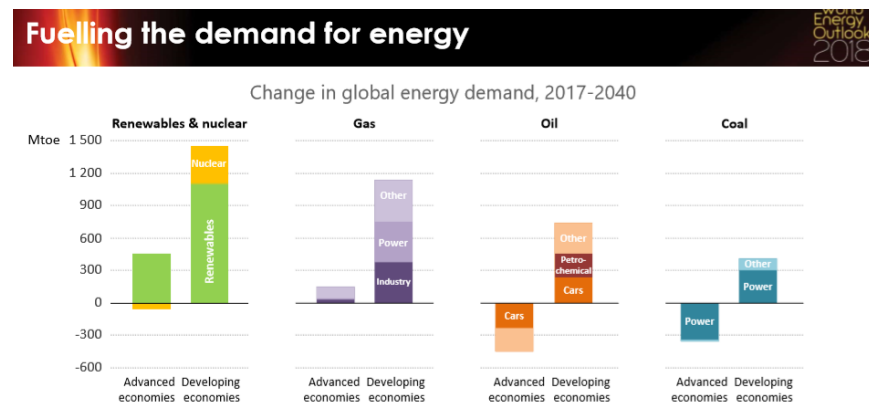
(We provide thematic lens here, while traditional IR would focus more on State-level interactions)

The rest (most) of the world

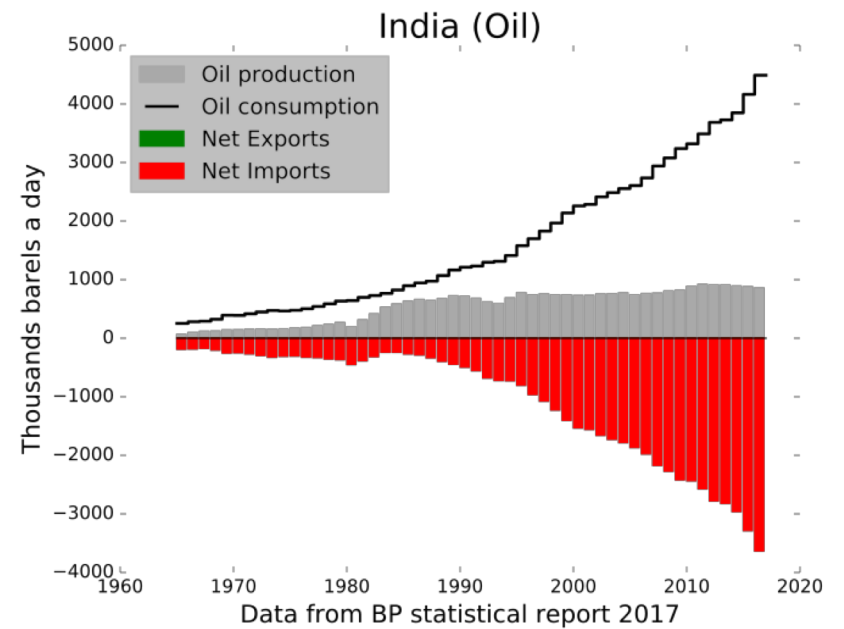
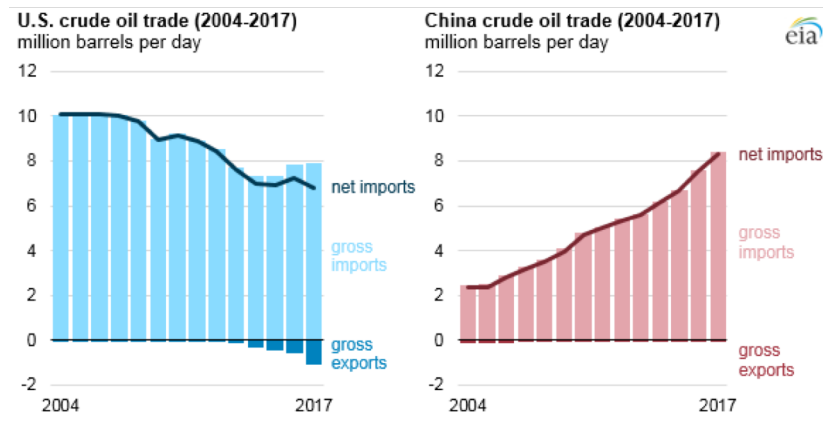
# The energy transition is largely a developing country story



IEA WEO 2017

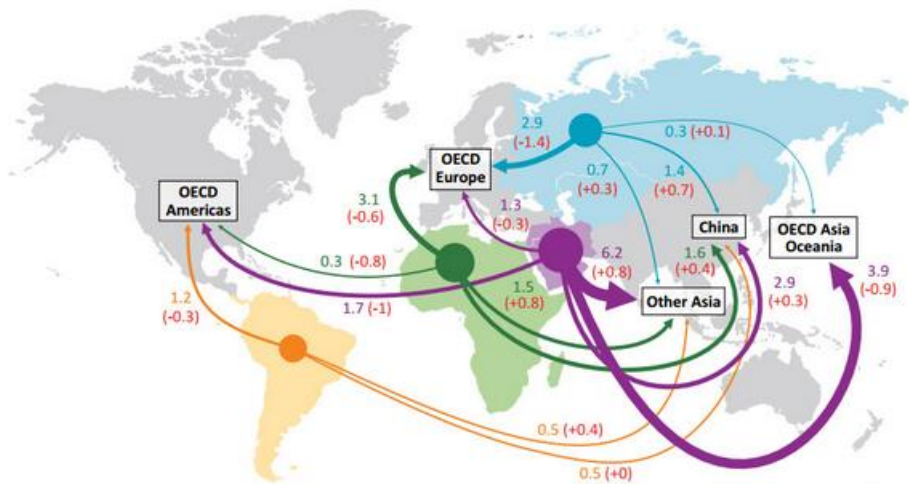


# Changing demand/priorities



# Changing trade maps for oil and gas

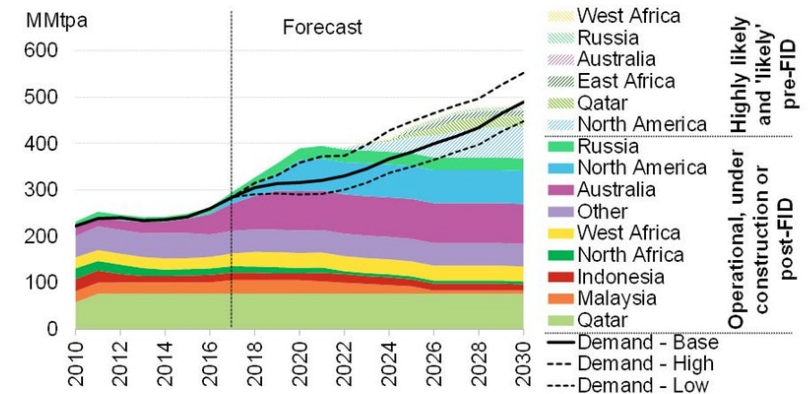
Figure 1.4 Crude exports in 2018 and growth over 2012-18 for key trade routes



This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Source: IEA, 2013a.

