

Decarbonization Research Consortium

WELCOME

24 March 2023

nps.edu/decarb



Decarbonization Research Consortium Meeting

24 March 2023 / 2 – 5 ET / 11 – 2 PT

Agenda

- 2:00 – 2:20 Welcome/Introductions
Welcome from George Washington University, [Dr. Pam Norris](#),
Vice Provost for Research
- 2:20 – 2:35 Presentation: [Integer Technologies](#), Dylan Temple, Josh Knight
- 2:35 – 3:15 Context: Current Decarbonization Efforts, Bill Muras, NPS
Roadmap Discussion
- 3:15 – 4:15 Collaborative Research Presentations:
University of South Carolina (+ Alternative Fuels)
- 4:15 – 5:00 Admin/Homework/Conclusion

Current Decarbonization Efforts and Roadmap Discussion

24 March 2023

Bill Muras

Agenda

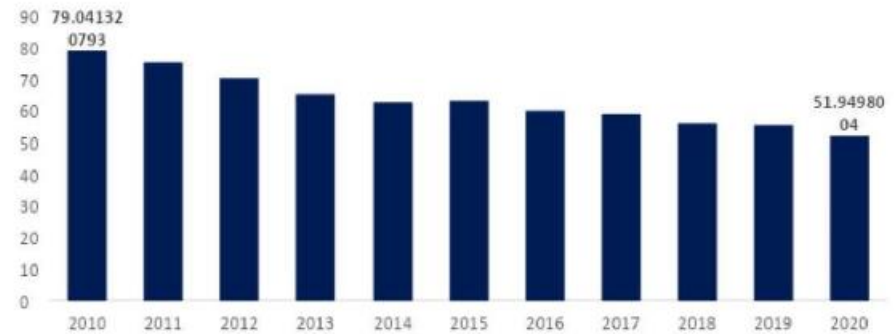
- Energy & Emissions Data
- Guidance Documents and Summary
- Roadmap/Strategy Synthesis

Some DoD Energy & Emissions Data

- Overall DoD emissions decreased ~34% from 2010 to 2020

Evolution of total GHG emissions reported by the U.S. Department of Defense (*)

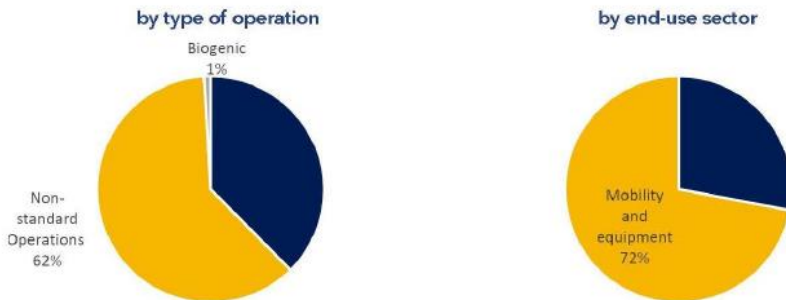
Unit: million tons of CO₂ equivalent



(*) Scope (1) and (2): Emissions directly emitted by the department's buildings and equipment (1) and emissions emitted by the department via its purchases of energy produced by third parties (2)

Structure of U.S. Department of Defense reported GHG emissions in 2020

Unit: share in % of U.S. Department of Defense volume emissions



- Roughly 70% of the total emissions are from operational platforms

Figure 2. DOD GHG Emissions (Department of Energy, 2022).

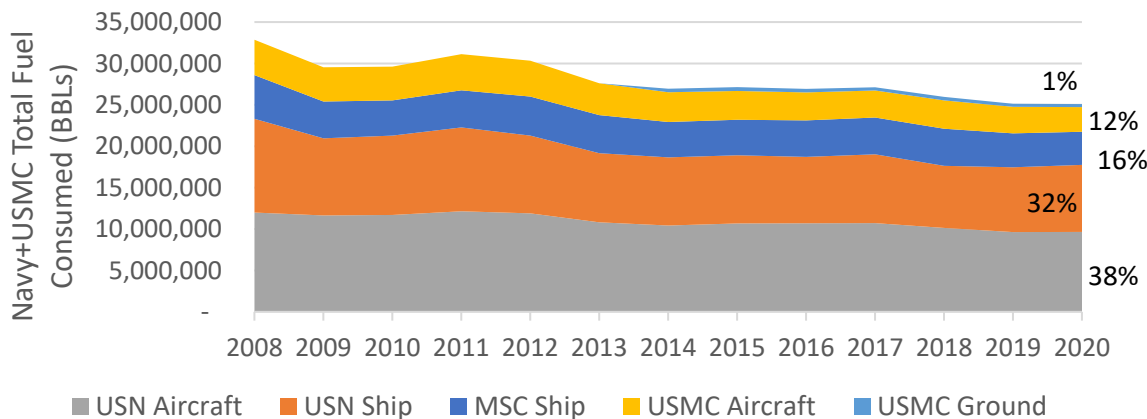
Some Navy Energy & Emissions Data

Table 1. DoD Operational Energy Demand by Service

	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21e	FY22e	
Operational Energy Demand, Million Barrels	Army	10.1	7.3	7.1	7.6	9.2	9.0	8.1	9.3	9.3
	Navy	28.2	28.5	28.5	28.4	26.0	28.1	27.9	25.3	25.3
	Air Force	48.6	52.0	49.6	49	51.9	45.3	41.2	46.7	46.2
	Marines	0.2	0.2	0.2	0.2	0.5	.38	0.4	0.5	0.5
	Other DoD	0.3	0.5	0.4	0.3	0.9	.77	0.3	1.0	1.0
	Total Demand	87.4	88.6	85.7	85.5	88.5	83.6	77.6	82.8	82.3
Expenditures (Billions)	\$14.0	\$14.1	\$8.7	\$8.2	\$9.1	\$11.0	\$9.20	\$8.24	\$8.40	

