

*Operational energy enables us to kill people and break things in order to win the war*

# Operational Energy & Innovation

8 April 2022

## Mace Carpenter

Office of the Secretary of Defense; Undersecretary for Defense (Acquisition & Sustainment; Environment and Energy Resilience; Operational Energy-Innovation



# Russian/Ukraine War

People walk under a destroyed railway bridge over a main road near the village of Novobakhmutivka that leads into the east Ukrainian city of Donetsk, in a picture sent from the warzone today. (Businesscon Blogspot)

Lack of fuel has left Russia in an embarrassing situation, and its vehicles and troops easy pickings for Ukrainian soldiers who have set fire to dozens if not hundreds of vehicles and captured Russian forces. (The Jerusalem Post)



Problems with logistics, running out of fuel, bad maps, all sorts of other things. Vox—Mason Clark



Scott Gehlbach, a University of Chicago political economist, said there was “lots of evidence that Russia botched the logistics of its military operation.” Western Journal



The Russian advance into Ukraine has temporarily slowed, probably because of logistical problems and strong resistance, Britain’s Defense ministry said on Saturday. UK Defense Ministry



Putin is furious, that he expected a quick surrender from Kiev, and that the invading Russian forces weren’t equipped for a long war — and that after ten days, the Russian forces will face serious problems with supply lines, fuel, equipment, ammunition, etc. (National Review)

Russian forces are continuing to face stiff resistance from the Ukrainian military as fuel and logistics problems have hampered their advance in the northern sections of the country, a senior Pentagon official said Sunday (Wash Times 27 Feb 22)

# Overview

- Global Energy
- OE Background
- OE Today
- OE Innovation
- Adversaries





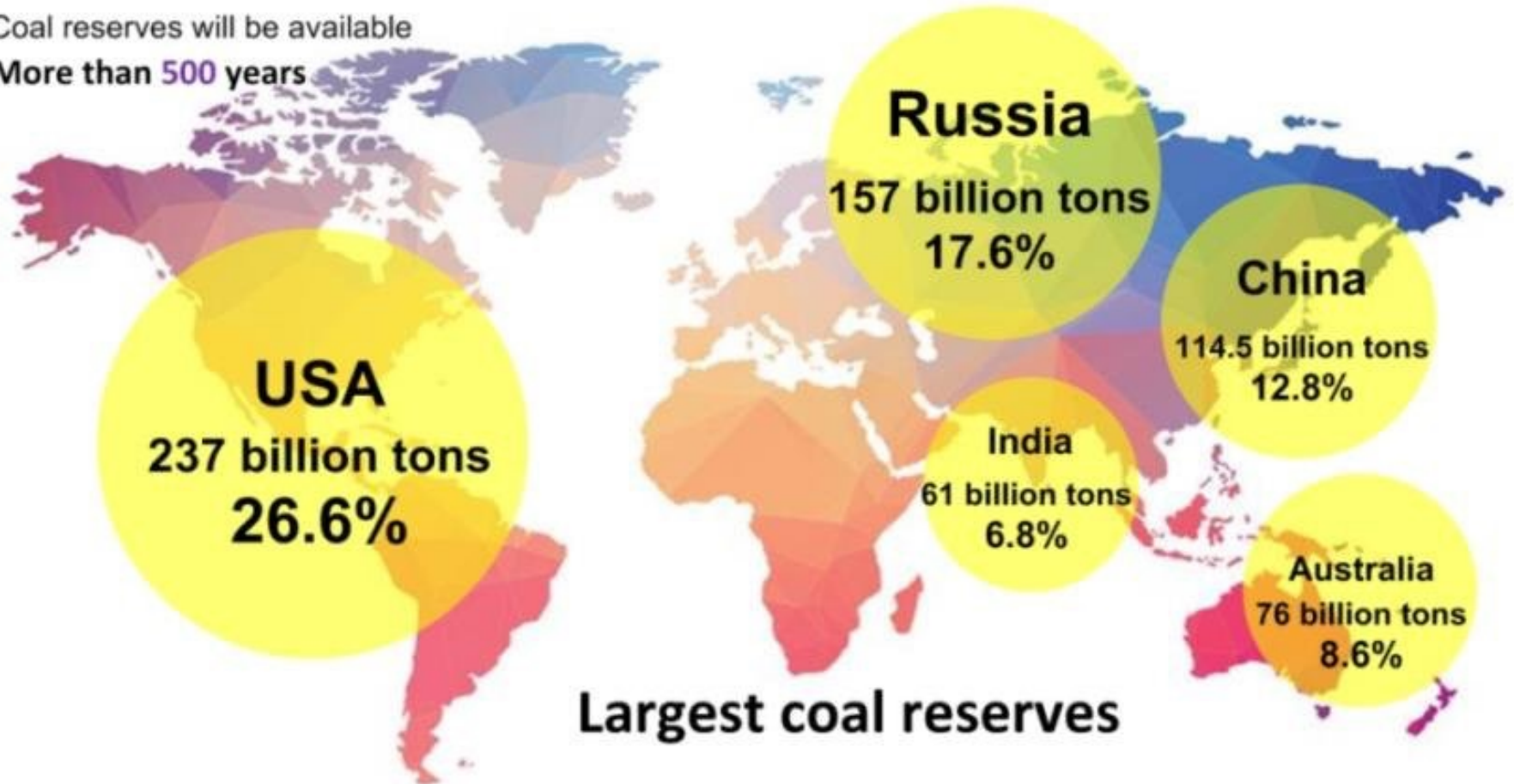
# Global Energy





# Coal Reserves

Coal reserves will be available  
More than **500** years

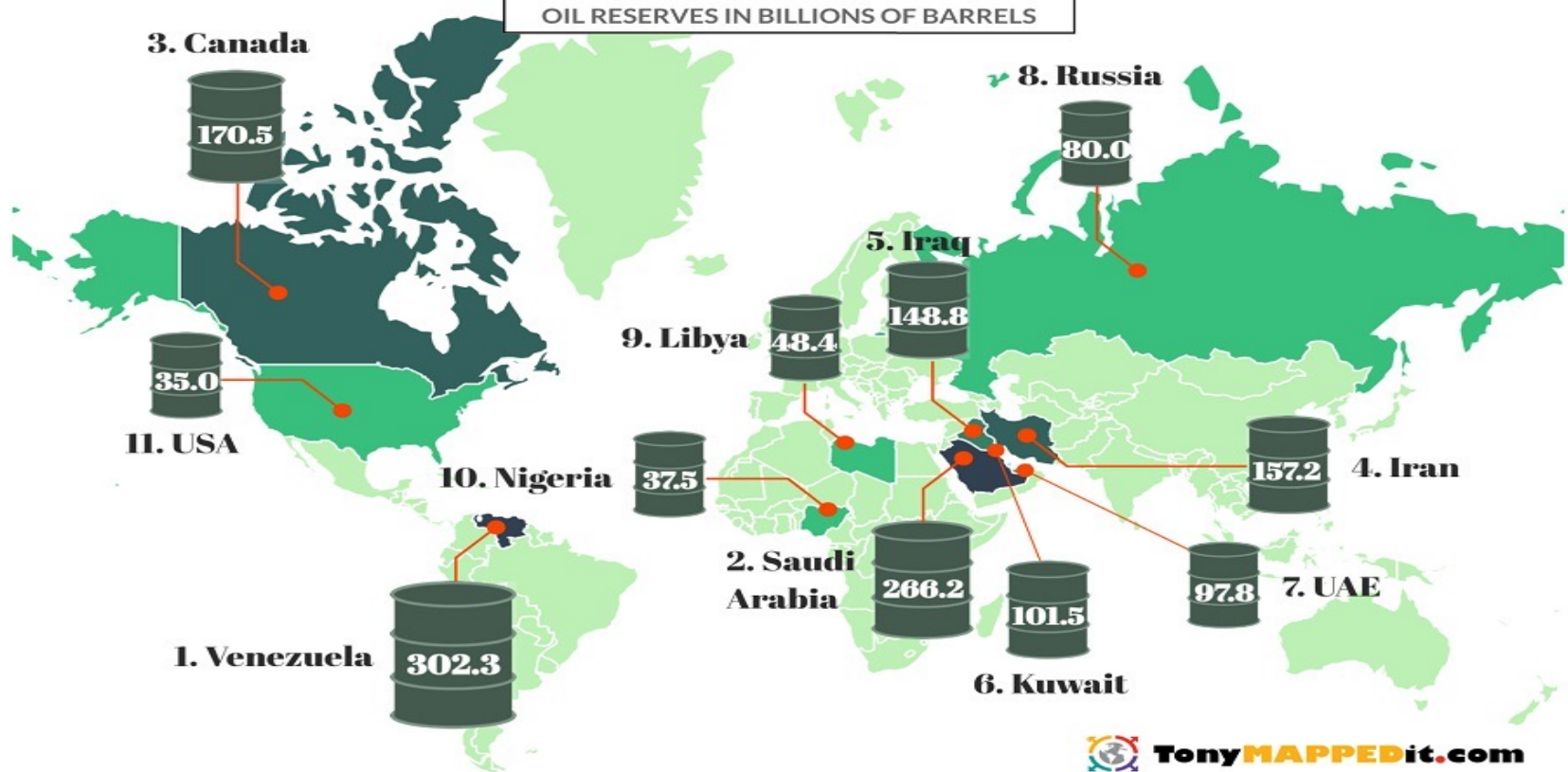


Largest coal reserves

# Proven Oil Reserves

## Proved Oil Reserves

OIL RESERVES IN BILLIONS OF BARRELS



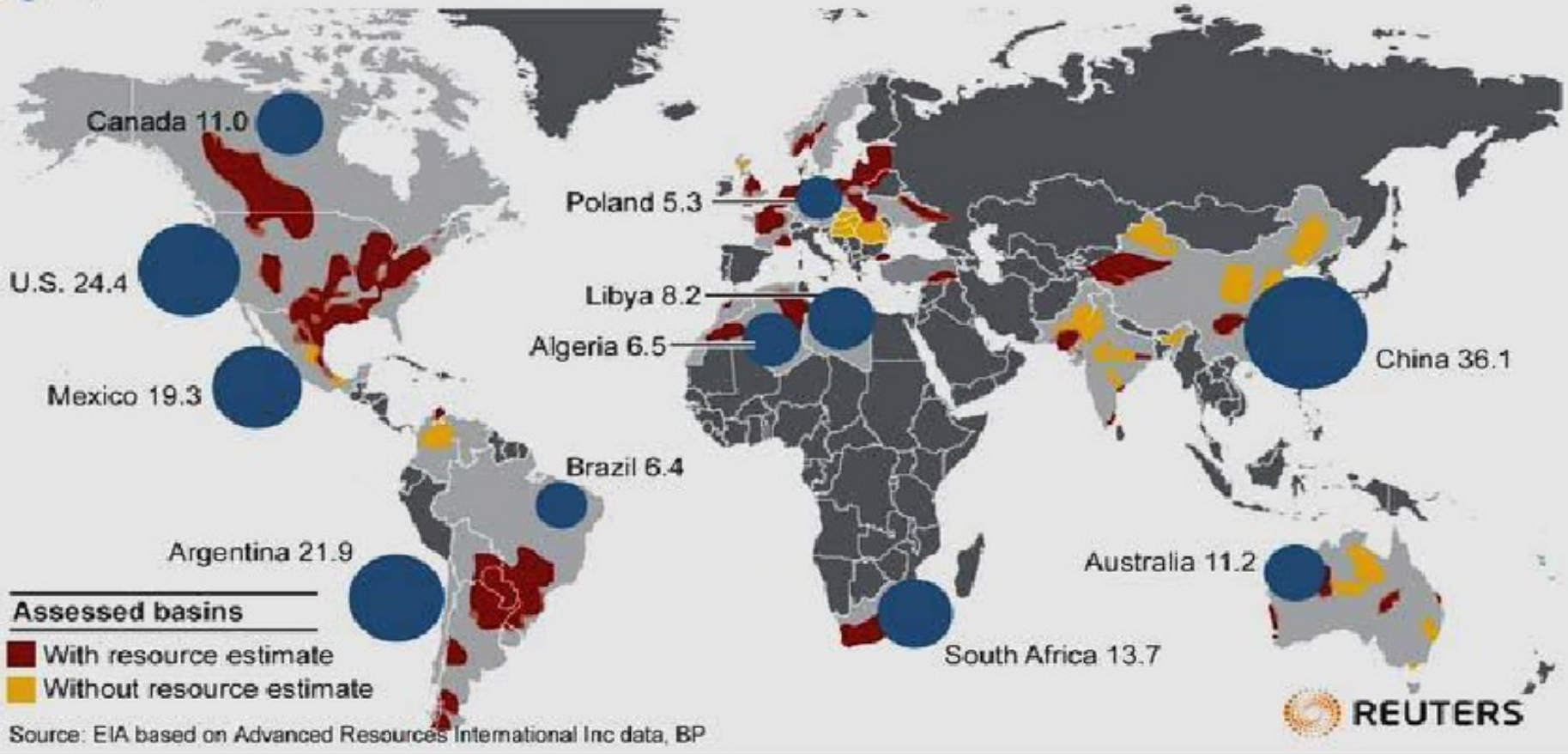
 **TonyMAPPEDit.com**

Data set: 1 January 2018

# Global Shale Reserves

## Global shale gas basins, top reserve holders

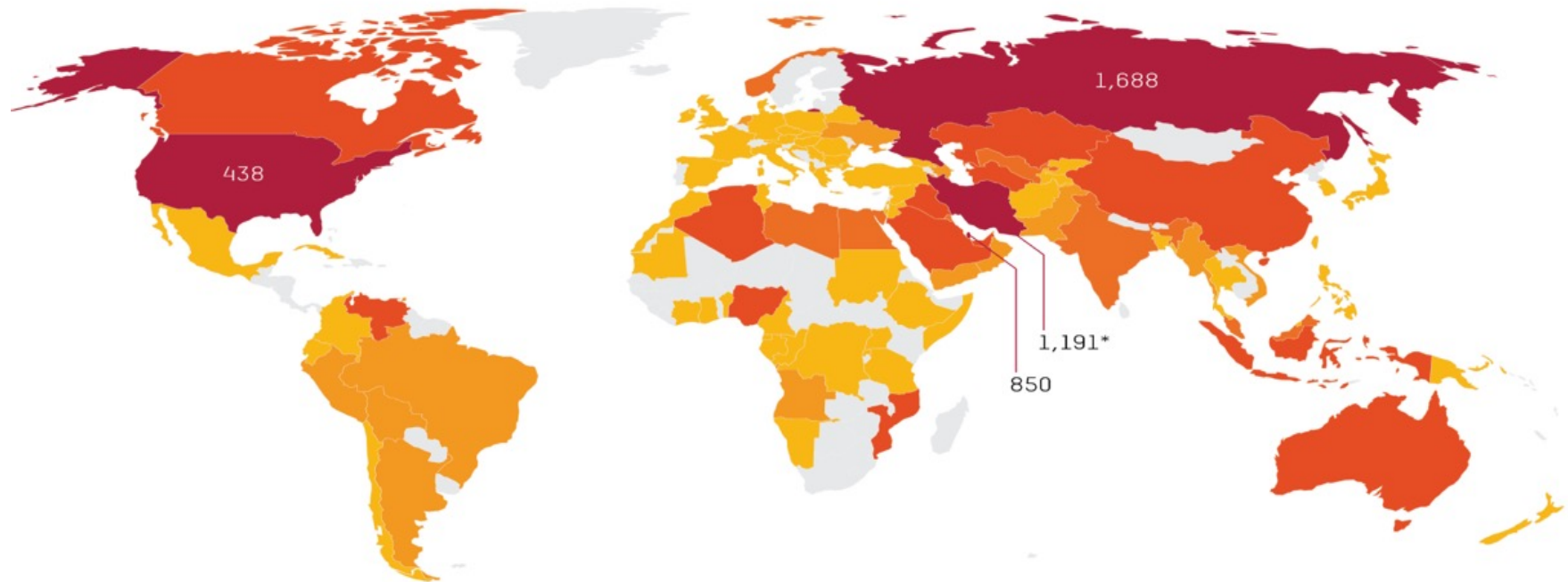
● Top reserve holders 200 - Trln cubic metres