Global LNG demand and supply capacity



Note: 'Highly-likely' and 'likely' pre-FID projects are included on this chart. The likelihood of a project being built by 2030 is assessed based on the project's regulatory stage, project size, infrastructure, developers' financial strength, offtake contracts, and sovereign risks.

Source: Bloomberg New Energy Finance, Poten & Partners, customs data.

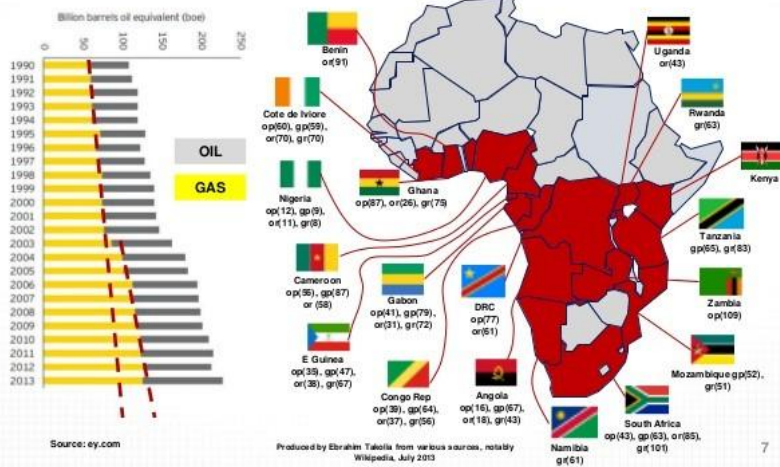
# Opportunity

## Oil & Gas Developments – Africa

### Africa Oil & Gas Reserves

### Regional snapshot of offshore exploration developments in Southern Africa

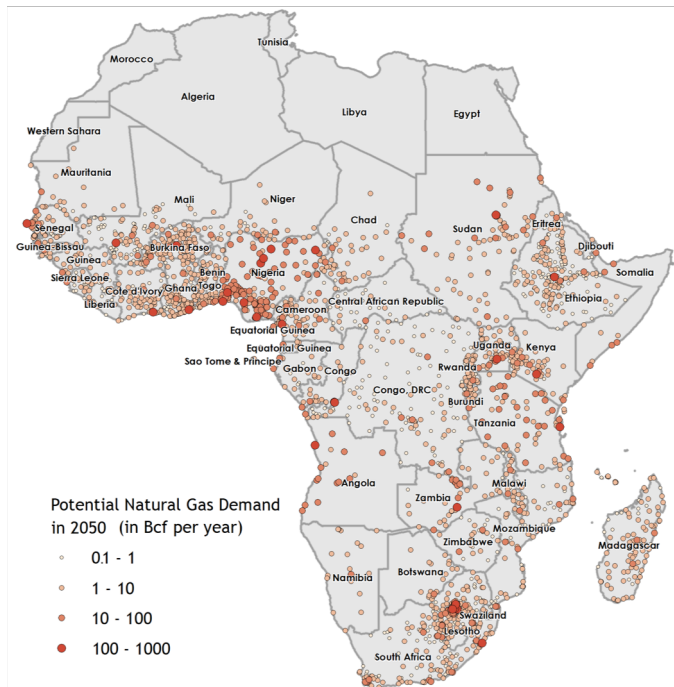
Oil Production World Rank op ( ) Natural Gas Production World Rank gp ( )  
Proven oil Reserves World Rank or ( ) Proven natural gas Reserves World Rank gr ( )



<p>CNOOC - China</p> <p>Nigeria</p> <p>Savannah Petroleum - UK</p> <p>Niger</p> <p>ZPEP - China</p> <p>Ethiopia</p> <p>CNPC - China</p> <p>Sudan</p> <p>Anadarko - US</p> <p>Mozambique</p> <p>Rosneft - Russia</p> <p>Mozambique</p> <p>PERENCO - UK</p> <p>Republic of Congo</p> <p>ELF - France</p> <p>Cameroon</p>	<p>Statoli - Norway</p> <p>Mozambique</p> <p>South Africa</p> <p>Petronas - Malaysia</p> <p>Cameroon</p> <p>Mauritania</p> <p>South Africa</p> <p>Chevron - United States</p> <p>Angola</p> <p>Botswana</p> <p>Republic of Congo</p> <p>Sudan</p> <p>São Tomé and Príncipe</p> <p>British Petroleum - UK</p> <p>Mozambique</p> <p>South Africa</p> <p>Zimbabwe</p>	<p>Sinopec - China</p> <p>Angola</p> <p>Cameroon</p> <p>Djibouti</p> <p>Egypt</p> <p>Ethiopia</p> <p>Gabon</p> <p>Ghana</p> <p>Nigeria</p> <p>Total - France</p> <p>Botswana</p> <p>Cameroon</p> <p>Gabon</p> <p>Gambia</p> <p>Lesotho</p> <p>Namibia</p> <p>Republic of Congo</p> <p>South Africa</p> <p>Royal Dutch Shell - Netherlands</p> <p>Algeria</p> <p>Angola</p> <p>Republic of Congo</p> <p>Egypt</p> <p>Gabon</p> <p>Ghana</p> <p>Kenya</p> <p>Liberia</p> <p>Libya</p> <p>Mozambique</p> <p>Nigeria</p> <p>Tunisia</p>	<p>ENI - Italy</p> <p>Algeria</p> <p>Angola</p> <p>Republic of Congo</p> <p>Egypt</p> <p>Equatorial Guinea</p> <p>Ethiopia</p> <p>Ghana</p> <p>Ivory Coast</p> <p>Kenya</p> <p>Mauritius</p> <p>Morocco</p> <p>Mozambique</p> <p>Nigeria</p> <p>São Tomé and Príncipe</p> <p>Senegal</p> <p>South Africa</p> <p>Tunisia</p> <p>Zambia</p> <p>Zimbabwe</p>	<p>Exxon - United States</p> <p>Algeria</p> <p>Angola</p> <p>Republic of Congo</p> <p>Egypt</p> <p>Equatorial Guinea</p> <p>Ethiopia</p> <p>Ghana</p> <p>Ivory Coast</p> <p>Kenya</p> <p>Mauritius</p> <p>Morocco</p> <p>Mozambique</p> <p>Nigeria</p> <p>São Tomé and Príncipe</p> <p>Senegal</p> <p>South Africa</p> <p>Tunisia</p> <p>Zambia</p> <p>Zimbabwe</p>
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# Natural gas and development?