- FY 20 DoD operational energy
 - Air Force ~53%
 - Navy & USMC ~36%

Navy+USMC Total Fuel Consumed



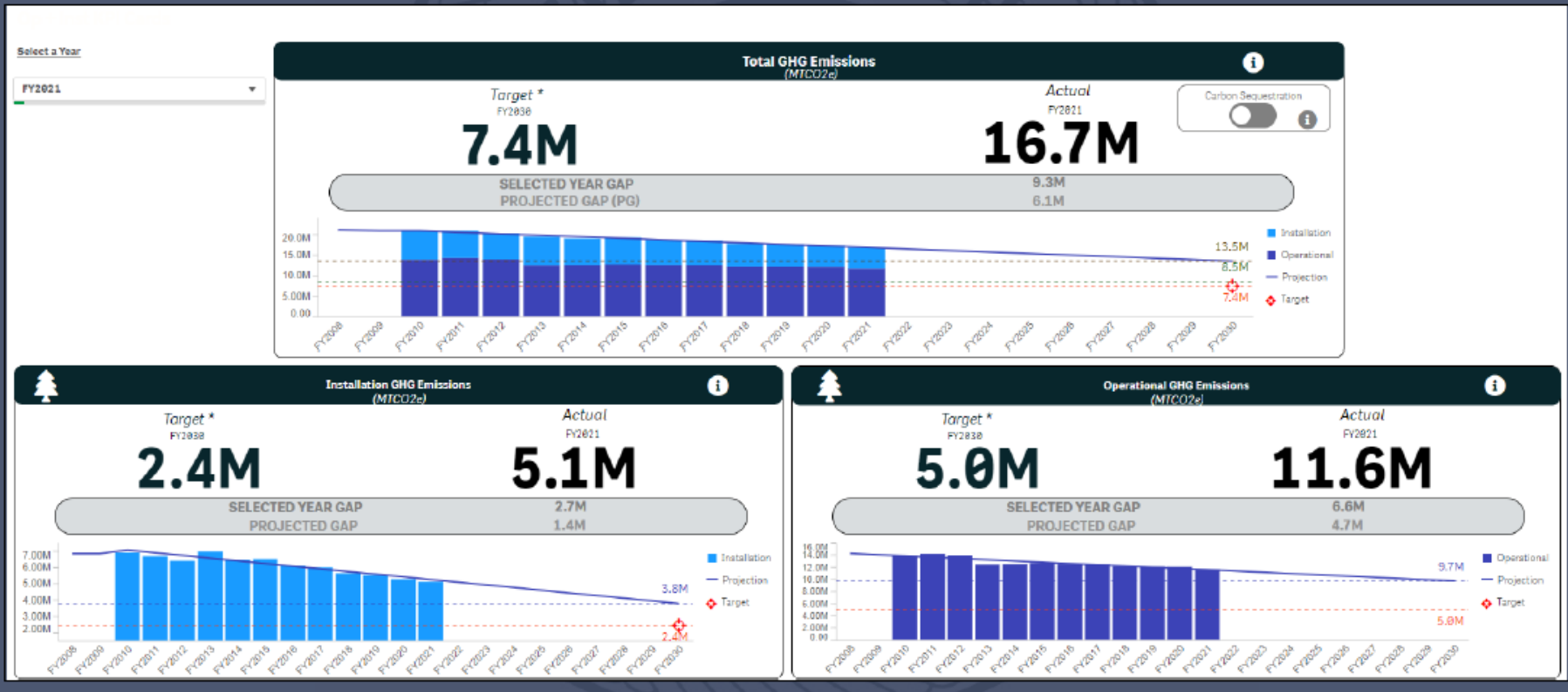
- Navy operational energy
 - ~24% reduction from 2008 to 2020
 - Roughly 50/50 split between aircraft & ships
 - 2017 GGF report: ~75% from reduced underway hours and force structure

Some Navy Emissions Data

Greenhouse Gas Inventory: Department of Navy		FY20 GHG Emissions (Standard Operations, Non-Standards Operations, Biogenic Sources) (MT CO2e)			
Scope and Category	<u>Navy</u>	<u>USMC</u>	<u>TOTAL</u>	<u>% of Total</u>	
Scope 1: On-Site Fuel Consumption at Federal Facilities	1,180,800	296,568	1,477,368	8.4%	
Scope 1: Mobile Emissions--Vehicles, Aircraft, Ships, and Equipment	11,727,080	150,618	11,877,698	67.6%	
Scope 1: Mobile Emissions--Passenger Fleet Vehicles	98,800	49,269	148,069	0.8%	
Scope 1: Fugitive Emissions--Fugitive Fluorinated Gases and Other Fugitive Emissions	254,868	-	254,868	1.4%	
Scope 1: Fugitive Emissions--On-site Wastewater Treatment	2,594	1,638	4,232	0.0%	
Scope 1: Fugitive Emissions--On-site Landfills and Municipal Solid Waste Facilities	43,335	145,322	188,657	1.1%	
Scope 1: Manufacturing and Industrial Process Emissions	-	-	-	0.0%	
Subtotal Scope 1	13,307,477	643,415	13,950,891	79.4%	
Scope 2: Purchased Electricity	2,760,140	712,112	3,472,252	19.8%	
Scope 2: Purchased Biomass Energy	80,555	-	80,555	0.5%	
Scope 2: Purchased Steam and Hot Water	97,862	-	97,862	0.6%	
Scope 2: Purchased Chilled Water	-	-	-	0.0%	
Scope 2: Purchased Combined Heat and Power Electricity, Steam & Hot Water	-	-	-	0.0%	
Subtotal Scope 2	2,938,557	712,112	3,650,669	20.8%	
Scope 2: Reductions from Renewable Energy Use	(15,344)	(8,786)	(24,130)	-0.1%	
Subtotal Scope 1 & 2	16,230,690	1,346,740	17,577,430	100.0%	
	92.3%	7.7%			