# Natural Gas Reserves

## THE NEW GLOBAL GAS MARKET: ESTIMATED RESERVES BY COUNTRY



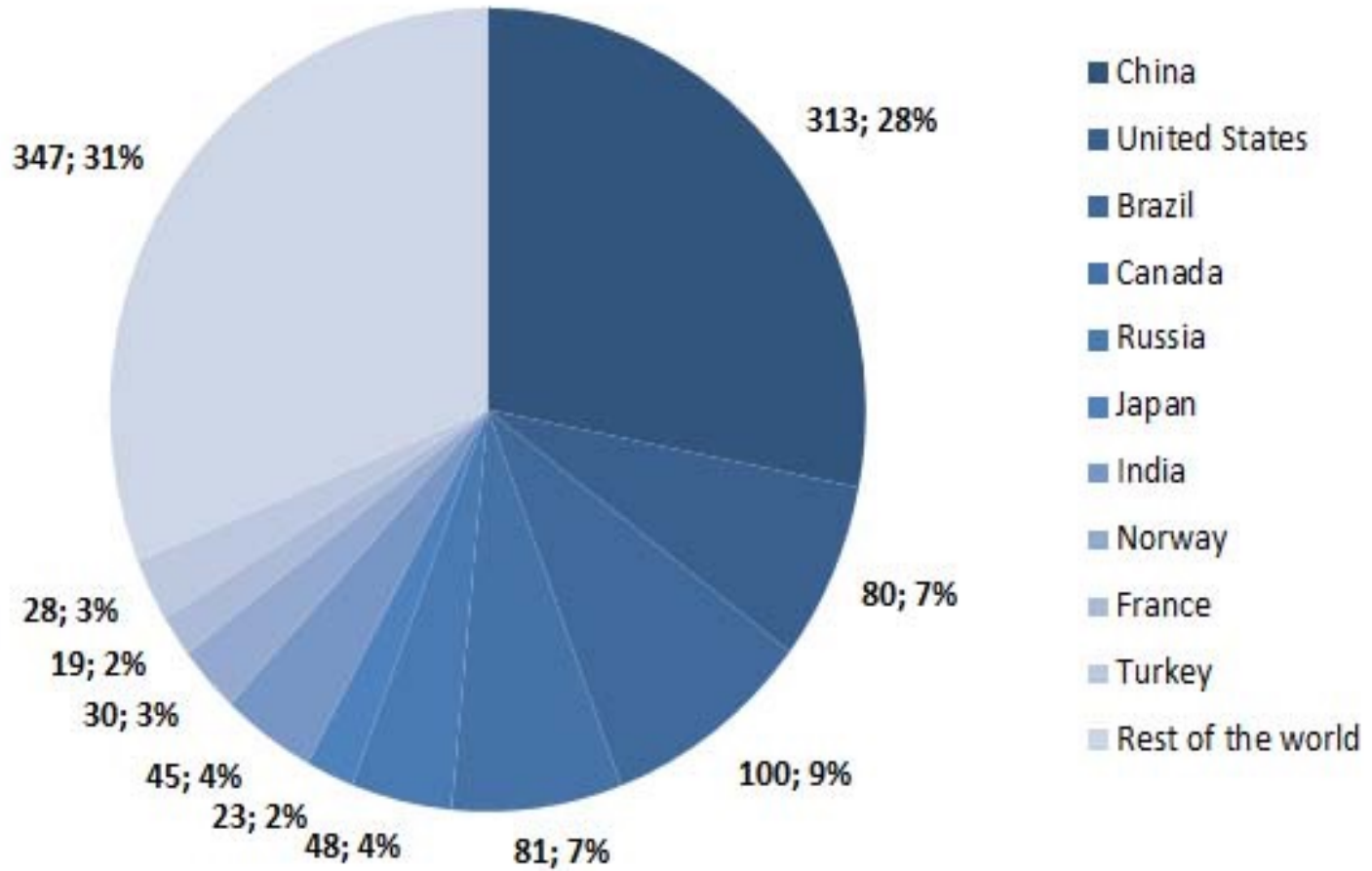
Gas Reserves (Tcf): ● Below 10 ● 10 to 40 ● 40 to 70 ● 70 to 400 ● Above 400

\*Most of Iran's natural gas production is currently consumed domestically. Iran could become a major supplier to Europe and Asia through the development of new LNG infrastructure in the future; however, at present, US-led sanctions are limiting those prospects.

The color scale is a log scale thus showing greater differentiation among countries with small reserves. Source: U.S. Energy Information Administration

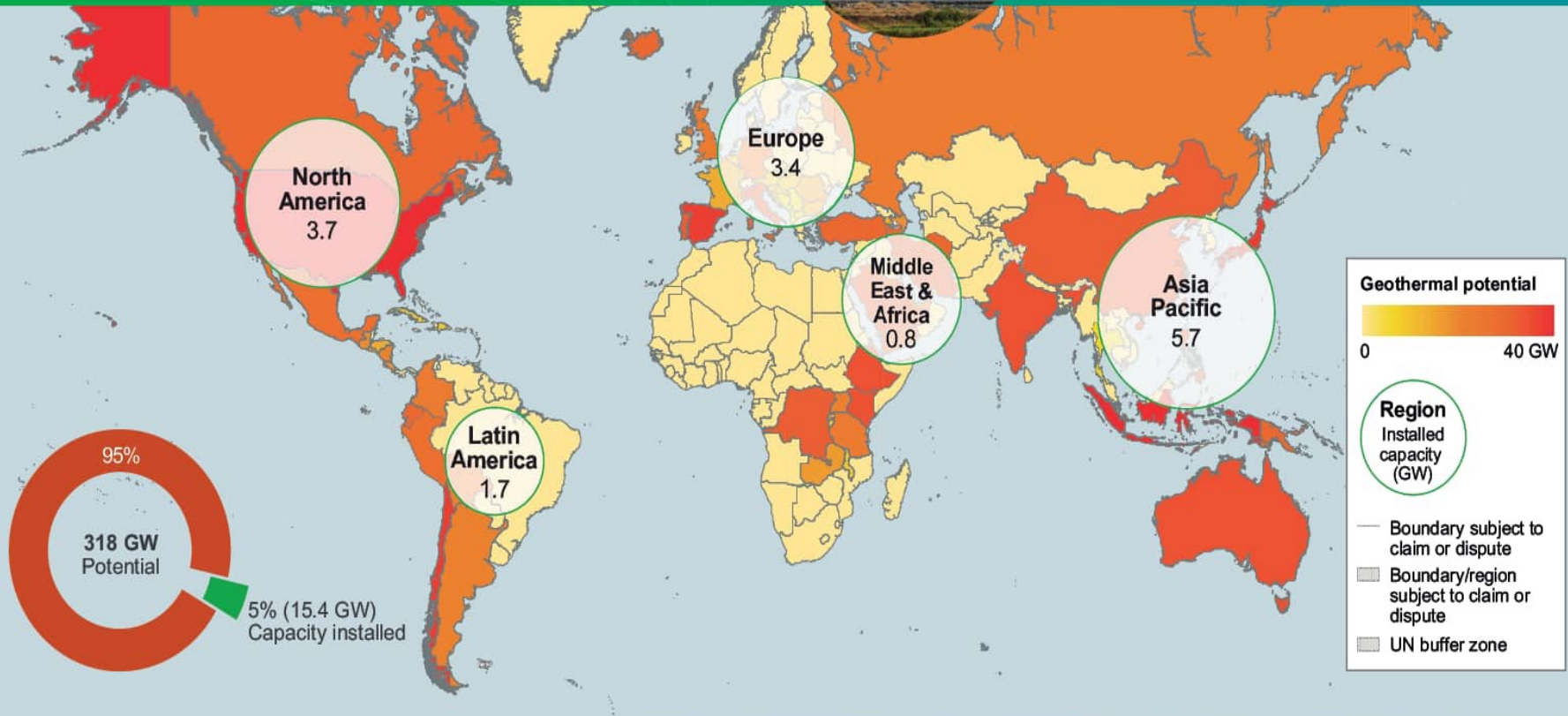
# Hydro Power

Data in gigawatts (GW) and in percentage



# Geothermal Power

## Global Geothermal Power Installed capacity vs global potential

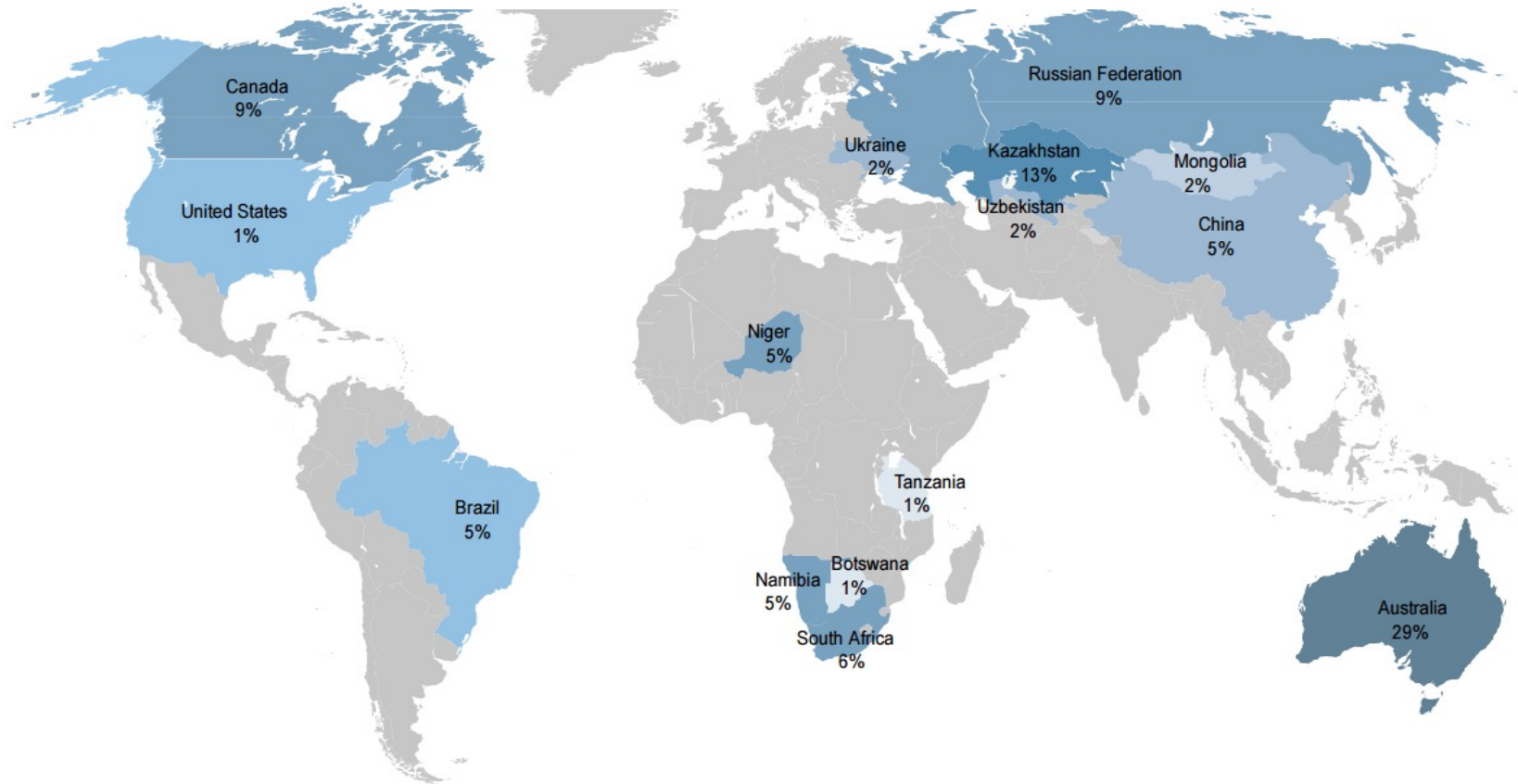




# Uranium Deposits

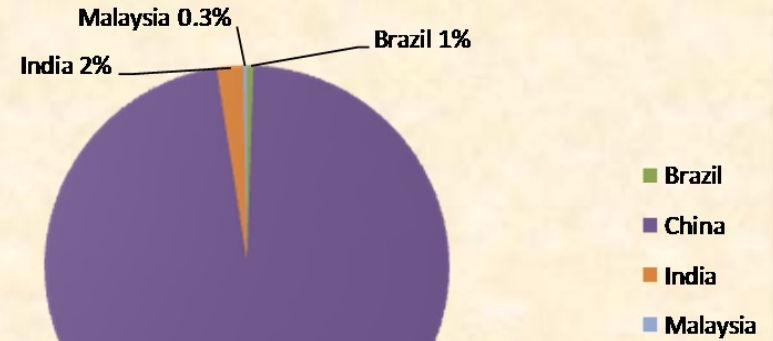
**Figure 1.1. Global distribution of identified resources**