Estimated potential natural gas demand in sub-Saharan Africa by 2050.



Energy Research & Social Science

Volume 39, May 2018, Pages 74-77



Perspective

## Signalling, governance, and goals: Reorienting the United States Power Africa initiative

Todd Moss <sup>a, b, c, d, e</sup>, Morgan Bazilian <sup>a, d, e</sup>

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<https://doi.org/10.1016/j.erss.2017.11.001>

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### Abstract

Power Africa, the United States' effort to boost electrification on the continent launched in 2013, has made an impressive start. Progress toward generation and connections goals are on track. The initiative has catalyzed significant private sector investment, built a diverse portfolio, and embraced a range of technologies including natural gas. Nevertheless, Power Africa faces political and institutional hurdles that threaten its continued success and perhaps its very survival.

## Flaring and planning



Governments, oil companies, and development institutions around the world are encouraged to endorse the “Zero Routine Flaring by 2030” Initiative.

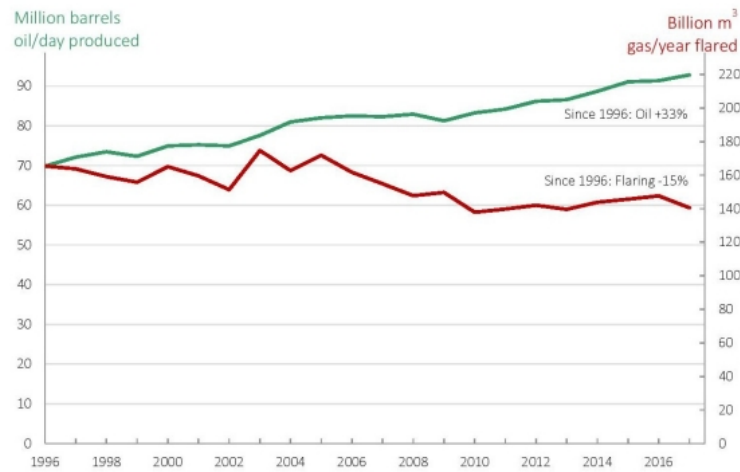
USA has endorsed.

About 140 billion cubic meters annually. Enough to produce 750 billion kWh power

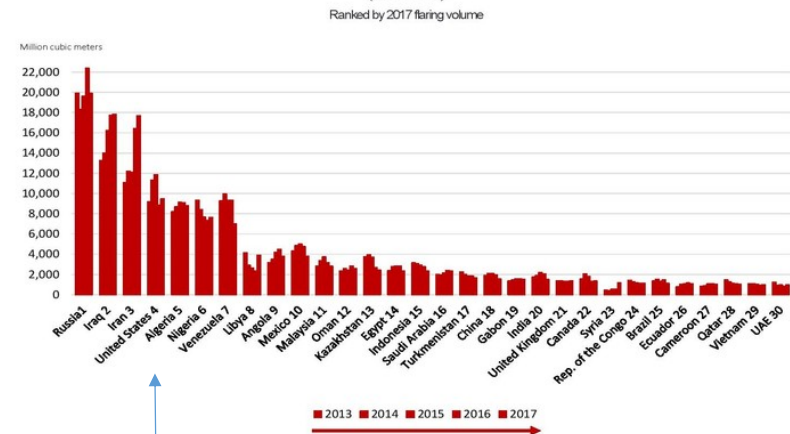
More than the entire power consumption on the African continent currently

# #4

Global gas flaring and oil production 1996-2017



The new ranking – top 30 flaring countries (2013-17)



## Minerals and metals

# Movements and Memes

## COPPER: THE BUILDING BLOCK OF THE ENERGY TRANSITION

**FEATURED RESOURCES**

**Renewable Energy: A Sustainable Power of the Copper Industry**  
As energy innovation is rolling out on a global scale, the world economy is on the track for a.  
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The implementation of solar PV and thermal energy storage is helping to accelerate housing, particularly in the 150,000 new.  
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**Blue Laser Enables Copper Welding and Addition Manufacturing**  
Cutting, welding and additive manufacturing of copper wire leads to more efficient assembly, saving time, increasing quality and reducing footprint.

**COPPER: THE BUILDING BLOCK OF THE ENERGY TRANSITION**

Jointly presented by the International Copper Association and the International Energy Copper Council, this event will focus on the contribution copper is making to the 21st century energy transition.

**WORKSHOP DATE:** Friday, 5 October 2018 | **TIME:** 14:00  
**LOCATION:** United Church Hall, London

**Energy Transition Technologies**

- The Impact of China's One Belt One Road Initiative on Mineral Demand – Gu Liangping, China Minerals
- Competitive Analysis of the 2 Billion Tonne Appliances Market – Kishor Mehta, The Martec Group
- Challenges Affecting Copper in the \$120 Billion Motors Market – Giuseppa Kallian-Schulze, BMW Advisory Group, on behalf of MetalPlex