Some Navy Emissions Data

DON Total GHG Emissions



DoN PIO Dashboard

DON Total Operational GHG Emissions



Greenhouse Gas Emissions from DON Operations: Driver Tree



Major Guidance Documents

Primary

- EO 14008 – Tackling the Climate Crisis at Home and Abroad (*Jan 2021*)
- EO 14057 - Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability (*Dec 2021*)
- DoD Climate Adaptation Plan (*Sept 2021*)
- DoN Climate Action 2030 (*May 2022*)

Secondary

- US National Blueprint for Transportation Decarbonization (*Jan 2023*)
- FAA Aviation Climate Action Plan (*2021*)
- IMO GHG Strategy (*2018*)
- DOE Hydrogen Shot (*June 2021*)
- DOE SAF Grand Challenge (*Sept 2022*)
- USAF Climate Action Plan (*Oct 2022*)
- US Army Climate Strategy (*Feb 2022*)
- Summary of World Military Activities (*NPS – 2023*)

Sample Capability Evolution Plan (CEP)

Guidance Document Summary CEP (1 of 3)

Guidance, Timelines and Targets	2020s	2030s	2040s
<p>EO 14057</p> <ul style="list-style-type: none"> - 100% carbon-free electricity (CFE), including 50% 24/7 CFE - 100% zero-emission <u>light duty</u> vehicle acquisitions - 100% zero-emission vehicle acquisitions - 50% building portfolio emissions reduction - net zero emissions building portfolio - 65% reduction in scope 1 & 2 GHG emissions - Net zero emissions economy-wide 			
<p>Navy Climate Action 2030</p> <ul style="list-style-type: none"> - Generally mimic EO 14057, plus - DRAFT 15% increase in range/persistence across all forward deployed strike formations 			

Guidance Document Summary CEP (2 of 3)

Guidance, Timelines and Targets	2020s	2030s	2040s
<p>US Transportation Decarbonization Blueprint</p> <ul style="list-style-type: none"> - 5% of the global deep-sea fleet are capable of using zero-emission fuels - Net zero emissions from international shipping - Reduce aviation emissions by 20% - Net-zero GHG emissions from the U.S. aviation sector - Catalyze the production of <ul style="list-style-type: none"> - at least three billion gallons of SAF/year - ~35 billion gallons by 2050 		<p>★ 2030</p> <p>★ 2030</p> <p>★ 2030</p>	<p>2050 ★</p> <p>2050 ★</p> <p>2050 ★</p>
<p>IMO GHG Strategy</p> <ul style="list-style-type: none"> - Reduce carbon intensity of international shipping by <ul style="list-style-type: none"> - At least 40% - Pursue efforts towards 70% - Cut annual GHG emissions by at least half 		<p>★ 2030</p>	<p>2050 ★</p> <p>2050 ★</p>
<p>DOE Hydrogen Shot</p> <ul style="list-style-type: none"> - Reduce cost of clean hydrogen by 80% to \$1 per 1 kg in 1 decade 		<p>★ 2031</p>	

Guidance Document Summary CEP (3 of 3)

Guidance, Timelines and Targets	2020s	2030s	2040s
<p>DOE SAF Grand Challenge</p> <ul style="list-style-type: none"> - Scale up domestic production of SAF with a minimum of 50% life cycle GHG reduction <ul style="list-style-type: none"> - At least 3 billion gallons - 35 billion gallons (100% of projected use) 		<p style="text-align: center;">★ 2030</p>	<p style="text-align: center;">2050 ★</p>
<p>USAF Climate Action Plan</p> <ul style="list-style-type: none"> - Increase operational energy intensity of flying missions <ul style="list-style-type: none"> - By 5% - By 7.5% - Complete successful pilots of drop-in compatible SAF at two operational AF locations, with 10% SAF blend at same or lower cost 	<p style="text-align: center;">★ 2026</p>	<p style="text-align: center;">★ 2027</p> <p style="text-align: center;">★ 2032</p>	
<p>US Army Climate Strategy (<i>none directly relevant to Navy problem set</i>)</p>			
<p>World Military Activities</p> <ul style="list-style-type: none"> - General trend towards net zero by 			<p style="text-align: center;">2050 or later ★</p>