(<USD 130/kgU as of 1 January 2015)



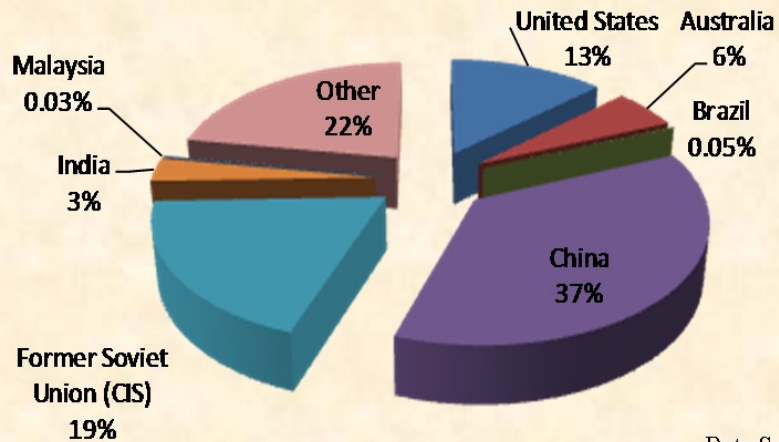
# Rare Earths

## Global Rare Earths Production - 2009



Data Source: USGS

## Global Rare Earths Reserves - 2009

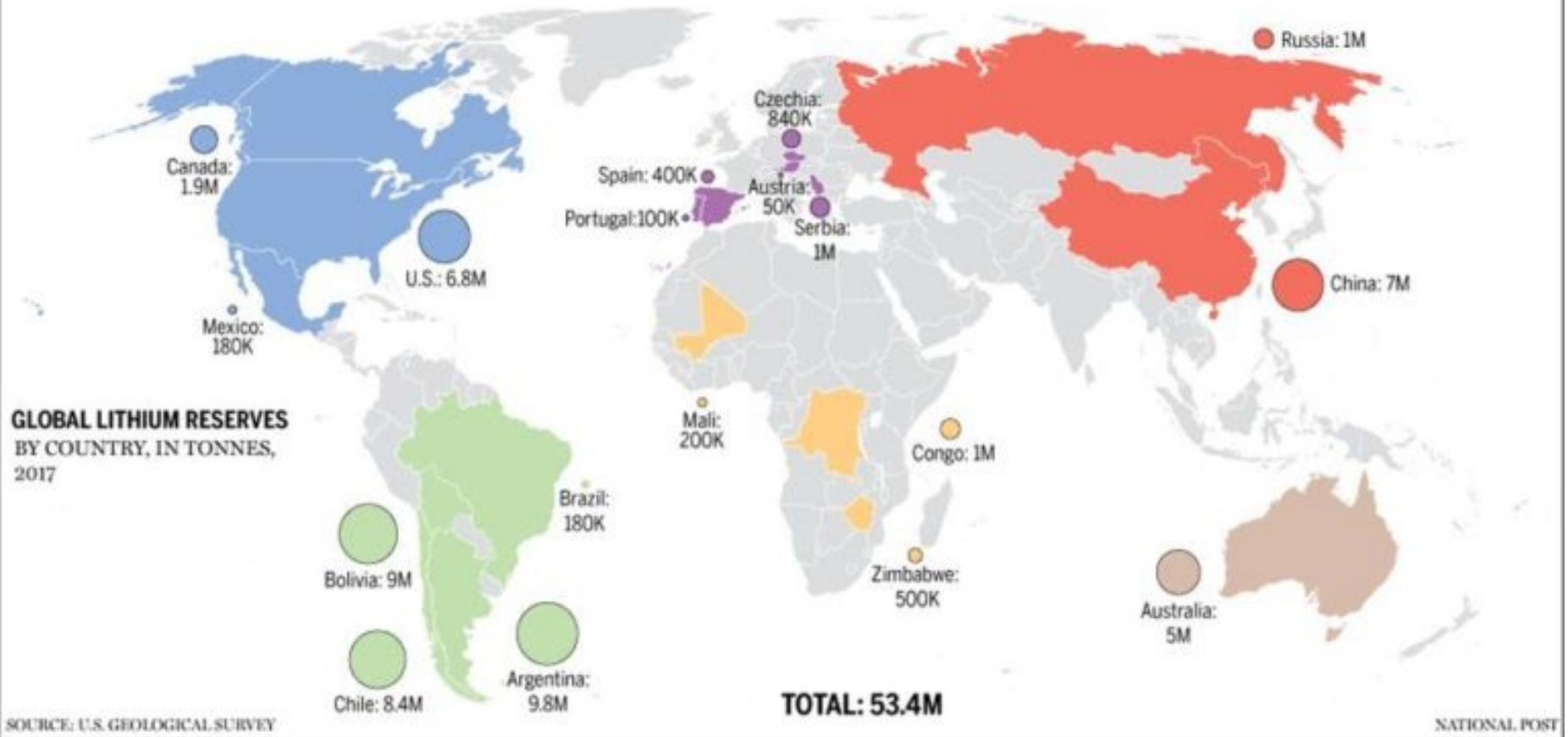


Data Source: USGS

# Known Lithium Reserves

## CHARGE OF THE LITHIUM BRIGADE

*As demand for electric vehicles rises, lithium — a key component of batteries — is fast emerging as a valuable commodity*

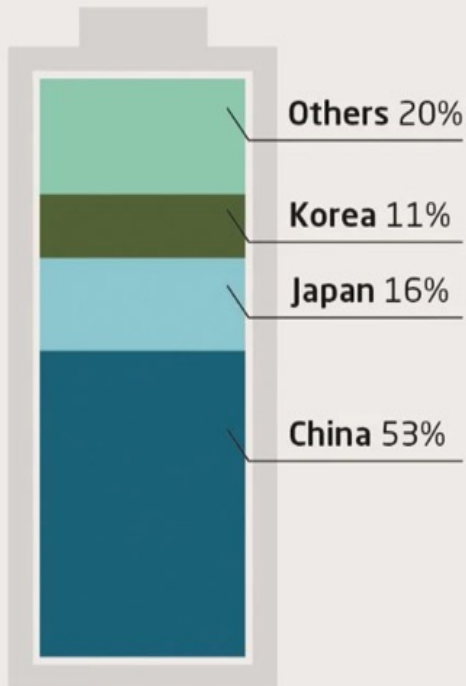




# Lithium Battery Production

The global EV battery market is dominated by Chinese companies

Seven out of the global top ten battery manufacturers are Chinese



	Company	Global Market Share, 2017 (%)*	Country
1	Contemporary Amperex Technology (CATL)	19	China
2	Panasonic	16	Japan
3	Build Your Dreams (BYD)	12	China
4	OptimumNano	9	China
5	LG Chem	7	Korea
6	Guoxuan High-Tech	5	China
7	Samsung SDI	4	Korea
8	Beijing National Battery Technology	3	China
9	BAK	3	China
10	Funeng Technology**	2	China
	Others	20	

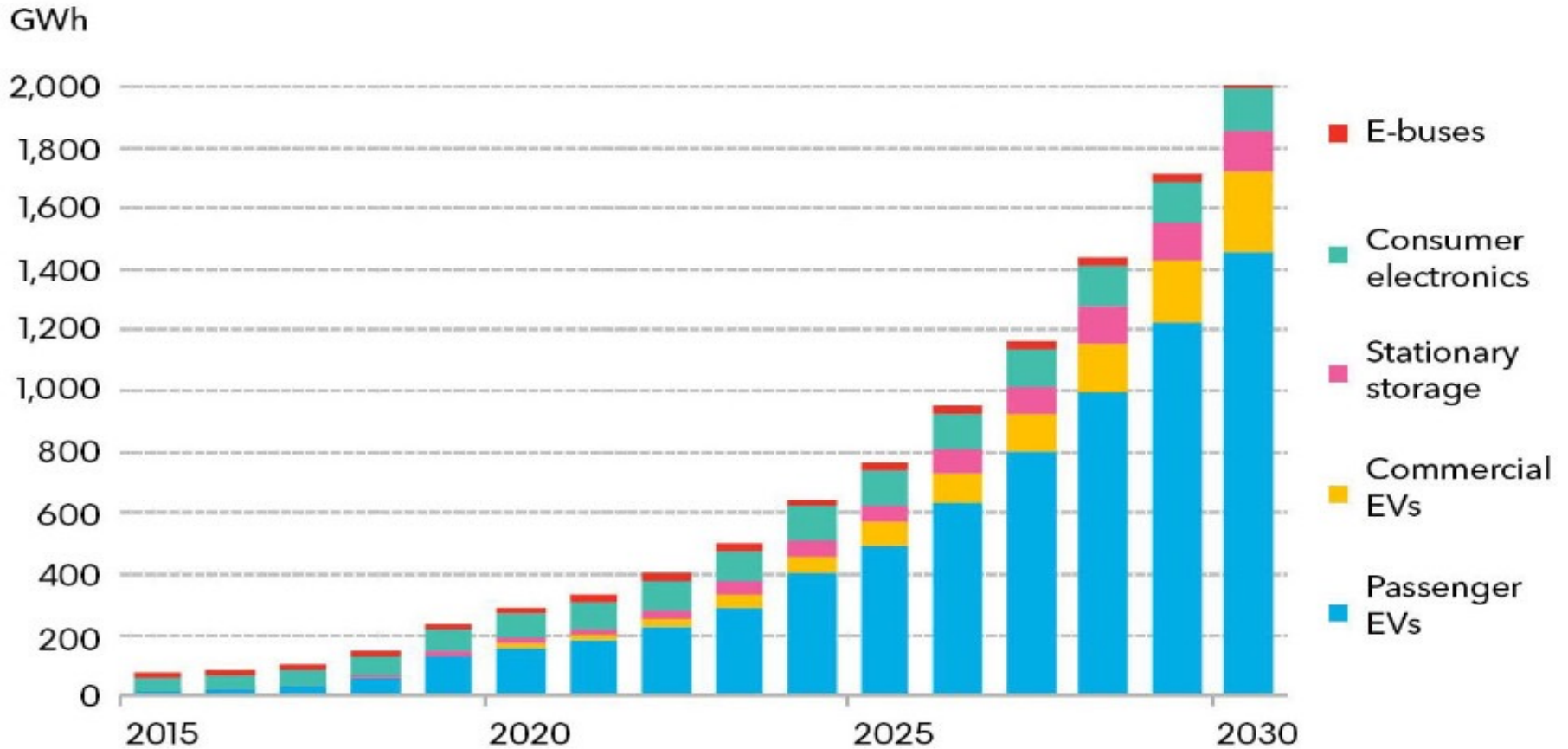
\* Based on EV lithium-ion battery shipments (GWh)

\*\* US-invested

Sources: China EV 100.

# Lithium Demand

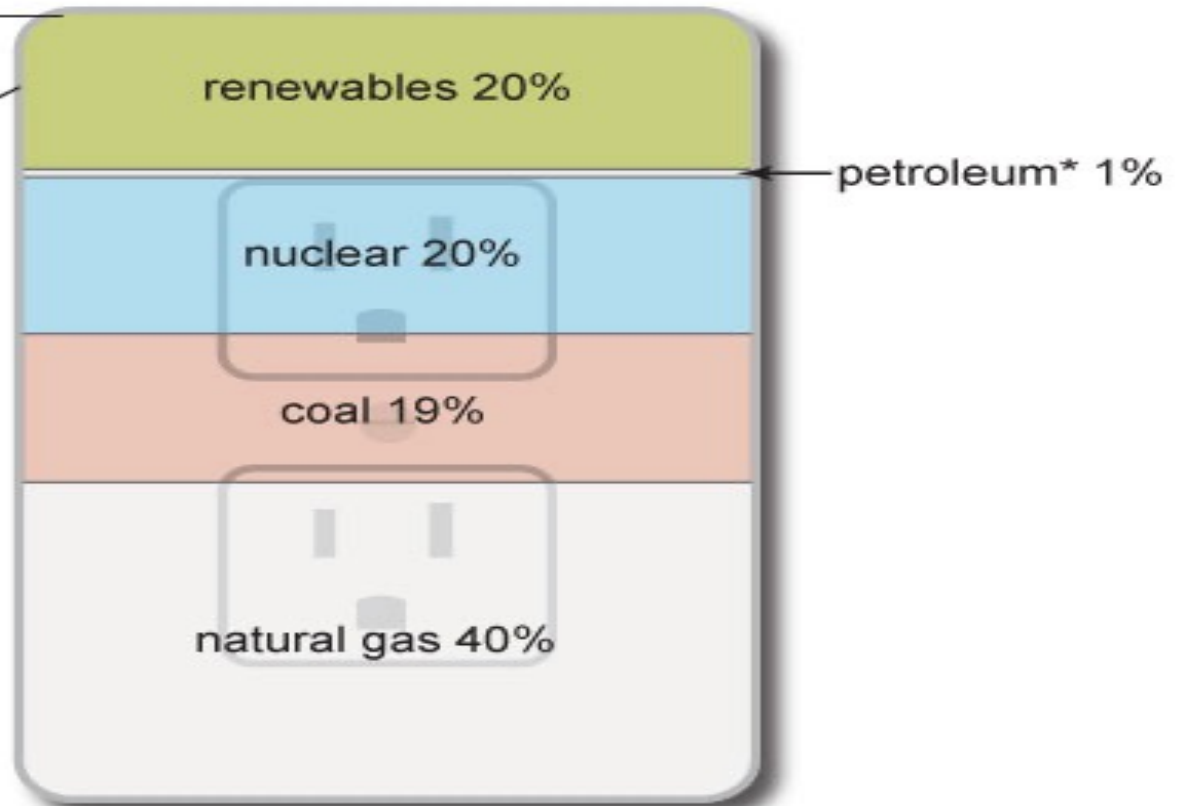
Annual lithium-ion battery demand



# United States Energy Sources

## Sources of U.S. electricity generation, 2020 Total = 4.12 trillion kilowatthours

wind	8.4%
hydro*	7.3%
solar	2.3%
biomass	1.4%
geothermal	0.4%



Note: Electricity generation from utility-scale generators. \* Hydro is conventional hydroelectric; petroleum includes petroleum liquids and petroleum coke, other gases, hydroelectric pumped storage, and other sources.