Copper's Role in Sustainability and Responsible Sourcing

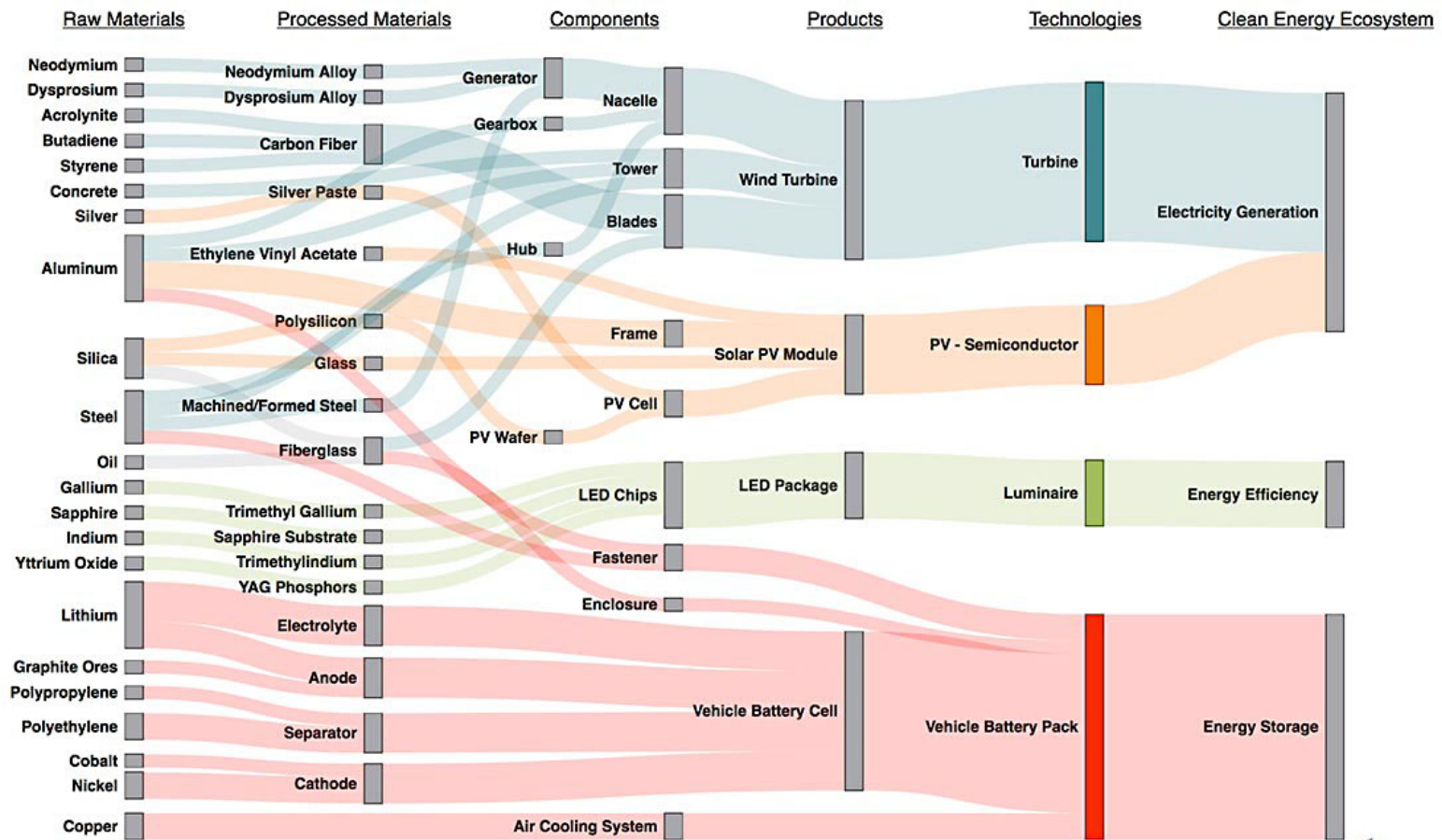
**Mining for Clean Energy**

How the global rise of solar power will drive demand for Canadian metals and minerals

100th Anniversary  
1917-2017



ICA, 2018



# USA “Critical” materials

- Aluminum (bauxite), used in almost all sectors of the economy
- Antimony, used in batteries and flame retardants
- Arsenic, used in lumber preservatives, pesticides, and semi-conductors
- Barite, used in cement and petroleum industries
- Beryllium, used as an alloying agent in aerospace and defense industries
- Bismuth, used in medical and atomic research
- Cesium, used in research and development
- Chromium, used primarily in stainless steel and other alloys
- Cobalt, used in rechargeable batteries and superalloys
- Fluorspar, used in the manufacture of aluminum, gasoline, and uranium fuel
- Gallium, used for integrated circuits and optical devices like LEDs
- Germanium, used for fiber optics and night vision applications
- Graphite (natural), used for lubricants, batteries, and fuel cells
- Hafnium, used for nuclear control rods, alloys, and high-temperature ceramics
- Helium, used for MRIs, lifting agent, and research
- Indium, mostly used in LCD screens
- Lithium, used primarily for batteries
- Magnesium, used in furnace linings for manufacturing steel and ceramics
- Manganese, used in steelmaking
- Niobium, used mostly in steel alloys
- Platinum group metals, used for catalytic agents
- Potash, primarily used as a fertilizer
- Rare earth elements group, primarily used in batteries and electronics
- Rhenium, used for lead-free gasoline and superalloys
- Rubidium, used for research and development in electronics
- Scandium, used for alloys and fuel cells
- Strontium, used for pyrotechnics and ceramic magnets
- Tantalum, used in electronic components, mostly capacitors
- Tellurium, used in steelmaking and solar cells
- Tin, used as protective coatings and alloys for steel
- Titanium, overwhelmingly used as a white pigment or metal alloys
- Tungsten, primarily used to make wear-resistant metals
- Uranium, mostly used for nuclear fuel
- Vanadium, primarily used for titanium alloys
- Zirconium, used in the high-temperature ceramics industries

Under the Executive Order, these commodities qualify as “critical minerals” because each has been identified as a non-fuel mineral or mineral material that is essential to the economic and national security of the United States, that has a supply chain vulnerable to disruption, and that serves an essential function in the manufacturing of a product, the absence of which would have significant consequences for the economy or national security.

Copper demand in energy efficiency sectors almost doubles from 4.7 Mt in 2017 to reach 9.7 Mt by 2035