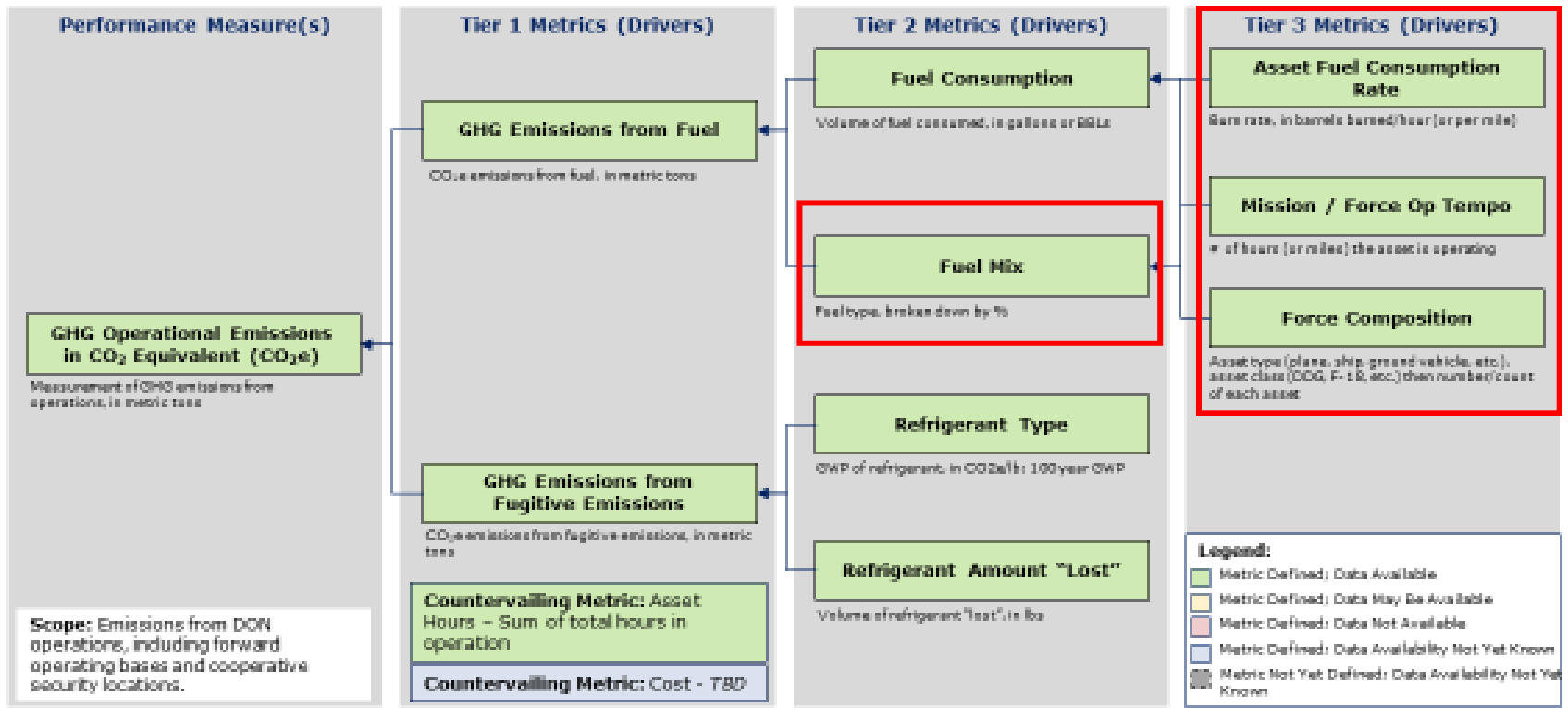
DoN PIO Driver Trees

Driver Tree – Operational Decarbonization

BLMF: Team has completed an Operational Decarbonization dashboard and drill-down pages.

Next Steps: Team has completed short-term enhancement requests and created an instance of the dashboard in SIPR; next step to incorporate additional datasets to enhance future projections.

Performance Goal: Reduce Climate Threat – The Department must reduce its greenhouse gas emissions and draw greenhouse gases out of the atmosphere, stabilize ecosystems, and achieve, as an enterprise, the nation’s commitment to net-zero emissions by 2050.



13 January 2023

Performance Management

10

NPS Report – Pathways to Net Zero

Strategy	Estimated Reduction %			
	Base	#2	#3	#4
Energy Efficiency	5.0%	7.0%	8.0%	9.0%
Operational Efficiency	5.0%	7.0%	8.0%	8.0%
Force Structure	0.0%	0.0%	0.0%	0.0%
Low Carbon Fuels	20.0%	22.5%	25.0%	25.0%
Hydrogen	7.0%	7.0%	8.5%	15.0%
Unmanned Systems	4.0%	5.0%	8.0%	11.0%
Battery Storage	4.0%	7.5%	10.0%	10.0%
Renewables	5.0%	7.5%	10.0%	9.0%
CCS/CCUS	20.0%	22.5%	22.5%	13.0%
Remaining Emissions	3.31	1.54	-	-