Source: U.S. Energy Information Administration, *Electric Power Monthly*, February 2021, preliminary data



# OE Background



# Operational Energy

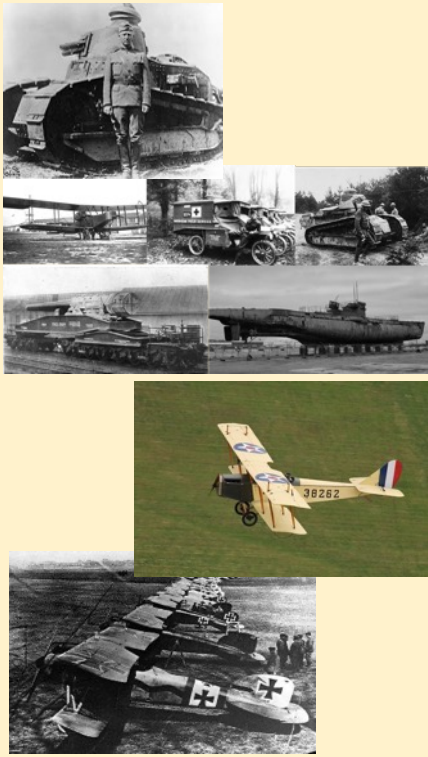
- The United States Department of Defense (DoD) defines operational energy as “**the energy required for training, moving, and sustaining military forces and weapons platforms for military operations.**”
  - Air, land, sea, space platforms
  - Forward bases and microgrids

# History of Modern OE

## World War I

1914

The Allies—"swimming in oil"—acquired more mechanized weapon systems



## World War II--Germany

1939

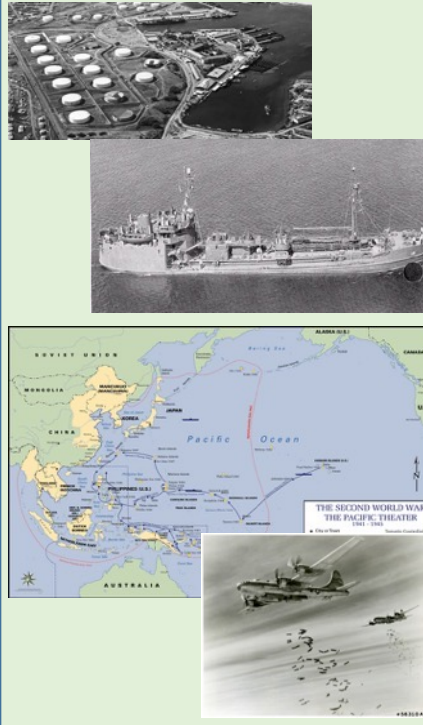
OE powered military tanks, ships, and planes and became the focus for major military battles—the Allies dominated



## World War II--Japan

1945

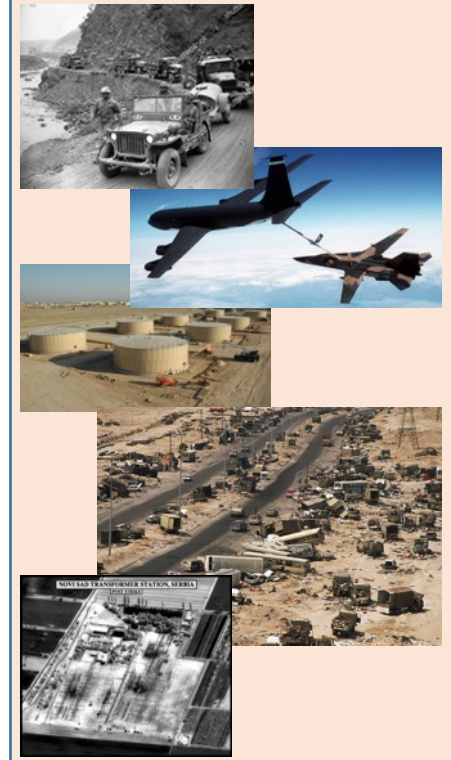
Before the war, Japan sourced the US for 90% of its petroleum—cut from the East Indies oil fields, their military languished



## Post World War II

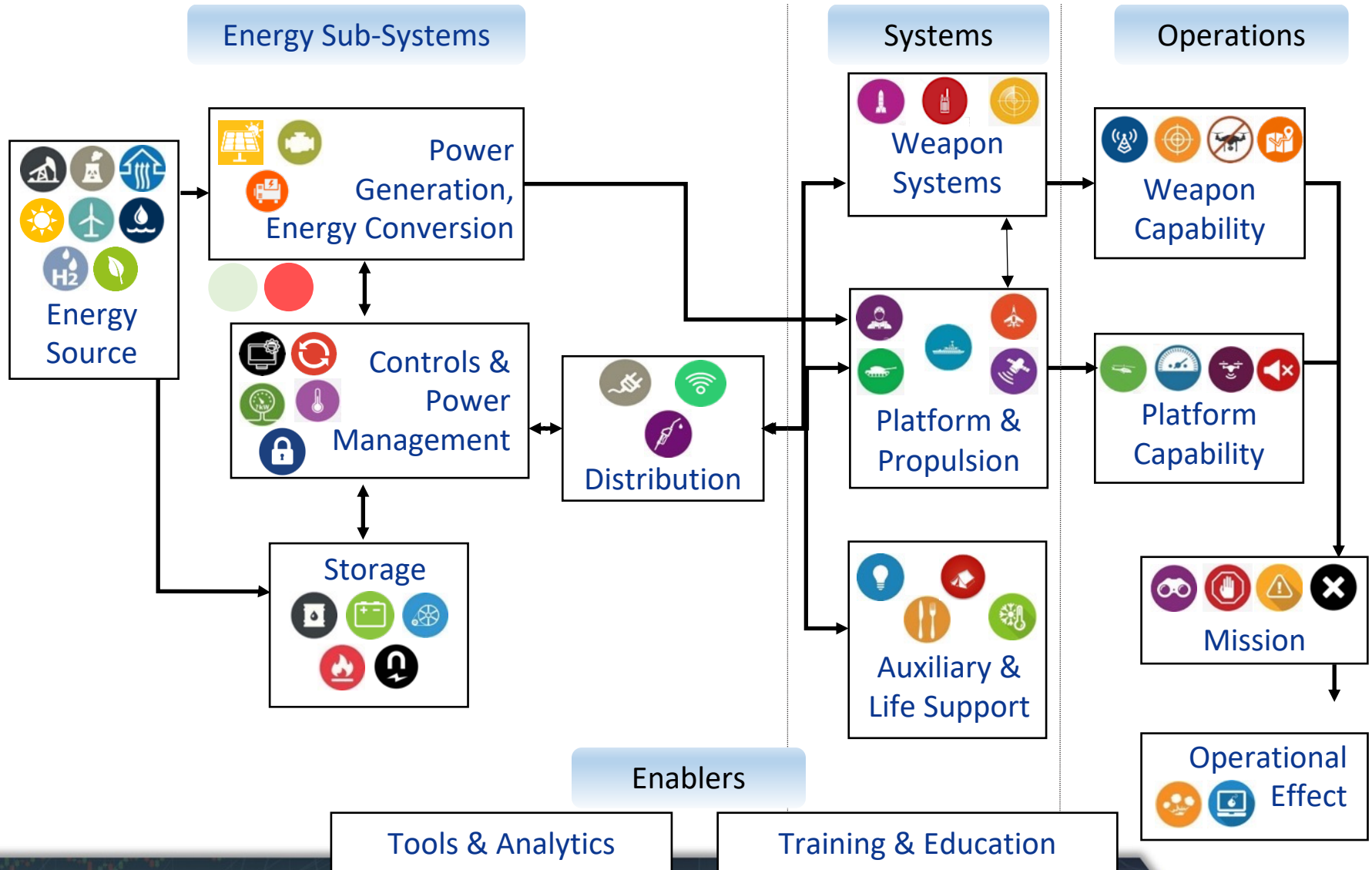
1950 → 2021 →

OE continues to power militaries—oil has been a cause for war, and a primary & vulnerable target in war





# Operational Energy Ontology



# Military and Fossil Fuels

- Currently the military relies on fossil fuels
  - Aircraft
  - Land Vehicles
  - Naval platforms (non-nuclear)
  - Forward basing / Microgrids
- Fossil fuels are vulnerable to energy attack and other disruptions

# Fossil Fuel—Pro

- US has among the greatest fossil fuel reserves in the world
  - Largest coal reserves
  - With shale, among largest natural gas
- Infrastructure in place
- Great energy densities
- Availability
- Low Cost
- Most pollutants addressed
- Reliable

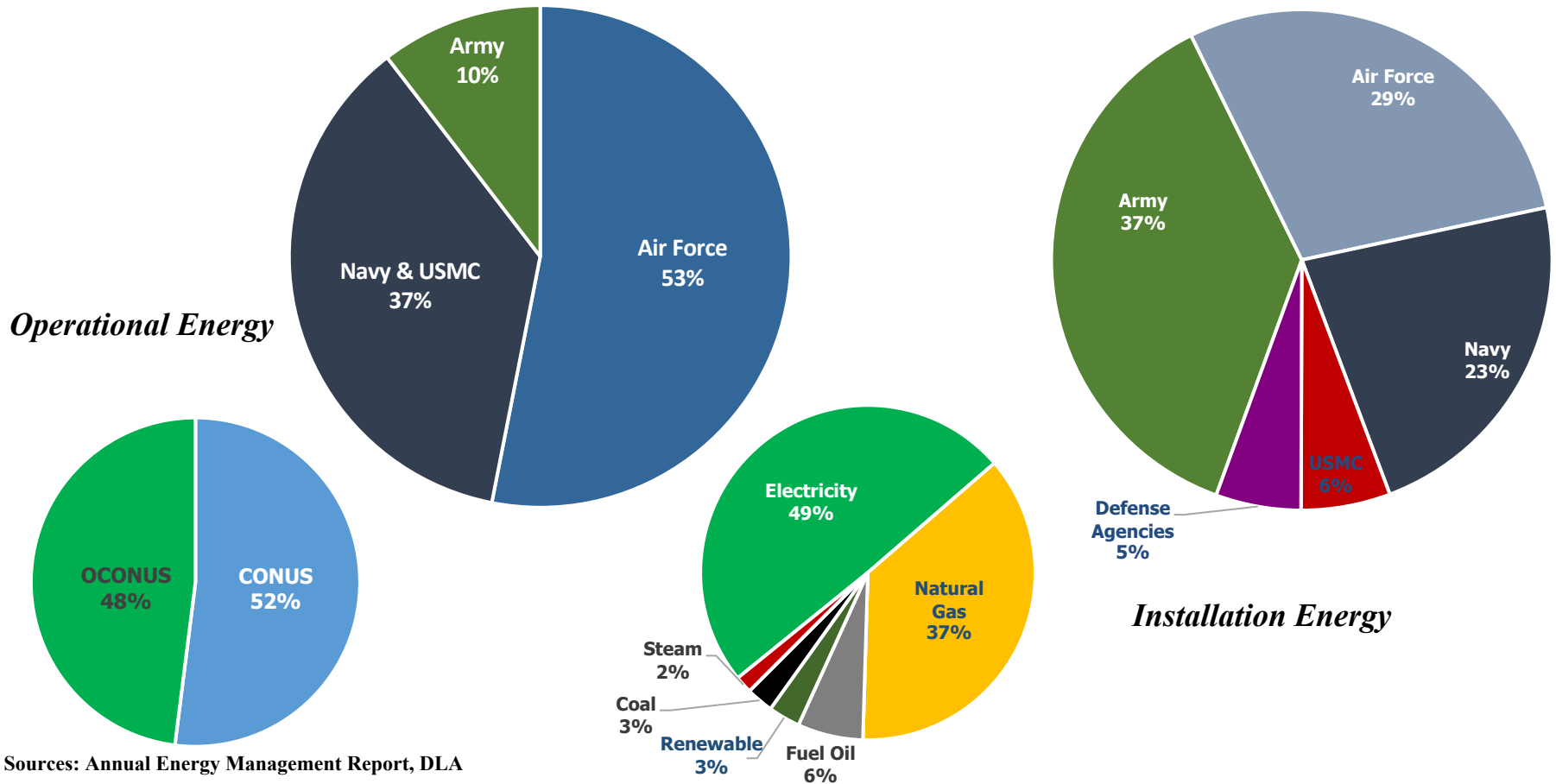


# Fossil Fuel—Con

- POL requires distribution to refineries and refining before usable
- Greenhouse gas emitters
- Vulnerable to attack
  - Convoys (Afghanistan)
  - Storage (Air attack story)
- For operational energy may have significant logistics trail
- Story about Price Sultan Air Base
- Reserves
- Increased cost
- Non-renewable
- Political challenges
- Mining challenges