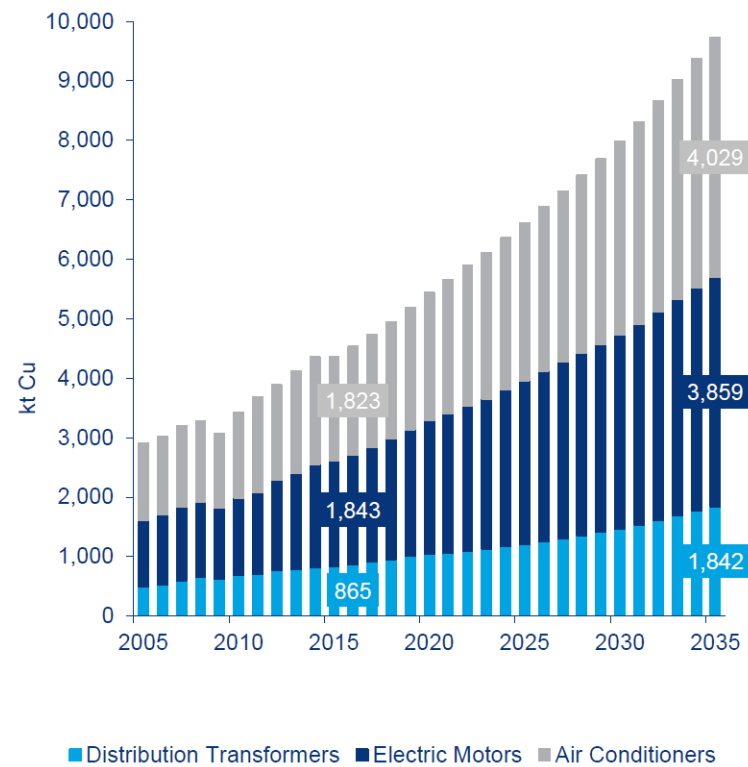
**Distribution Transformers**



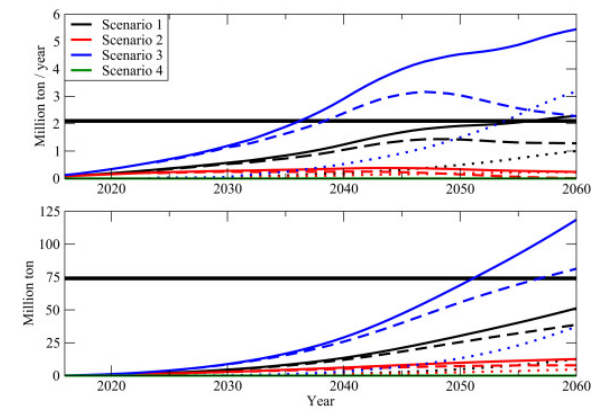
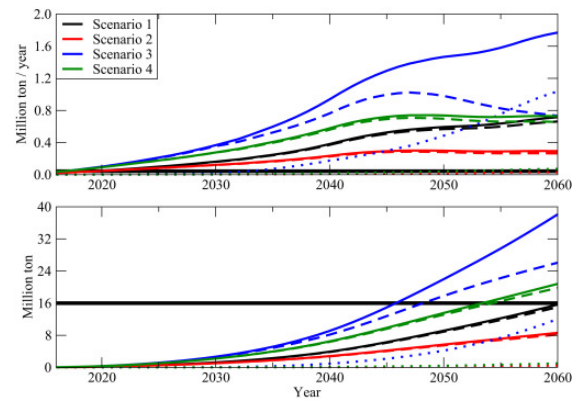
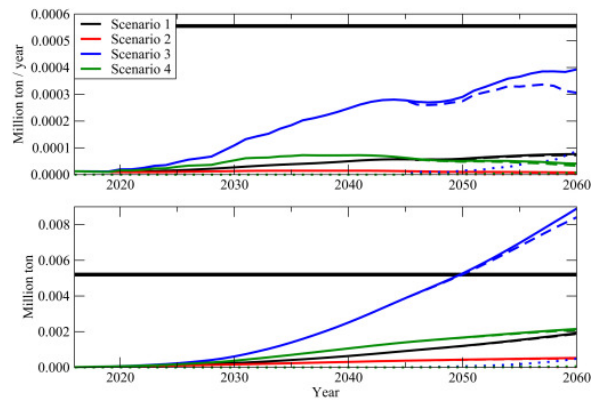
**Electric motors**



**Air Conditioners**







## Tellurium; Lithium; and Nickel

<https://www.sciencedirect.com/science/article/pii/S0301421518302726#f0020>

Europe also looking at these issues...

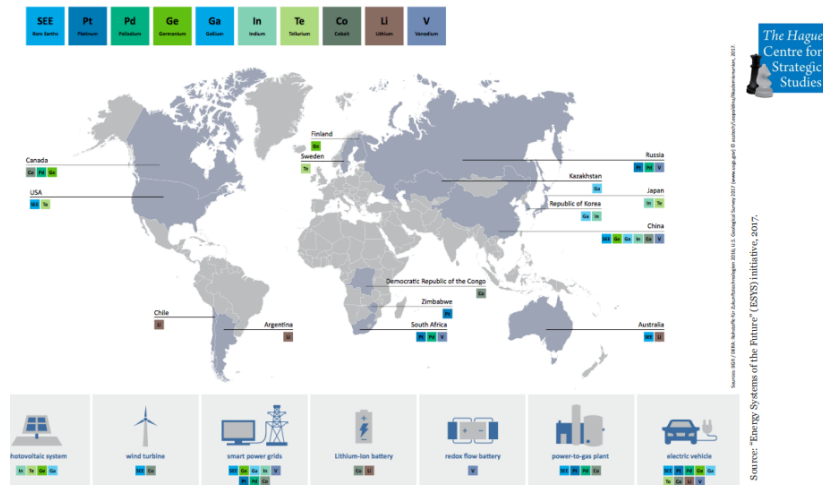
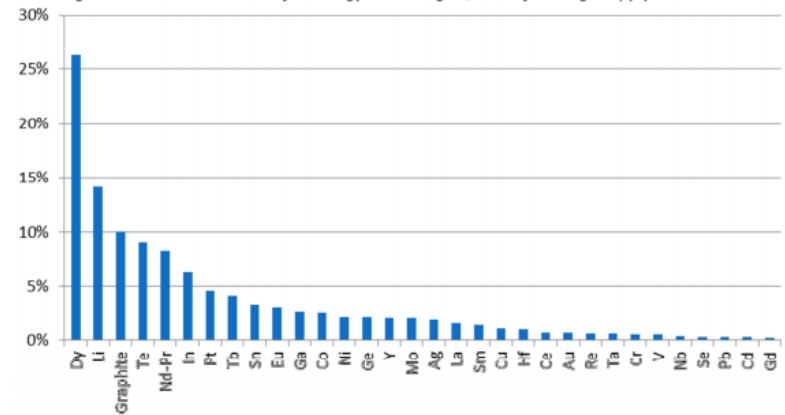


Figure 1: EU metals demand for energy technologies, as % of average supply 2020-2030



# And China and Japan.....

■ Web Exclusive

### The Chinese Investment that Could Boost Chile's Lithium Boom – and Help Climate Change, Too

BY JORGE HEINE AND ANDERS BEAL | NOVEMBER 7, 2018

A Chinese firm wants to invest billions, but has met resistance.



Workers take samples of salt brine in the Salar de Atacama, Chile.  
Oliver Larrea/Retna; Construction Photography/Retna/Getty Images

 Such are the riches to be found in them, that the Andes mountains have been described as a gigantic open pit mine.