Navy OE Emissions Pathway 4: Aspirational
ILLUSTRATIVE

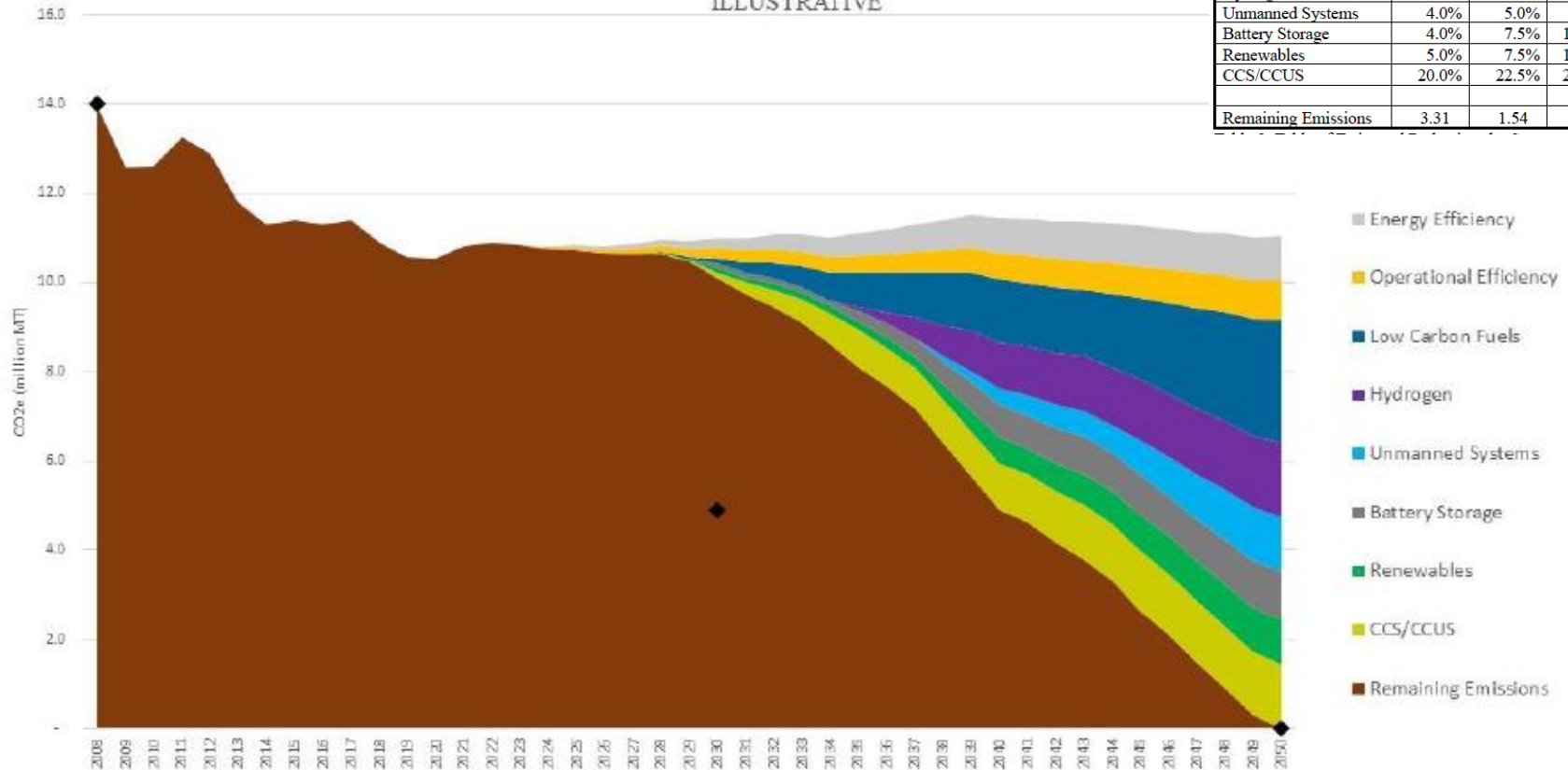