# DOD-wide Energy Footprint



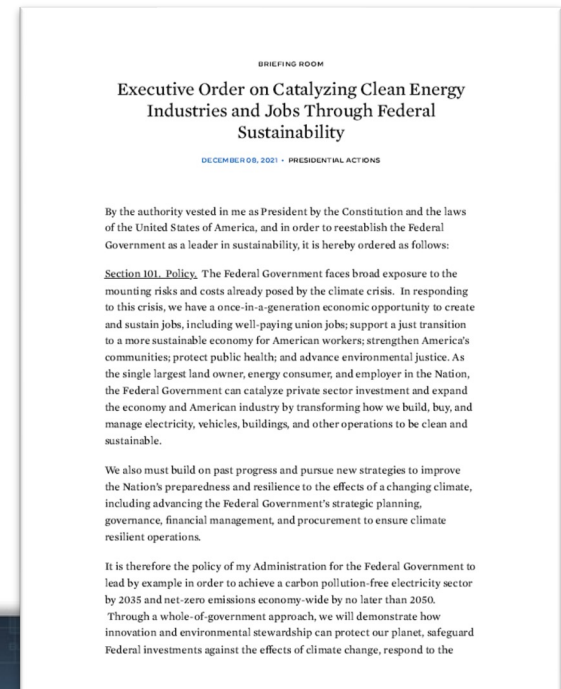
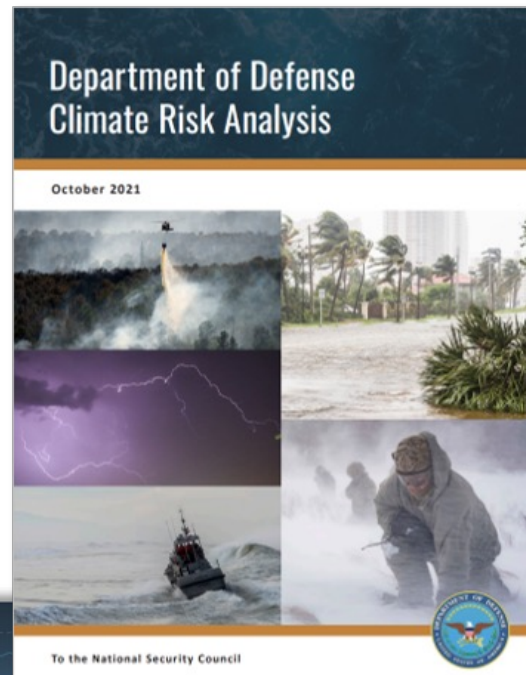
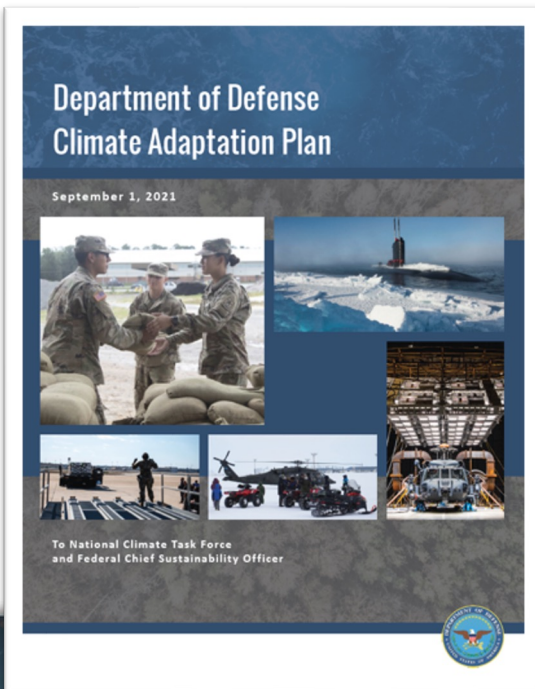
**Operational Energy:** Energy required for training, moving, and sustaining military forces and weapons platforms for military operations

**Installation Energy:** Energy to support mission activities at permanent military installations, including non-tactical vehicles



# Climate Change Challenge

- DOD is experiencing the effects of climate change today.
- We are facing a range of requirements to both adapt to and mitigate these challenges.
- DOD cannot meet these challenges without significant technological and scientific innovation



# Microgrids



WAES



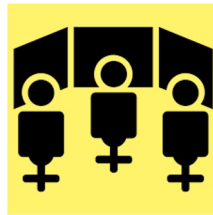
OIL REFINERIES



Hi Speed Log

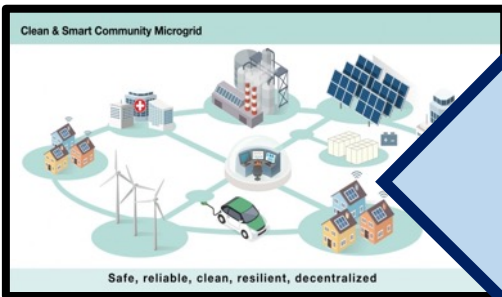


eTHOR

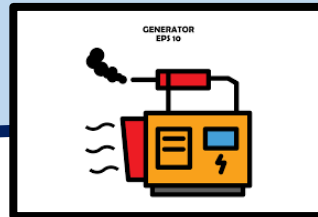


OEMS  
ROPES  
DMMS JOESF

TMS  
LEAP-M RASP-CASA TEC

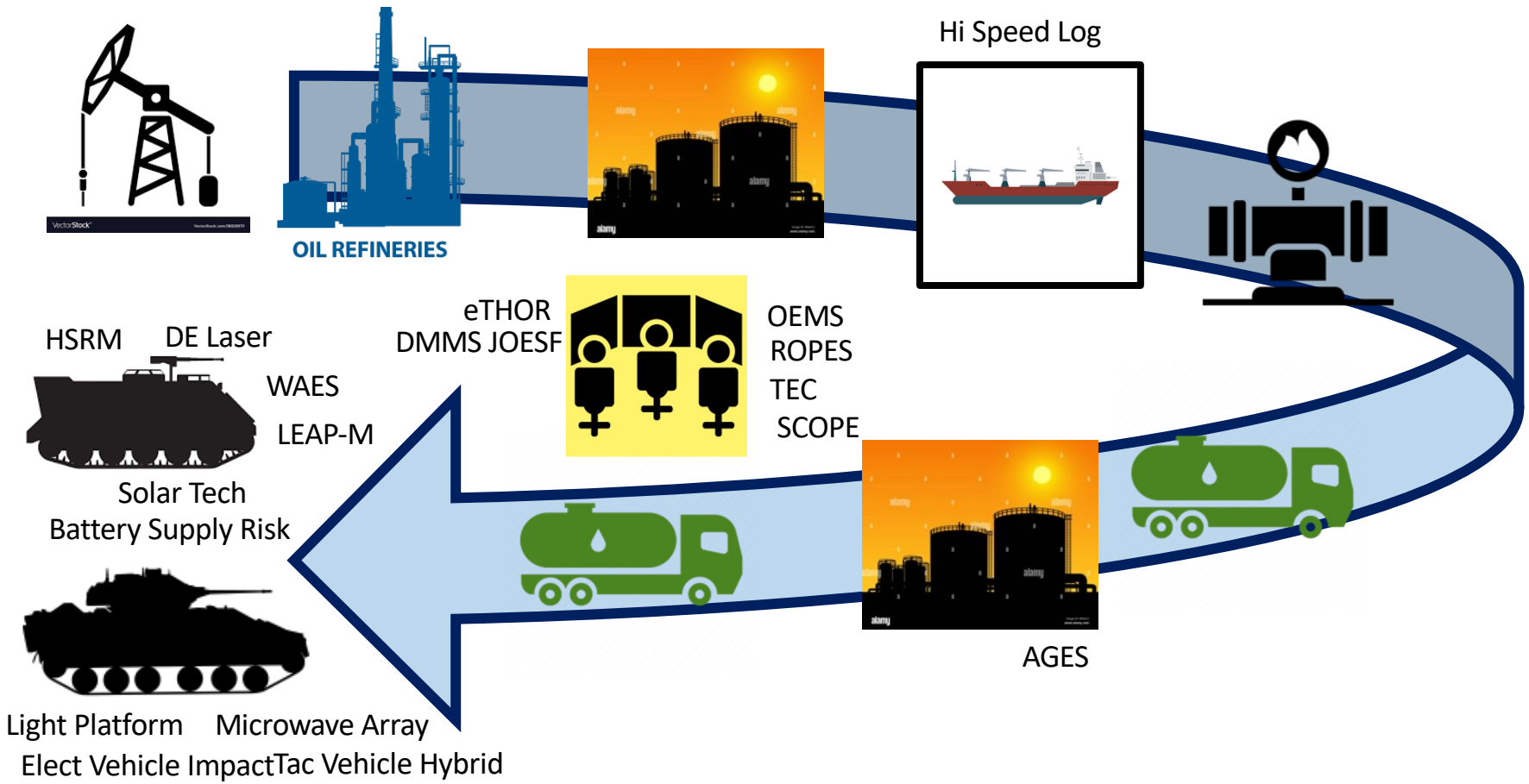


AGES



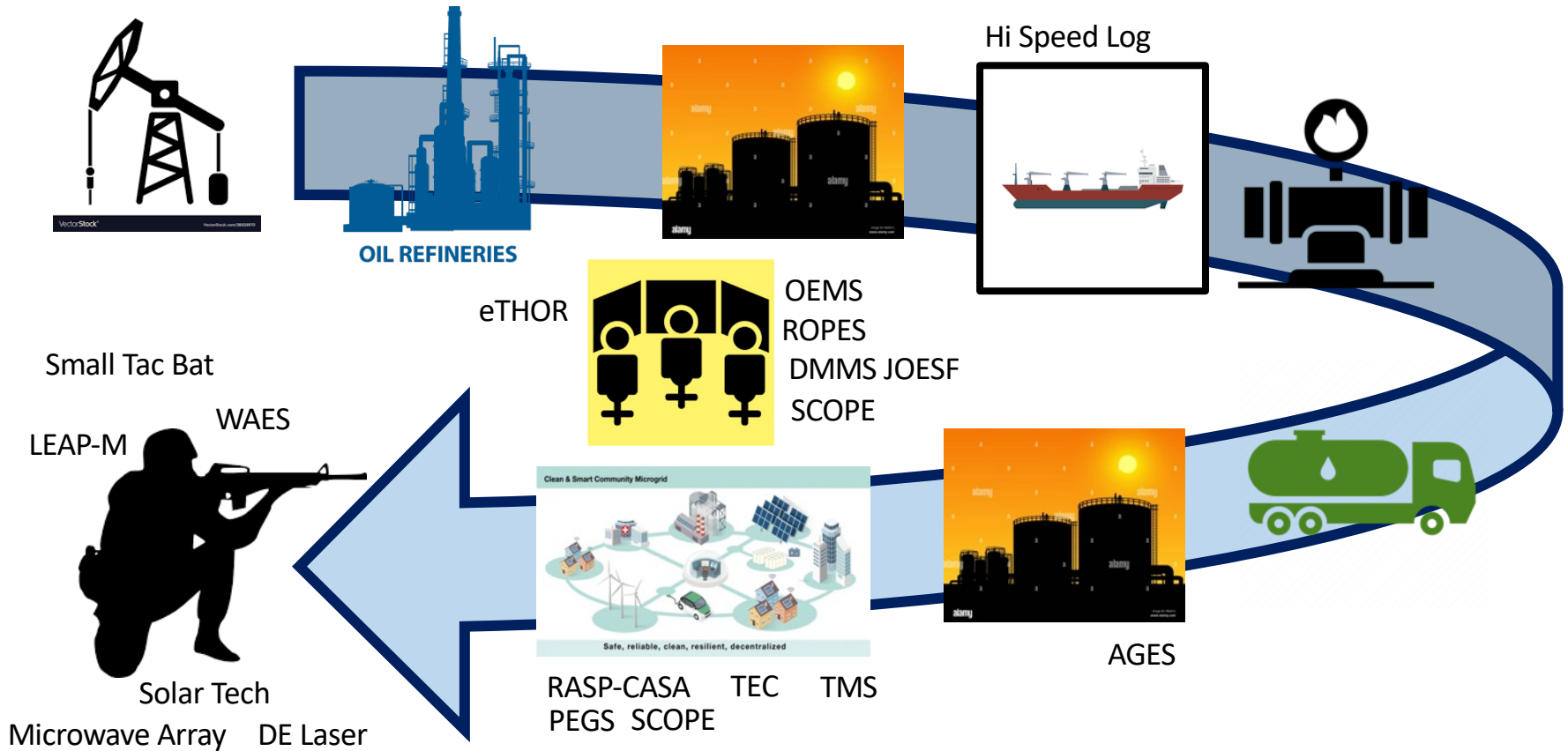
Battery Supply Risk    PEGS  
Microwave Array    DE Laser