 18

Something similar can be said of the Atacama Desert in Northern Chile, the driest in the world and home to several coveted global commodities. The previous century saw interest in its nitrates, and more recently the Atacama has been touted as an exceptional source of solar energy, capable of generating all of Chile's electricity needs and more. Now, lithium, which has been called the



The Big Read Mining

➔ Add to mFT

### Electric vehicles spur race to mine deep sea riches

Miners want to tap subsea cobalt deposits for green technologies, but environmentalists worry



Critical Materials Institute  
AN ENERGY INNOVATION HUB

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Resources Education Working with CMI



CMI new recycling process turns discarded magnets into new magnetic material



#### About CMI



CMI Webinar: Rare Earth Magnets:  
Yesterday, Today and Tomorrow  
John Ormerod, Magnet Applications, Inc.  
October 30, 2018

The next CMI webinar on October 30 will feature John Ormerod of Magnet Applications, Inc. He will present "Rare Earth Magnets: Yesterday, Today, and Tomorrow." There is no fee to register for a CMI webinar; registration is required to receive a link to the webinar. Link to registration page: [https://mines.zoom.us/webinar/register/WN\\_V...](https://mines.zoom.us/webinar/register/WN_V...)

#### CMI Highlights



The Federal Laboratories Consortium honored an acid-free dissolution rare-earth magnet recycling process developed by CMI researchers at Ames Laboratory with a 2018 Notable Technology Development Award. [Link](#)

#### CMI in the News

- Ames Laboratory:  
[Critical Materials Institute takes major step toward printed anisotropic magnets](#)
- ISU College of Engineering News:  
[Alex King receives international Acta Materialia Hollomon Materials & Society Award](#)
- Federal Laboratory Consortium:  
[Acid-free dissolution rare-earth magnet recycling process](#)
- Ames Laboratory:  
[Rare-earth magnet recycling tech wins innovation award](#)
- Resource World Magazine:  
[Specialty Metals Report](#)
- CleanTech Alliance:  
[Showcase recap: Recycling electronic devices](#)



**Table 2**  
Cobalt production and reserves (metric tons) ([Drexhage et al., 2017](#) based on USGS, 2016).

Country	Mine production	Reserves
Congo (Kinshasa)	63,000	3,400,000
Australia	6000	1,100,000
Cuba	4200	500,000
Zambia	2800	270,000
Philippines	4600	250,000
Russia	6300	250,000
Canada	6300	240,000
New Caledonia	3300	200,000
Madagascar	3600	130,000
China	7200	80,000
Brazil	2600	78,000
South Africa	2800	31,000
Other countries	7700	633,000
Total	120,400	7,162,000

# Minerals and conflict

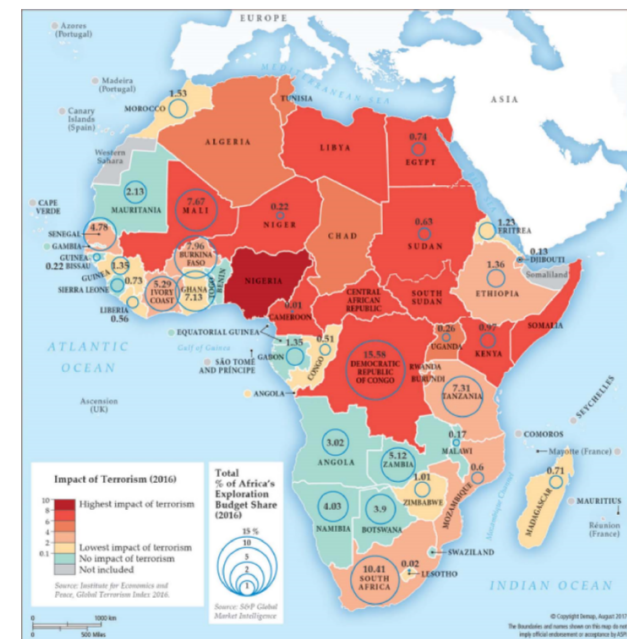
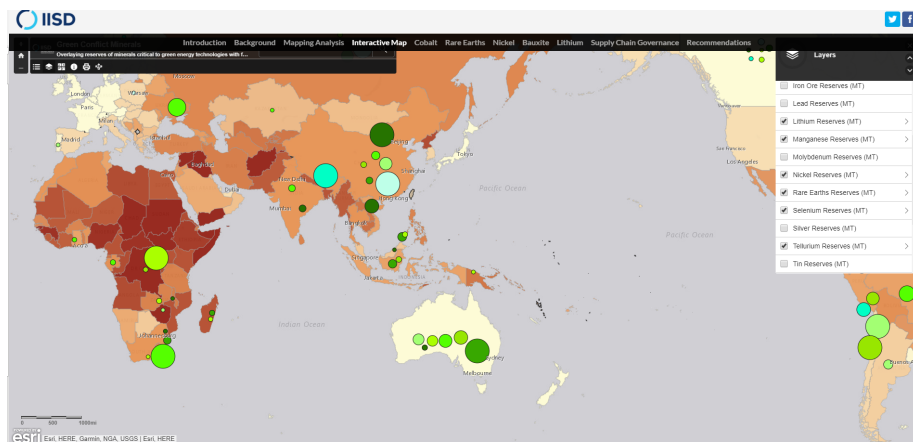
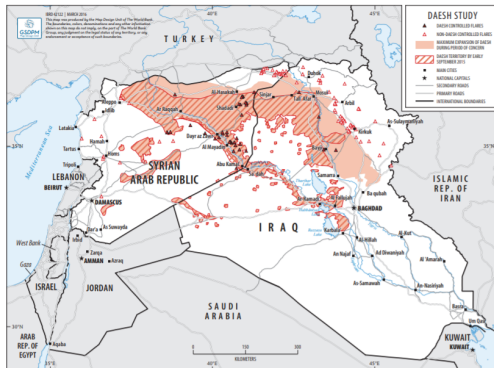


Fig. 3. Mining exploration budget and terrorism impact (Sharland et al., 2017).