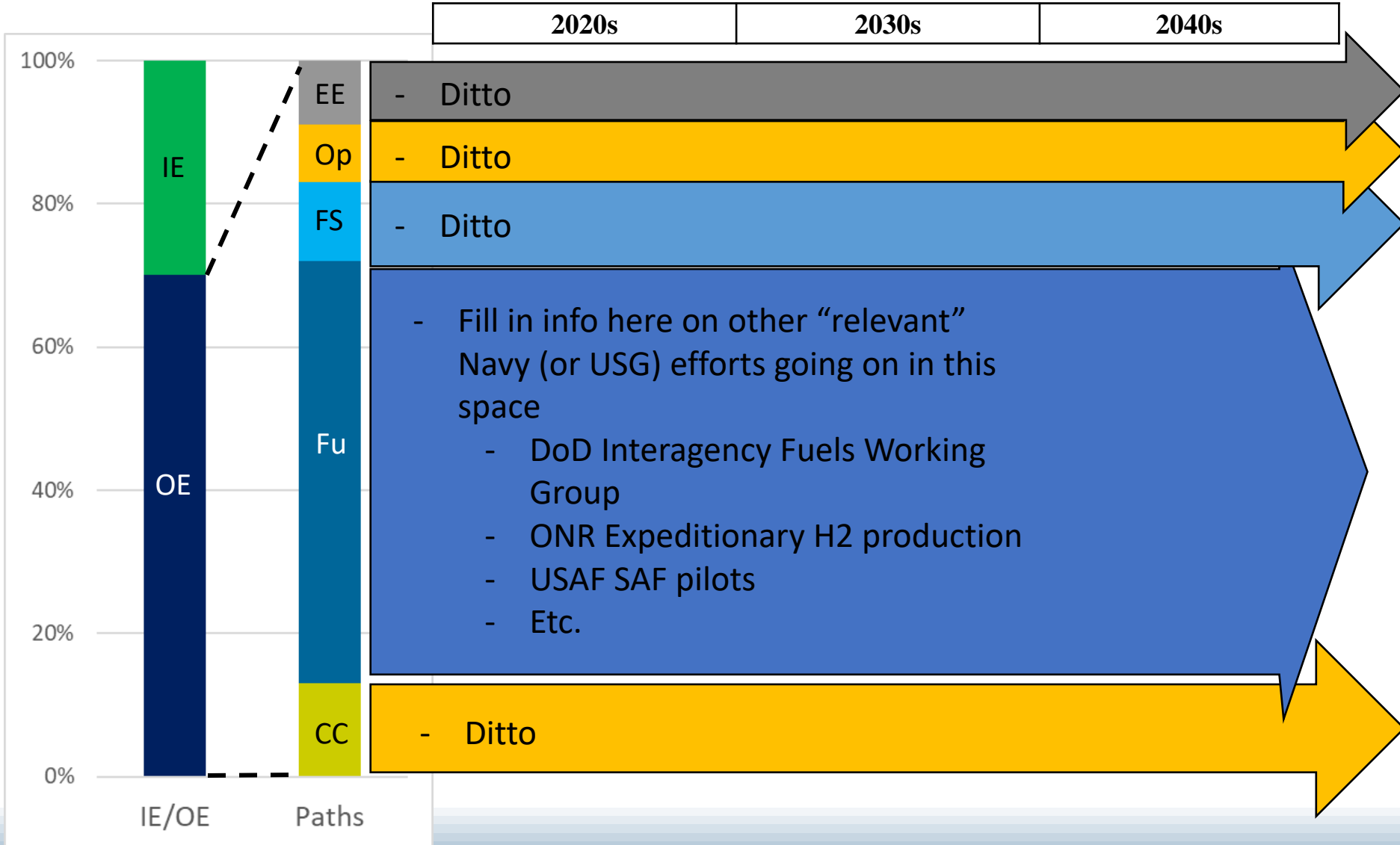
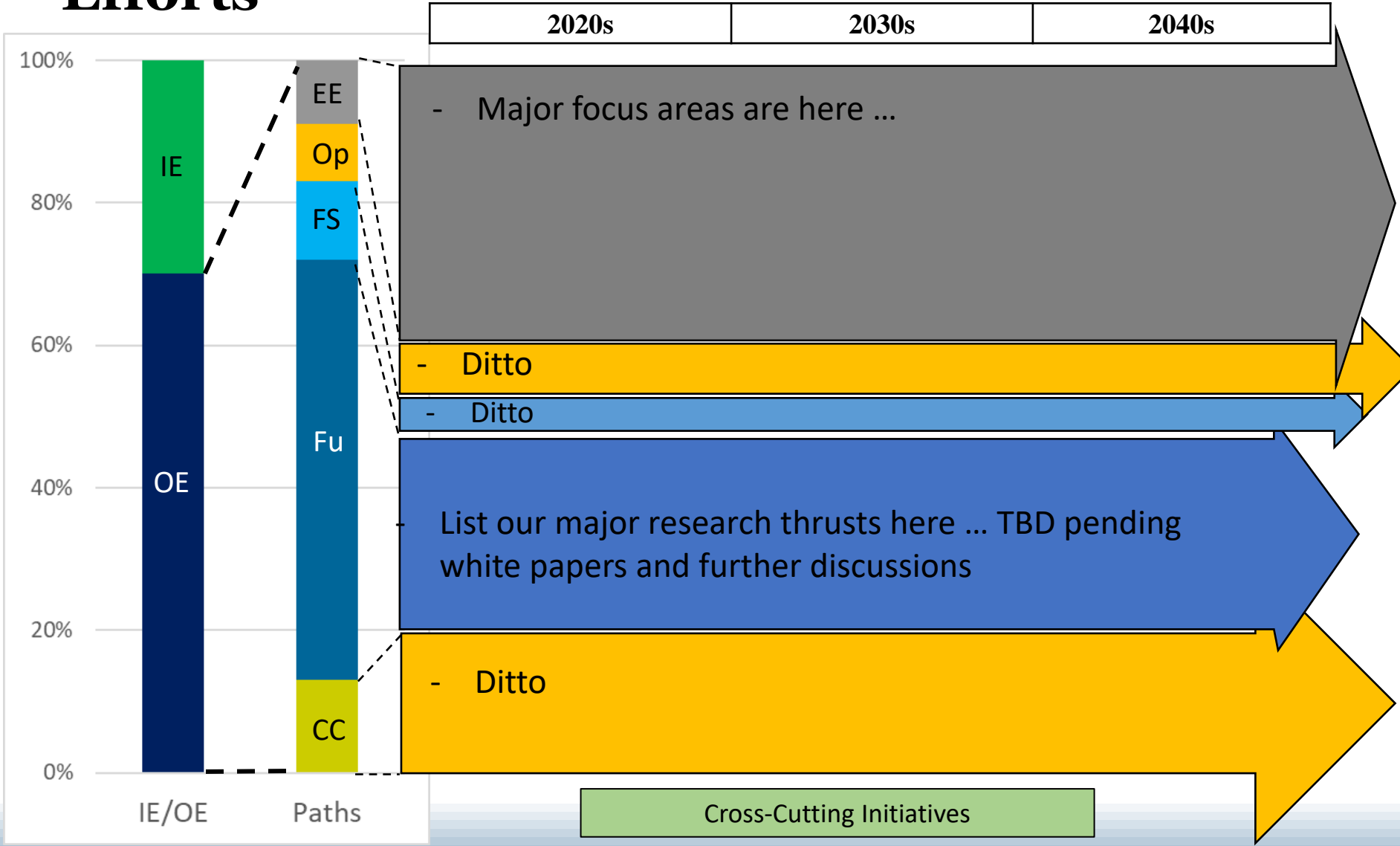