# Land Platforms

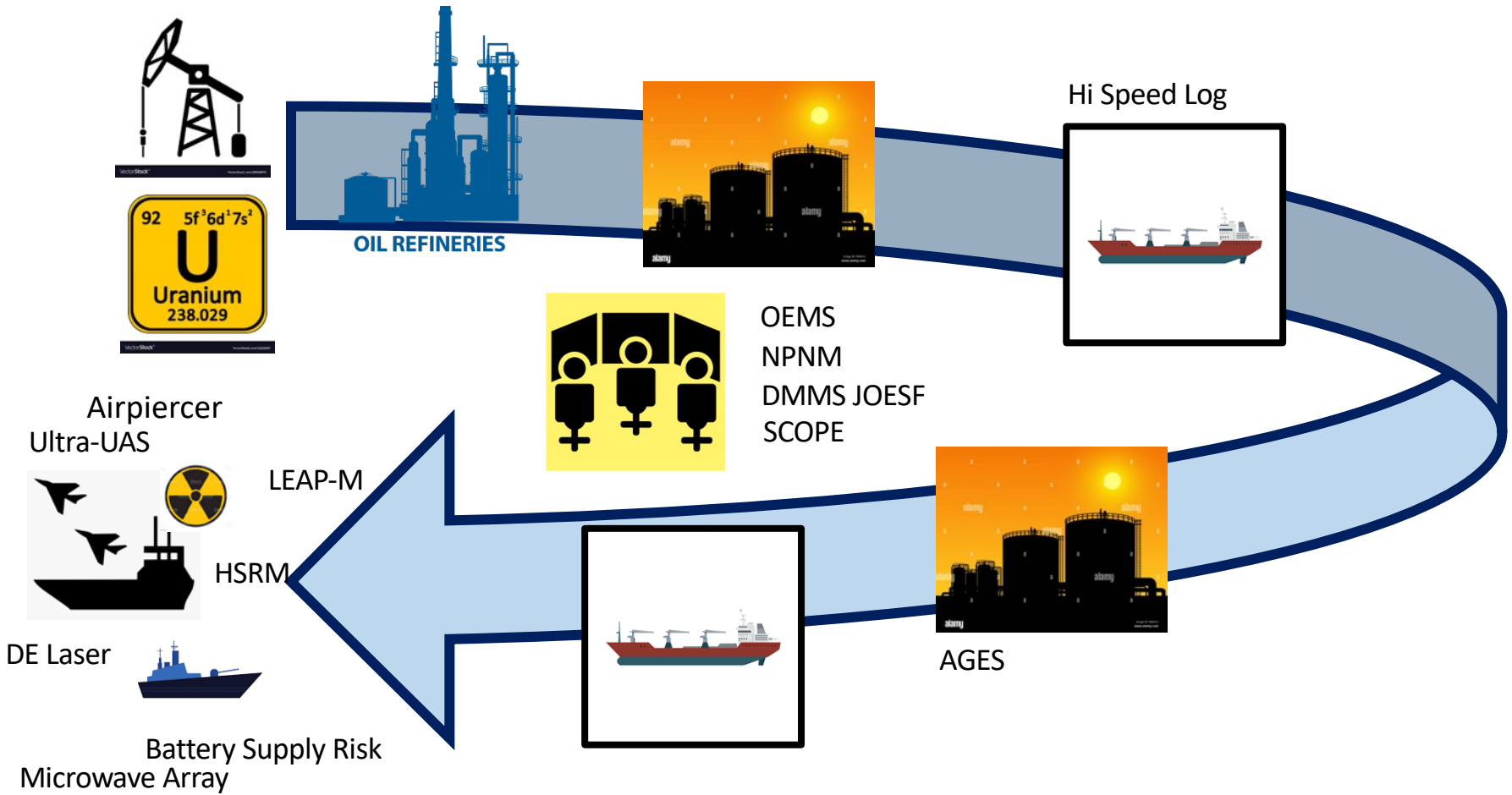




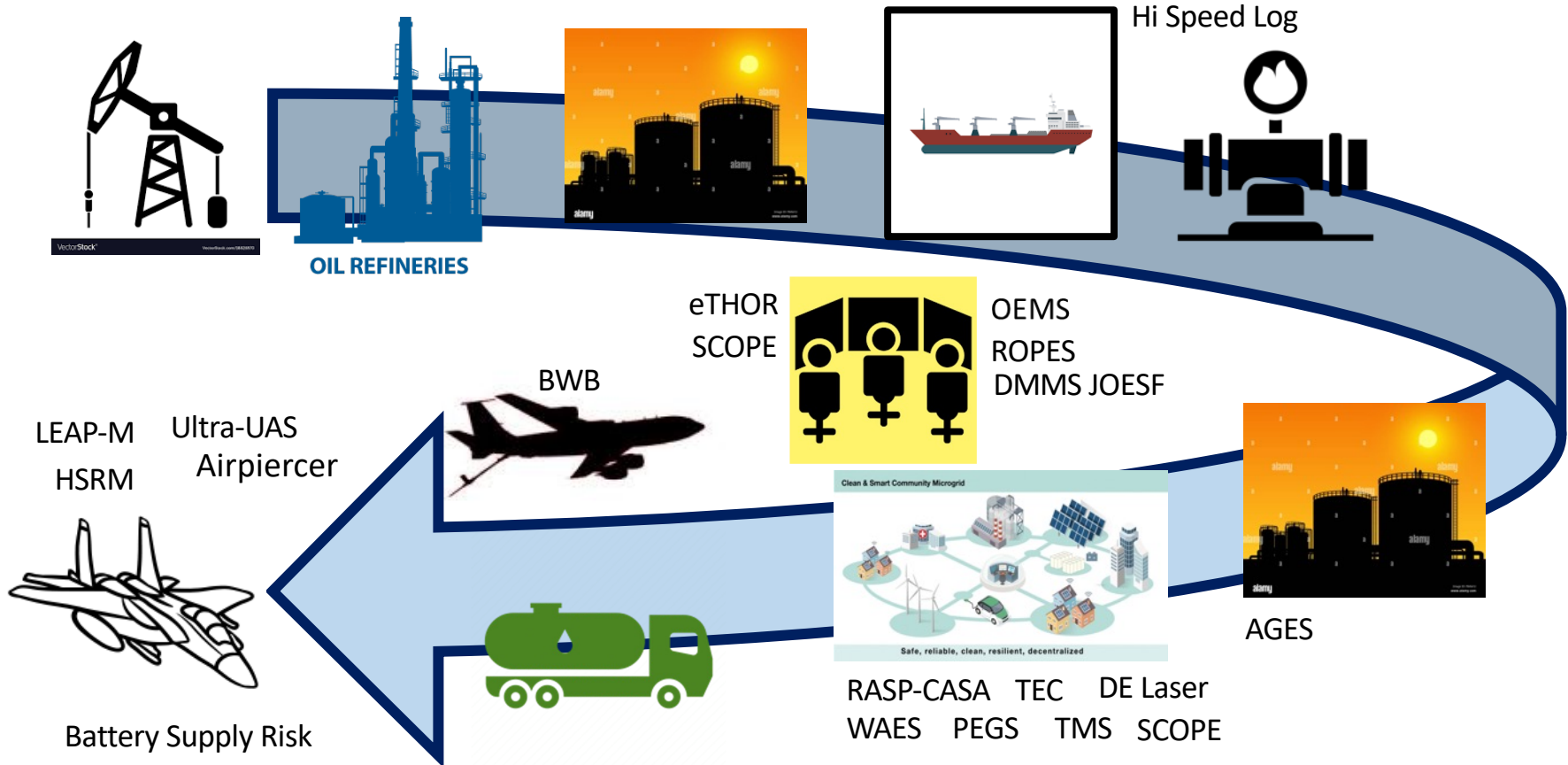
# Dismounted Soldiers



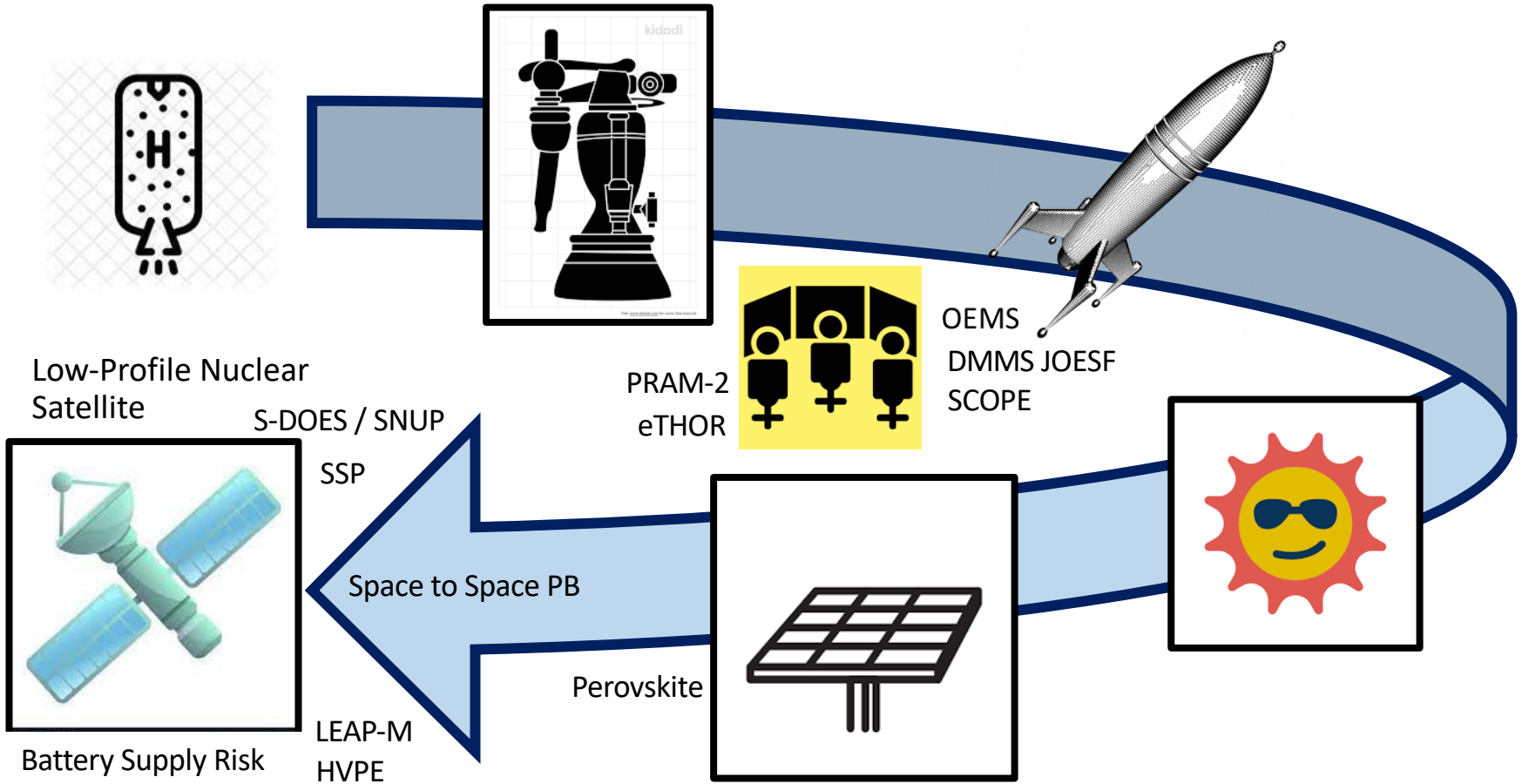
# Naval Platforms



# Aircraft



# Space Platforms





# OE Guidance

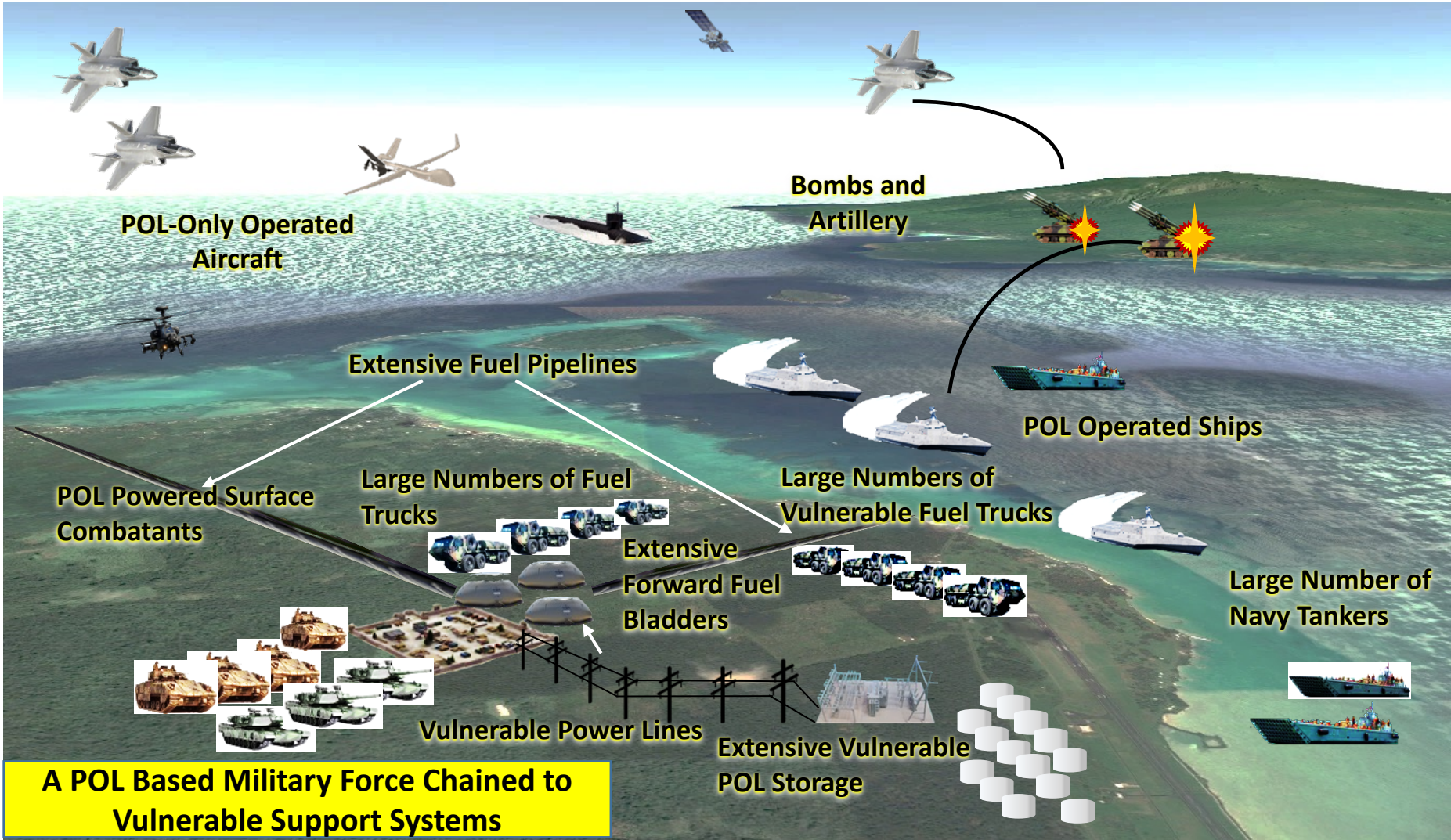
- Interim National Security Strategic Guidance
  - Clean energy / climate emphasis
- Infrastructure Investment & Jobs Act
  - Clean energy / Climate emphasis
- National Defense Authorization Act
- National Defense Appropriation Act
- National Defense Strategy
- DOD Climate Adaptation Plan
  - Clean energy / Climate emphasis