Energy and conflict

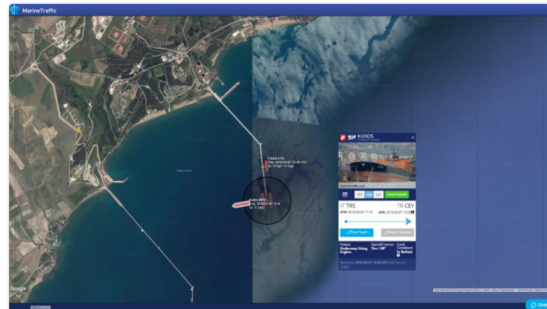
# New ways to monitor geopolitics

Figure 1: Iraq and Syria Oil Production, Fields, and Daesh Control, March 2016



**TankerTrackers.com** @TankerTrackers · Mar 7

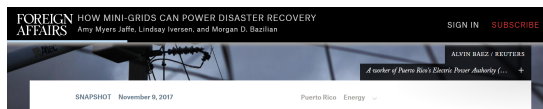
KUDOS has now arrived at the KRG berth in the port of Ceyhan, Turkey. She last departed Ceyhan on December 11th with 424K barrels to Croatia. Was only half full. #OOTT



World Bank, 2017; Tanktrackers on Twitter



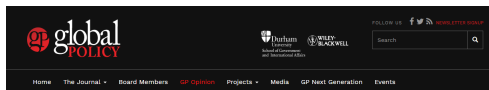
# Energy and peace



## How Mini-Grids Can Power Disaster Recovery

New Energy Technologies and the Future of Humanitarian Aid

By Amy Myers Jaffe, Lindsay Iversen, and Morgan D. Bazilian



GP Opinion | The Peace Dividends of Energy Infrastructure – North Korea, Iran and Beyond

## The Peace Dividends of Energy Infrastructure – North Korea, Iran and Beyond

By Morgan D. Bazilian and Saleem H. Ali - 29 August 2018



Morgan D. Bazilian and Saleem H. Ali explore the possibilities of using pipelines, or other energy infrastructure, as a basis for peace. The resumption of negotiations of using pipelines, or other energy infrastructure, as a basis for peace has emerged again, this time on the Korean peninsula. The Korean energy market of South Korea has become increasingly important to the United States as it becomes a major producer of liquefied natural gas (LNG). However, it would be worth more to consider for South Korea to also consider gas from its regional neighbors, particularly Russia. Only three days after the historic summit between President Trump and North Korean leader Kim Jong Un, Russian gas giant Gazprom announced that it was revisiting talks of a pipeline to South Korea. It is also interesting to consider the recent high level engagement between North Korea and Iran as the US maintains a paradoxical denouement of conflict with the former and an escalation of belligerence with the latter. In the case of Iran, energy infrastructure is adding an additional variable in U.S.-Turkey relations as well since Turkey has an established pipeline with Iran. Yet the prospect for peace dividends in the struggle case was also evident when President Trump granted an Iran sanctions waiver to a Caspian gas pipeline project to Turkey and Europe in which Iran's national oil company has a 10% stake.

### From the Journal

#### CHALLENGE AND SECURITY



Absent or Involunt? Women's Movements and the United Nations



## YaleGlobal Online

Topics Regions Special Reports Books Multimedia Resources Globalization Most Popular

Prior we diving for oil, the most traded commodity on global markets and the world's leading energy source. Much production is in volatile regions, and hence, as Title surprise that production and trade in crude oil and refined petroleum products have produced a flourishing black market that presents socioeconomic, geopolitical, and environmental challenges, including deterioration of the rule of law. Illegal trade in hydrocarbons also presents a global security concern, funding dangerous non-state actors, ranging from the Islamic State terrorists to Mexican drug cartels, explain Per-Charl Axelsson, Morgan D. Bazilian and Cyril Widdershoven, all associated with the Payne Institute of the Colorado School of Mines. Illicit oil trade harms producers and non-producers, wealthy and poor nations alike. Despite grave implications worldwide for such illegal trade, governmental and industry efforts to halt the practice have so far been ineffective or even non-existent. – Yafael

## The World's Most Dangerous Black Markets

Illegal trade of oil and other hydrocarbons flourishes and poses serious environmental and security challenges

■ Per-Charl Axelsson, Morgan D. Bazilian and Cyril Widdershoven | Tuesday, October 9, 2018



GP Opinion | Much Ado About Nord Stream 2: Pipeline Politics and European Energy Security

## Much Ado About Nord Stream 2: Pipeline Politics and European Energy Security

By Alex Gilbert and Morgan D. Bazilian - 26 September 2018



Alex Gilbert and Morgan D. Bazilian explore how the USA can improve European energy security.

On Tuesday, U.S. President Trump warned the United Nations General Assembly that "Germany will become totally dependent on Russian energy if it does not immediately change course."

The Trump Administration's foreign policymaking, particularly on issues of trade and Russia, often entails major disagreements with a GOP-controlled Congress, and highlights unilateral action. On Nord Stream 2 (a proposed pipeline from Russia to Germany which would in thousands of miles away from U.S. soil), however, the President, the State Department, and bipartisan majority in Congress universally approve the pipeline. They are now excluding diplomatic pressure begun in the Obama Administration.

In 2013, the Countering America's Adversaries Through Sanctions Act authorized the Administration to impose sanctions for Russia-Europe pipelines at its discretion. Additionally, several proposed bills are now heading through Congress that would mandate sanctions against companies participating in Nord Stream 2. During the recent Helsinki Summit, Nord Stream 2 was a central and contentious issue. President Trump criticized Chancellor Merkel for Germany's role in the pipeline, and discussed it with President Putin. The U.S. foreign policy (new) consensus is driven largely by: geopolitical competition with Russia; energy security; role in Ukraine and NATO members; economic and climate cohesion; broader concerns about Russian threats to EU energy security; and competition between Russian gas and



## Energy's Changing Role in Relief Aid

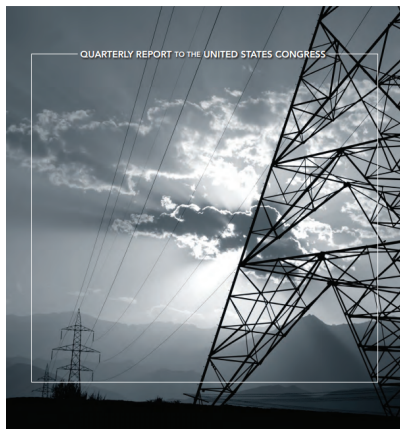
With record numbers of forcibly displaced people, international aid agencies aim for an energy efficiency upgrade with renewables

■ Morgan D. Bazilian, Lilliana Benitez, Glada Lahn, David Mozerensky and Sherwin Das | Tuesday, November 20, 2018