Figure 19. Pathway 4: Aspirational

Overall Operational Navy Path to Net Zero



Operational Decarbonization Consortium Efforts



Cross-Cutting Initiatives

Design

Ship Integration

Demo/Testing



Back-Up / Delete

Platform Decarbonization Roadmap Outline

- 1) **Clear Mission Statement and Purpose**
- 2) **Navy Specific Considerations and Constraints**
- 3) **Alignment with Other Decarbonization Efforts**
 - Overview of USG/DoD/Navy decarbonization efforts and select relevant commercial/international efforts
 - Define timelines and targets
 - Scope of this effort, including identified gaps, relative to other efforts
- 4) **Platform Decarbonization Focus Areas**
 - Develop timeline and roadmap for each, tied to specific areas of research needs, with milestones as applicable
- 5) **Summary Integrated Roadmap**

Platform Decarbonization Focus Areas

- 24 Feb Proposed – Old

- 1) Technology

- 1) Direct drag reduction
- 2) Propulsive loss reduction
- 3) Propulsion and power generation
- 4) Electrical energy storage
- 5) Waste heat recovery
- 6) Renewable energy

- 2) Operations

- 3) Fuels

- Current Proposed – New

- 1) Technology

- 1) Propulsive efficiency improvements and direct drag reduction
- 2) Propulsion and power generation
- 3) Electrification & Hybridization
- 4) Thermal management and materials
- 5) Shipboard carbon capture

- 2) Operations

- 3) Fuels

- 4) Whole ship and system level design considerations

- 5) Ship integration and technology scaling for shipboard use

- 6) Modeling, test sites and demonstration capability

Navy Specific Constraints/Considerations

Some aspects of the Navy unique mission(s) to keep in mind

- Navy platforms operate:
 - Forward presence
 - Contested logistics
 - Replenishment at sea
- Navy platforms are:
 - Space constrained
 - Often/Sometimes power constrained
 - Operated by 18-19 year old sailors
 - Long-lived \$1B+ assets

Some other Consortium considerations

- Short-, Mid- and Long-Term Horizons
- Retro-fit versus new build
- Not just an economic decision
- Potential future force structure – UxVs
- “Collaborate with the past”

Guidance Document Excerpts

Sec. 102. Government-wide Goals. (a) Leading the Nation on a firm path to net-zero emissions by 2050 and achieving the policy set forth in section 101 of this order will require bold action to transform Federal procurement and operations and secure a transition to clean, zero-emission technologies. Through a coordinated whole-of-government approach, the Federal Government shall use its scale and procurement power to achieve:

(i) 100 percent carbon pollution-free electricity on a net annual basis by 2030, including 50 percent 24/7 carbon pollution-free electricity, as defined in section 603(a) of this order;

(ii) 100 percent zero-emission vehicle acquisitions by 2035, including 100 percent zero-emission light-duty vehicle acquisitions by 2027;

(iii) a net-zero emissions building portfolio by 2045, including a 50 percent emissions reduction by 2032;

(iv) a 65 percent reduction in scope 1 and 2 greenhouse gas emissions, as defined by the Federal Greenhouse Gas Accounting and Reporting Guidance, from Federal operations by 2030 from 2008 levels;

(v) net-zero emissions from Federal procurement, including a Buy Clean policy to promote use of construction materials with lower embodied emissions;

Source: signed Executive Order 14057 “Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability”