# OE Innovation



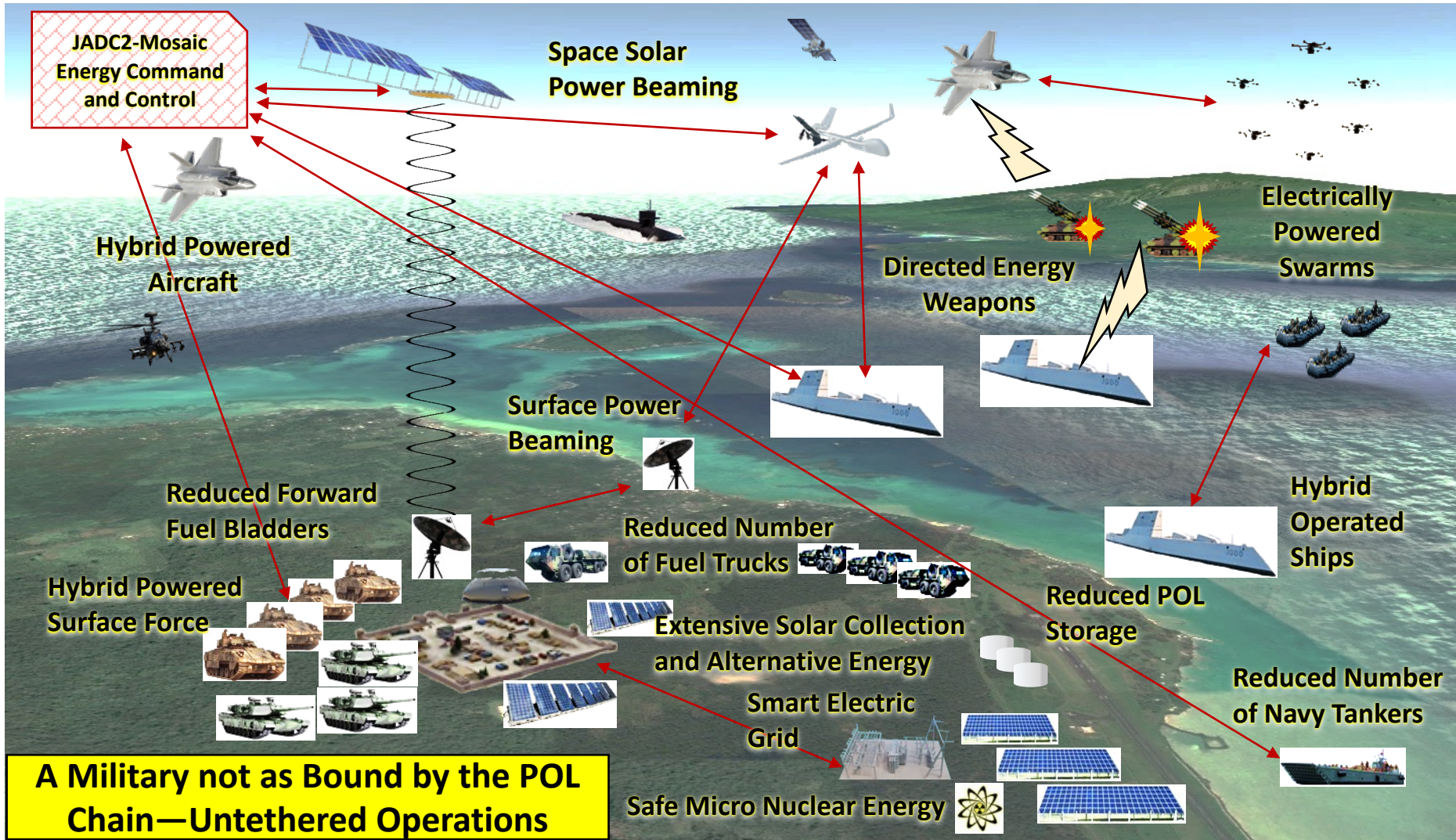


# Current Energy Operations





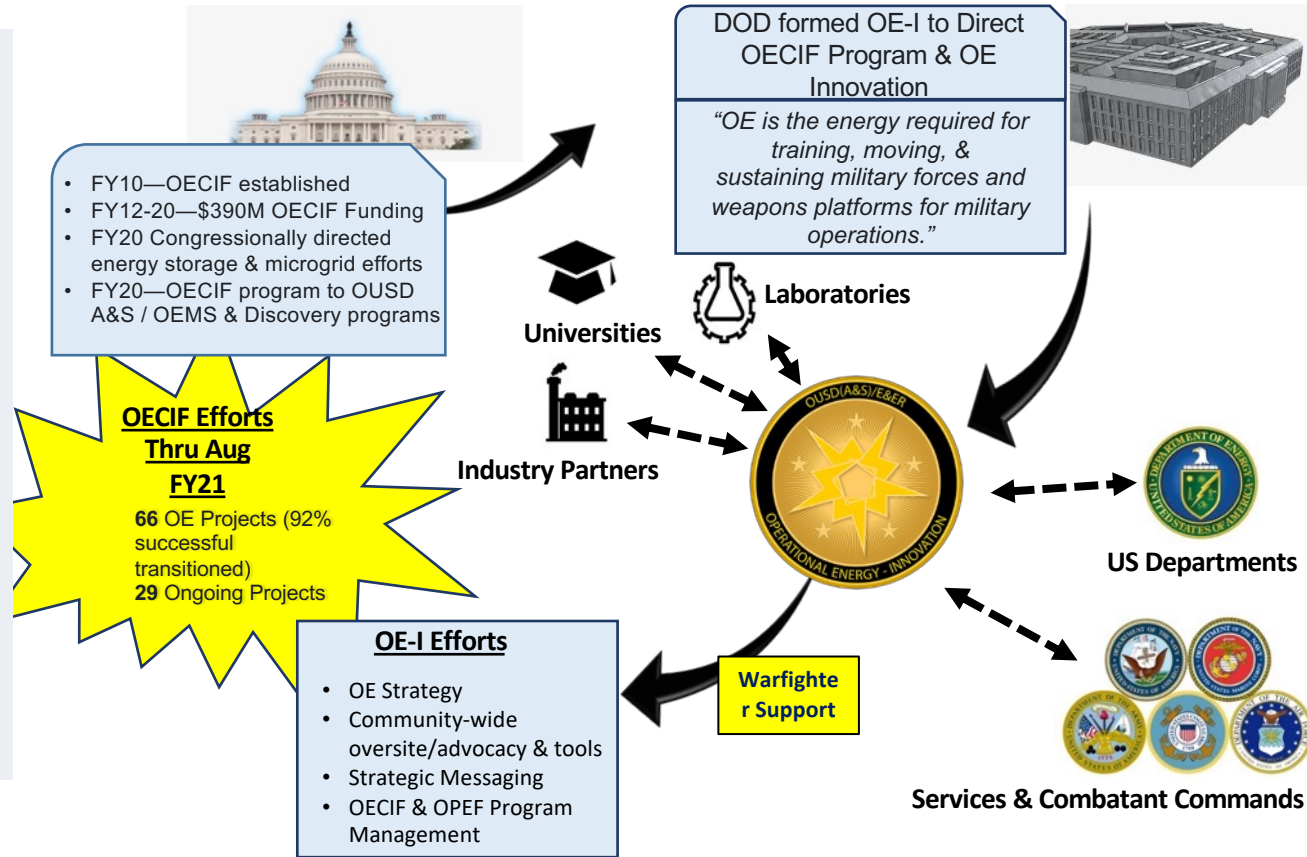
# Future Energy Operations





# OE-I Background & Missions

- Energy Innovation Leadership & Advocacy
- Operation Energy Innovation Policy
- Program Management
  - Operational Energy Capability Improvement Fund
  - Operational Energy Prototyping Fund
- Tools & Analytics
  - Operational Energy Management System (OEMS)
  - Project Assessment
- Strategic Communication



# Innovation – Portfolio

## Strategic Environmental Research and Development Program (SERDP) Environmental Security Technology Certification Program (ESTCP)



- Track record of providing S&T foundations to overcome DoD's toughest environmental challenges.
- Research investment focused on DoD unique, large cost, and risk issues
- Established in 1991 (10 U.S.C. Section 2901 – 2904), DoD, DOE, EPA partnership



- Track record of demonstrating innovative and cost-effective environmental and energy technologies
- Transitions technology out of the lab and into DoD Infrastructure; Capitalize on past investment
- Built to promote implementation through social and regulatory acceptance in the broader community.

## Operational Energy Capability Improvement Fund (OECIF)

### Operational Energy Prototyping Fund (OEPF)



OECIF

- Highly successful program with over 90% successful transition rate out of S&T for 60+ projects
- Advanced technology demonstrations focused on powering the force, electrifying the battlespace, and commanding energy
- Established in 2012 and highlighted in FY2021 NDAA



OEPF

- Identify and demonstrate the most promising, innovative, and cost-effective technologies and methods that address high-priority operational energy requirements
- Will result in 2+ year acceleration of warfighter capability – increases velocity ahead of Service transition to programs of record

# Energy Strategy Development Framework

- Context
  - Where and under what conditions is the energy being used?
- Objective
  - What is the energy required to support?
- Capability
  - What are the realistic technical, infrastructure and funding limits?
- Strategy
  - What is the method to get from needs to objective?
- Execution
  - How will the effort be conducted? And amended?
- Continuance
  - How will the OE be supported and upgraded in the future?

# DOD Operational Energy S&T Strategy

## Lines of Effort



### Powering the Force

Advance energy generation and energy maneuver to all fixed and mobile platforms while reducing vulnerability and carbon emissions



### Electrifying the Battlespace

Improve electrical energy capabilities, and aid in transitioning to more electrically powered transportation; evolve OE into a more effective, and less vulnerable electric combat force



### Commanding Energy

Lead in creating energy awareness throughout the entire force, support Joint All Domain Command & control, and develop near real time energy awareness and energy command & control at all levels



# RuthAnne Darling (Commanding Energy)

- DOD-Wide Operational Energy Management System (OEMS) Expansion
- Naval Power Network Monitoring (NPNM), Naval Secure Power PMO
- Resilient Operational Power and Energy Sensing (ROPES), DEVCOM ARL

# Paul Jaffe (Powering the Force)

- Tactical Energy Converter (TEC) Application & MIL-STD Testing, DEVCOM C5ISR
- Forward Deployed Refueling and Support Package to Enable COMMS and Situational Awareness (RASP-CASA), ONR/NRL
- Arctic Grid Energy Storage (AGES), NORAD & USNORTHCOM
- Warfighter Alternative Energy Study (WAES), DEVCOM C5ISR
- Solar Technologies to Prevent Premature Replacement of Tactical Vehicle and Generator Batteries, DEVCOM DAC

# Paul Jaffe (Powering the Force)

- High Speed Logistics, NAVFAC EXWC
- Blended Wing Body (BWB) Tanker, Air Force SEO
- 2026-2030 DOD Battery Supply Risk Assessment and Aggregation, NSWC Carderock
- Electric Tactical Humanitarian Operations Recovery (eTHOR), NIWC-Pacific
- Power Extender – Grid Source (PEGS), Army PM E2S2
- High Speed Rotating Machine (HSRM) Prototyping & Test, Naval Surface Warfare Center Philadelphia Division

# Powering Beaming



## Selected Laser Power Beaming Demos



EADS Astrium tracking laser to power rover (2003)



Kinki Univ. & Hamamatsu Photonics Inc. laser power to small helicopter (2007)



Lighthouse DEV Eye-safe laser demo (2012)



LaserMotive outdoor laser power to UAV (2012)



PowerLight point-to-point power link (2019)

DISTRIBUTION A: Approved for public release, distribution is unlimited

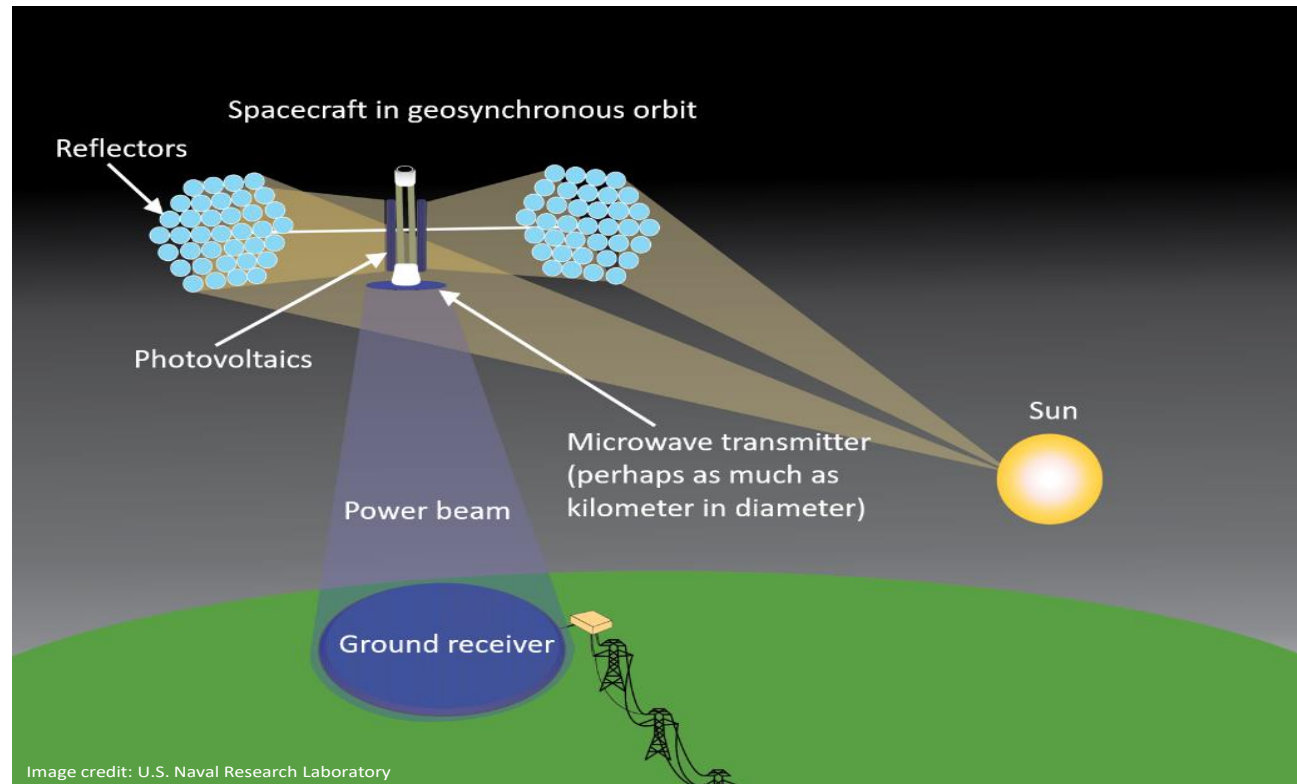


# Solar Power Beaming



## “Long” Space Power Beaming Application: Solar Power Satellites (“Space Solar”)

**Space Solar** is the collection of solar energy in space and its wireless transmission for use on Earth or other bodies



(This depiction is merely one of many proposed implementations)

Reference: <https://apps.dtic.mil/sti/pdfs/AD1082903.pdf>

15

DISTRIBUTION A: Approved for public release, distribution is unlimited

# Chris DePuma (Electrifying the Battlespace)

- Metrology-Enabled RF Integration Technology (MERIT), AFRL/RXSC
- Li-Ion Early Fault Predictive Monitor (LEAP-M), Naval Undersea Warfare Center
- Small Tactical Universal Battery Integration, DEVCOM C5ISR
- Efficient Microwave Array for Scalable Wireless Power Transfer
- Dual-use DE Laser Solution, ONR
- Light Expeditionary Energy Agile Platform (LEEAP), USINDOPACOM J4
- Impact of Vehicle Electrification Configurations on Energy-Related Sustainment and Performance, DEVCOM DAC
- Solar-Powered Phased Array Optimized for Thermal Performance and Mass-Specific Power (PRAM-2), NRL
- Space Qualifiable, Low-Cost, Perovskite Solar Cells for DoD Applications (SLPD), AFRL/RXSC