Survival and sustainability: The UNHCR provides solar cooking tools to refugees in Burkina Faso, and a Syrian girl carries water in a refugee settlement in Jordan

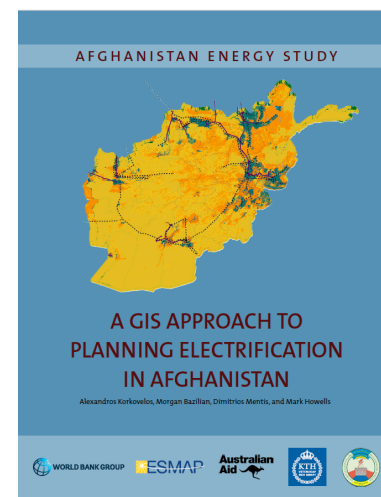
GOLDEN, COLORADO: The world has 100 million people in need of humanitarian aid. More than 68 million of these people have been displaced by conflict, a thousand rise



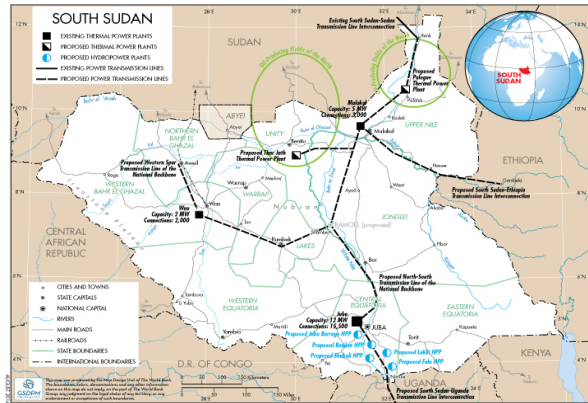
“In fragile and conflict-afflicted country settings, power system planning cannot ignore the inherent risks. . . . Such risks can, for example, manifest in projects being delayed, abandoned, or coming in at very high costs. Security issues can thus significantly hamper, or make infeasible, the delivery of power system master plans.”

—“*Considering Power System Planning in Fragile and Conflict States*”

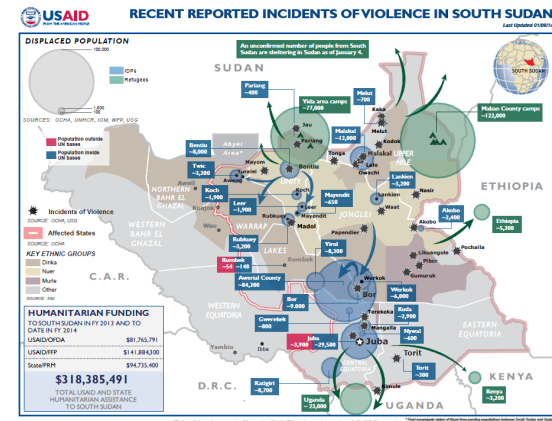
Source: Morgan Bazilian and Dimitrios Christopoulos, “Considering Power System Planning in Fragile and Conflict States,” *Cambridge Working Papers in Economics*, 11/10/2015, p. 2.



## South Sudan

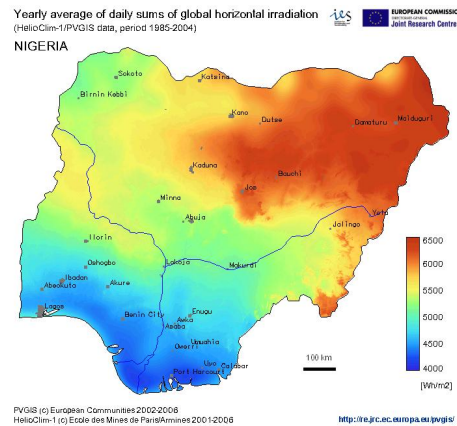


Assumption

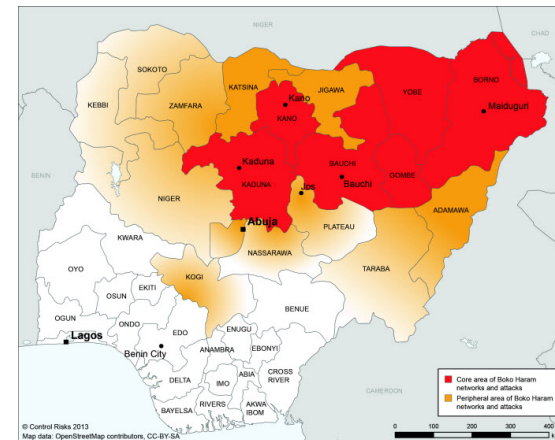


Reality

## Nigeria - Solar



Assumption

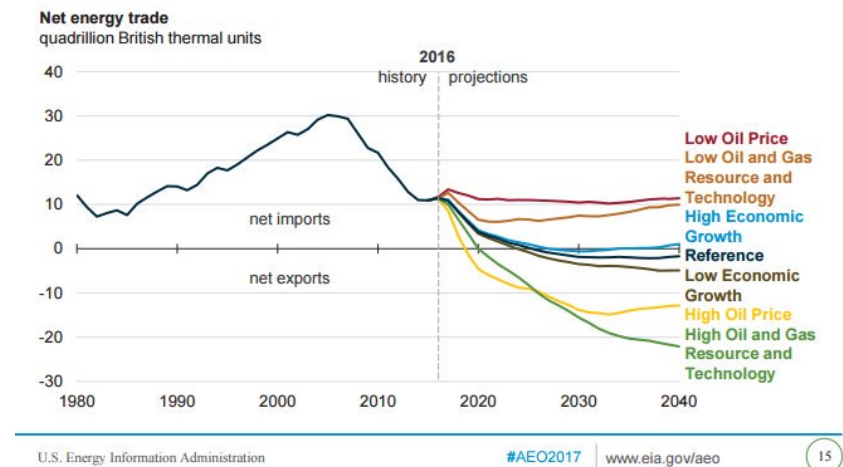


Reality

A bit on security and independence

# Analogies in oil and gas security

- Independence is the wrong framing. The world is interrelated and growing more so.
- Energy security “measured” through various metrics: HHI, governance; import dependency; reliability, etc.
- Consider and model:
  - Diversification of sources of supply (various fuels and technologies)
  - Diversification of supply chains
  - Resilience or the ability to handle shocks and recover from failures
  - Reducing energy demand to ease the burden on infrastructure
  - Redundancy in case failures occur
  - Distributing timely information to markets.
- Apply sophisticated metrics to critical or security of minerals and metals



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