# Chris DePuma (Nuclear Power)

- Airpiercer II, AFRL/RQTC
- Low-Profile Electric-Propulsion Nuclear Satellite (LENS), USSPACECOM
- DoD Space Domain Energy Strategy & Space Nuclear Power (SNUP) Study, AFRL/RXSC

# Eric South (Operational Energy Prototyping Fund)

- TMS Advanced, DEVCOM C5ISR
- Tactical Vehicle Hybridization, PM Transport
- Ultra-UAS—ECU for Enhanced Endurance, AFRL Rapid
- HVPE Lower Cost Photovoltaics, AFRL/RV
- Space to Space Powering Beaming, AFRL/RV
- DMMS and JOESF Integrated Prototype for Mobile Power Demonstration, NIWC-PAC
- Sensors for Collaboration Operational Power and Energy, DEVCOM ARL



# Additional Projects

- Solar Technologies to Prevent Premature Replacement of Tactical Vehicle and Generator Batteries, DEVCOM DAC
- Coupled Power and Thermal Management Technology for Directed Energy Support
- Rectenna Integrated onto UAV, CCDC AC
- Distributed Energy Provided Throughout the Seas (DEPTHs), ONR
- Generation 3 Li-ion 6T Batteries with Open-source BMS and Case, DEVCOM GVSC Energy Storage

# Future Battlespace—Near-Term

- Areas of improvement in next 5 years
  - Small scale CO<sup>2</sup> reduction
  - Energy command and control improvement
  - Energy efficiency
  - Microgrids
  - Service & Allied microgrid integration
  - Batteries
  - UAV endurance
  - Anti-idle
  - Aircraft efficiencies
  - Arctic power
  - Dismounted soldier power, recharge, and weight
  - Improved dismounted solar battery recharge
  - Reduced energy vulnerability
  - Improved energy simulation capabilities
  - Improved battery and microgrid failure awareness
  - Reduction on different types of batteries

# Future Battlespace—Mid-Term

- Areas of operational improvement 5 to 15 years
  - Moderate CO<sup>2</sup> reduction
  - Nuclear power
  - Major energy command and control improvement
  - Predictive battlespace energy capability
  - Advanced aircraft efficiencies
  - DE power
  - Power beaming
  - Electric support land platforms
  - Micro-nuclear power for microgrids
  - Light haul electric aircraft
  - Advanced safer and lightweight batteries
  - Energy common operating picture
  - Unmanned refueling
  - Major reduction in energy vulnerability
  - Significant reduction of fossil fuel requirement
  - Major improvement in energy simulation capability
  - Very low-cost photovoltaics
  - Space-to-space power beaming
  - Long endurance sensor power

# Future Battlespace—Far-Term

- Areas of Improvement 15 years and beyond
  - Major CO<sup>2</sup> reduction
  - Space solar power beaming
  - Global near real time energy awareness and command and control
  - Surface-to-surface and surface-to-air powering beaming
  - Primary DE weapon systems
  - Radioisotope powered aircraft
  - Electrified major combat vehicles
  - Space nuclear powered platforms
  - Major fossil fuel requirement reduction
  - Multi-frequency power beaming across all mediums



# Adversaries

- Other nations are investing heavily in innovative OE technologies
- If the US fails to maintain an advantage in OE, we risk another nation having a combat advantage



Space solar can provide "an inexhaustible source of clean energy for humans"  
—Pang Zhihao

# Backup



# Interim National Security Guidance 2021

- Today, more than ever, America's fate is inextricably linked to events beyond our shores.
- We confront a global pandemic, a crushing economic downturn, a crisis of racial justice, and a **deepening climate emergency**.
- We face a world of rising nationalism, receding democracy, growing rivalry with China, Russia, and other authoritarian states, and a technological revolution that is reshaping every aspect of our lives.
- **Key Priorities**
  - “Protect the security of the American people by defending against great powers, regional adversaries, and transnational threats.”
  - “Expand economic prosperity and opportunity by redefining America's economic interests, primarily by focusing on improving working families' livelihoods and achieving an economic recovery grounded in equitable and inclusive growth.”
  - “Realize and defend the democratic values at the heart of the American way of life by reinvigorating American democracy, living up to our ideals and values for all Americans, and uniting the world's democracies to combat threats to free societies.”

# Interim National Security Guidance 2021

- We have already **re-entered the Paris Climate Accord** and appointed a Presidential Special Envoy for climate, the first steps toward restoring our leadership and working alongside others to combat the acute danger posed by rapidly rising temperatures.
- The climate crisis has been centuries in the making, and even with aggressive action, the **United States and the world will experience increasing weather extremes and environmental stress in the years ahead**. But, if we fail to act now, we will miss our last opportunity to avert the direst consequences of climate change for the health of our people, our economy, our security, and our planet.
- We will make the clean energy transformation a central pillar of our economic recovery efforts at home, generating both domestic prosperity and international credibility as a leader of the global climate change agenda. And, in the coming months, we will convene the world's major economies and **seek to raise the ambition of all nations, including our own, to rapidly lower global carbon emissions**, while also enhancing resilience to climate change at home and in vulnerable countries.



# Interim National Security Guidance 2021

- Central to this agenda is building an equitable, **clean, and resilient energy** future, which is urgently required to head off the existential risk posed by the climate crisis.
- We will dramatically increase investments in technology research, development, and deployment that will power the **low-to-no carbon future** that we seek – We will use federal procurement to jumpstart demand for critical clean technologies like electric vehicles.
- And we will support the **accelerated growth in renewable energy** deployment, invest in climate- friendly infrastructure, build resilience to climate change, modernize our energy grid, and provide the international leadership required to encourage countries around the world to do the same.

# National Defense Strategy 2018

- Defense Objectives

- Defending the homeland from attack.
- **Sustaining Joint Force military advantages, both globally and in key regions.**
- Deterring adversaries from aggression against our vital interests
- Enabling U.S. interagency counterparts to advance U.S. influence and interests.
- Maintaining favorable regional balances of power in the Indo-Pacific, Europe, the Middle East, and the Western Hemisphere.
- Defending allies from military aggression and bolstering partners against coercion, and fairly sharing responsibilities for common defense.
- Dissuading, preventing, or deterring state adversaries and non-state actors from acquiring, proliferating, or using weapons of mass destruction.
- Preventing terrorists from directing or supporting external operations against the United States homeland and our citizens, allies, and partners overseas.
- Ensuring common domains remain open and free.
- **Continuously delivering performance with affordability and speed as we change Departmental mindset, culture, and management systems.**
- Establishing an unmatched **twenty-first century National Security Innovation** Base that effectively supports Department operations and sustains security and solvency.

# National Defense Strategy 2018

- Lines of Effort

- **Build a more lethal Joint Force.**

- Preparedness.
- Modern key capabilities—C2, space, cyberspace, lethality, maneuver, autonomous systems, resilient/agile logistics.
- Evolve operational concepts—All-domain C2, dispersed operations.
- Lethal, agile & resilient force posture—dynamic force employment, global operating model

- **Strengthen alliances as we attract new partners.**

- **Reform DOD business practices for greater performance and affordability.**

- Transition to a culture of performance.
- Deliver performance at the speed of relevance—not tech first, but ability to integrate it.
- Organize for innovation—consolidate, eliminate, restructure as required.
- Affordability into development
- Streamline rapid, iterative approaches from development to fielding.
- Harness and protect national innovation base—streamline and engage with industry.

# Climate Working Group

- Established 9 March 2021 in support of Executive Order 14008
- **Climate change represents growing threat to the US**
  - Department will immediately take action to address risk and implications in analyses, strategy development, and planning guidance.
  - **DOD will incorporate climate risk and analysis into:**
    - Installation planning, **modeling,**
    - **simulation, and wargaming.**
    - National Defense Strategy.
    - All other relevant **strategy, planning, & programming** documents including processes that support **DOD decision-making.**
- Membership
  - **Chair—SECDEF Special Assistant Joe Bryan**
  - Members: USD R&E, **USD A&S**, Comptroller, Service Secretaries, Service Chiefs, Chairman JCS, Chief Guard Bureau, Director Cost Assessment & Program Evaluation



# Climate Adaptation Plan

- Definitions

- **Adaptation:** Adjustment in natural or human systems in anticipation of or response to a changing environment in a way that effectively uses beneficial opportunities or reduces negative efforts.
- **Resilience:** The ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions.
- **Mitigation:** Measures to reduce the amount and speed of future climate change by reducing emissions of heat-trapping gases or removing carbon dioxide from the atmosphere.

# Climate Adaptation Plan

- DOD has identified **climate change as a critical national security issue** and threat multiplier and top management challenge.
- **Climate change will continue to amplify operational demands on the force**, degrade installations and infrastructure, increase health risks to our service members, and could require modifications to existing and planned equipment.
- **Extreme weather events are already costing DOD billions of dollars** and are degrading mission capabilities.
- **Not adapting to climate change will be even more consequential** with failure measured in terms of lost military capability, weakened alliances, enfeebled international stature, degraded infrastructure, and missed opportunities for technical innovation and economic growth.
- **DOD must take bold steps** to accelerate adaptation to reduce the adverse impacts of climate change.
- These **adaptation efforts must align with our strategic objectives and mission requirements**, ensuring that our military can deter aggression and defend the nation under all conditions.

# Strategy Enablers

- **CONTINUOUS MONITORING AND DATA ANALYTICS**

- Department will **continuously monitor and assess the relevant environmental conditions** on operations and installations, and the impacts of its actions, by leveraging the best available and actionable science, together with advances in data analytics, business intelligence, and efficient on-site and remote sensors.

- **ALIGNING INCENTIVES TO REWARD INNOVATION**

- **Incentivizing innovation...collaboration** across the federal government; between federal, state, and local governments; and with non-governmental organization (NGOs)

- **CLIMATE LITERACY**

- **Climate-informed workforce**

- **ENVIRONMENTAL JUSTICE**

- Environmental justice considerations require that training and testing, as well as acquisition actions, **not disproportionately impact low income and/ or minority population**

# Climate Adaptation Plan—Lines of Effort

- **CLIMATE-INFORMED DECISION-MAKING**

- Climate Intelligence
- Strategic, Operational, and Tactical Decision-Making
- Business Enterprise Decision-Making
- **Climate change considerations and impacts included in all relevant and applicable DOD decisions.**

- **TRAIN AND EQUIP A CLIMATE-READY FORCE**

- Train Safely in Extreme Conditions
- Assess Current and Future Equipment
- Assess and Adjust Requirements and Acquisition

- Test Equipment for Climate Effects

- **An agile force, trained and equipped to operate effectively in all anticipated climatic conditions.**

- **RESILIENT BUILT AND NATURAL INFRASTRUCTURE**

- Installation Resilience
- Preserve Test and Training Space
- Ecosystem Services
- **Built and natural infrastructure necessary for successful mission preparedness, military readiness, and operational success in changing conditions.**



# Climate Adaptation Plan—Lines of Effort

- **SUPPLY CHAIN RESILIENCE AND INNOVATION**
  - Assess Supply Chain Resilience
  - Harden and Shift to Onshore
  - Leverage Purchasing Power
  - **Uninterrupted access to key supplies, materials, chemicals, and services**
- **ENHANCE ADAPTATION & RESILIENCE THRU COLLABORATION**
  - Interagency and Intergovernmental
  - Partner Nations
  - Community Resilience
  - **Reduce adaptation costs and build unity of purpose through meaningful engagement with DOD stakeholders**

# Army—Powering the Army of the Future

- **The number 1 objective—use energy to provide greatest advantage on the battlefield.**
  - *Energy logistics.*
  - *Information-driven understanding.*
- Supply energy needed to whomever needs it wherever and whenever—like ammo, food, or water—**energy saves warfighter lives and essential to success.**
- Recognize the **need to meet growing power demands.**
- Support battlefield situational awareness including communications, info processing, & AI.
- Reduce fuel transport to save lives during resupply.
- Reduce weight the dismounted soldier has to carry.
- Reduce the weight of all types of vehicles
- Increase the Army Brigade’s **self-sustainment capability from 3 to 7 days.**
- **Providing rapid mobility** across a variety of terrain
  - for dismounted soldiers, vehicles, and forward operating bases.
- **Rapid setup and breakdown** times for forward operating bases;
- Maintaining or **reducing the time required to refuel, recharge**, or provide new sources of power.
- Use a wider range of globally available resources-- i.e., **fuel resources utilized by allies and adversaries.**
- Maintaining a capability to **disable or lock out energy resources that falls into hostile hands** particularly those with proprietary technology.
- Employing **environmentally friendly** technologies wherever practical.

# Air Force OE Strategic Goals and Objectives

- Goals
  - **Identify and deliver optimal operations planning and execution solutions for existing gaps.**
  - Provide innovative energy solutions for **new and legacy aircraft** and systems.
  - Furnish **energy-efficient weapons system sustainment analysis.**
  - Support the production of **energy-informed war plans.**
  - **Educate** the Force and build the culture for operational energy.
- In order to accomplish these strategic goals, our team will develop initiatives for each objective, set milestones for each initiative, and review progress as needed.
- The smart use of operational energy.
  - **Increases combat capability.**
  - **Lowers maintenance costs.**
  - **Increases aircraft lifespan.**
  - **Increasing operational agility** to reinforce mission success.

# Air Force OE and Climate Change Mitigation

- **AF expends 45% of government fuel—aviation accounts for 80% AF expenditure (\$5-7 billion/year)**
  - **8000 sorties fueled from a 1% savings**
- Aviation fuel and related logistics are risks to the warfighter
- Optimizing Fuel
  - **Technology**
    - Aerodynamics
    - Weight reduction
    - Advanced propulsion
    - Engine sustainment
  - **Process**
    - Planning software
    - Optimized operations
    - Efficient flying
    - Data visibility
- **Jigsaw** planning tool
  - Reduces 180K gallons per week
  - Reduces CO2 by 46K metric tons/year
- **Engine compressor blade coatings**
  - Reduces CO2 by 185K metric tons/year
- **Engine washing**
  - Reduces CO2 by 177K metric tons/year
- **Drag reduction**
  - Reduces CO2 by 186K metric tons/year
- Future
  - **Blended Wing Body** 30% more fuel efficient (OECIF supported)
  - **Adaptive engines** 25% more efficient