Guidance Document Excerpts

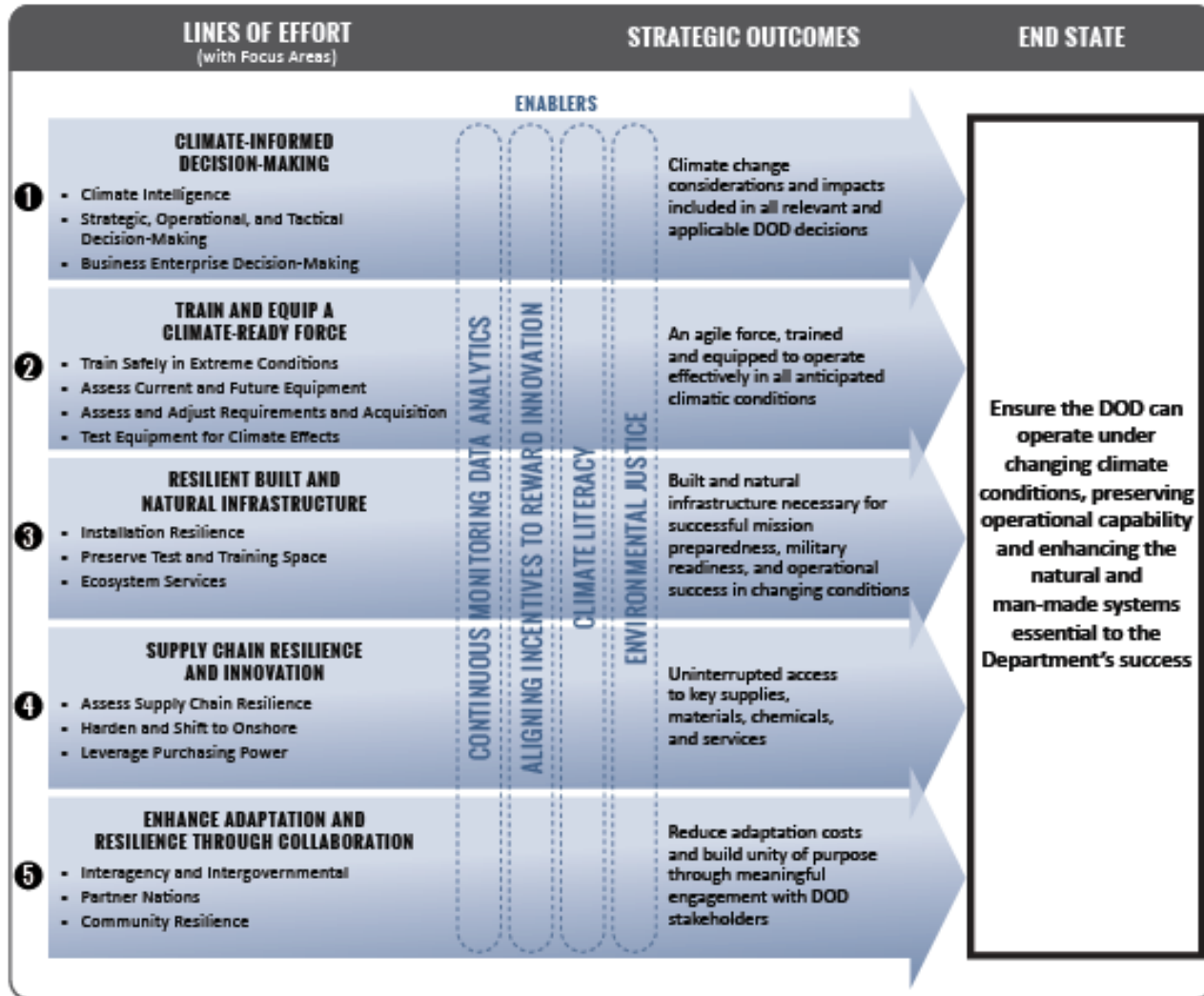


Figure 1. DOD Climate Adaptation Strategy Framework For Current and Future Force Decisions

Guidance Document Excerpts

Specific Targets

The nation has committed to achieve net-zero emissions economy-wide by 2050. Executive Order (EO) 14057, Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability, reiterated this commitment and added several other specific targets that apply to the DON. The DON will develop plans and initiatives to begin making progress towards implementing all applicable provisions in EO 14057, including:

- Achieving a 65 percent reduction in scope 1 and 2 greenhouse gas emissions department-wide by 2030 (measured from a 2008 baseline)
- Achieving 100 percent carbon pollution-free electricity (CFE) by 2030, at least half of which will be locally supplied clean energy to meet 24/7 demand
- Acquiring 100 percent zero-emission vehicles by 2035, including 100 percent zero-emission light-duty vehicle acquisitions by 2027
- Achieving a 50 percent reduction in emissions from buildings by 2032
- Annually diverting at least 50 percent of non-hazardous solid waste from landfills, including food and compostable materials, and construction and demolition waste and debris by 2025

Guidance Document Excerpts

Climate Action 2030



Climate Ready Force

To remain the world's dominant maritime force, the Department of the Navy must adapt to climate change. **A force that is resilient to climate impacts is more capable, agile and lethal.** We will enhance our operational capability, resilience, and reduce our climate impacts by aligning our climate actions to **strengthen maritime dominance, empower our people, and strengthen strategic partnerships.**

Performance Goals



Build Climate Resilience
Ensure that our forces, systems, and facilities can continue to operate effectively and achieve the mission in the face of changing climate conditions, and worsening climate impacts.

Reduce Climate Threat
Reduce our greenhouse gas emissions and draw greenhouse gases out of the atmosphere, stabilize ecosystems, and achieve, as an enterprise, the nation's commitment to net-zero emissions by 2050.

Targets

To achieve net-zero emissions economy-wide by 2050, the Navy and Marine Corps commit to:

- 65% reduction in greenhouse gas emissions departmentwide by 2030
- 100% carbon pollution-free electricity by 2030
- 100% zero-emission light-duty vehicle acquisitions by 2027
- 50% reduction in emissions from buildings by 2032
- 50% annual diversion of non-hazardous solid waste from landfills by 2025
- 1 million cars' worth of CO₂e drawn down by 2027 through nature-based solutions

Focus on Resilience

Nature-Based Resilience:

Mitigate shoreline erosion, protect mission-critical assets, and improve natural assets that are key to achieving resilient infrastructure and operations.

Shore Energy Resilience:

Install cyber-secure microgrids or comparable resilience technology that leverage carbon free power generation and long-duration battery storage.

Operational Energy Resilience:

Achieve a 15% increase in range/persistence across all forward-deployed strike formations on or before 30 September 2035.

Lines of Effort

Our strategy is organized around five lines of effort that are consistent with those laid out in the Department of Defense's (DoD) Climate Adaptation Plan.

1. Climate-informed decision making
2. Train and equip for climate resilience
3. Resilient built and natural infrastructure
4. Supply chain resilience and innovation
5. Enhances mitigation and adaptation through collaboration.



Guidance Document Excerpts



THE U.S. NATIONAL BLUEPRINT FOR TRANSPORTATION DECARBONIZATION

A Joint Strategy to Transform Transportation

4. Strategies to Decarbonize Transportation

- Increasing Convenience by Implementing System-Level and Design Solutions
- Improving Efficiency through Mode Shift and More Efficient Vehicles
- Transitioning to Clean Options by Deploying Zero-Emission Vehicles and Fuels



 <p>Maritime</p>	<p>3%</p>	<ul style="list-style-type: none"> Continue to support the Zero-Emission Shipping Mission (ZESM) goals to ensure that 5% of the global deep-sea fleet are capable of using zero-emission fuels by 2030, at least 200 of these ships primarily use these fuels across the main deep sea shipping route, and 10 large trade ports covering at least three continents can supply zero-emission fuels by 2030 REF Support the U.S. domestic maritime sector by performing more RD&D into sustainable fuels and technologies and incentivize U.S. commercial vessel operators to move towards lower GHG emissions Work with countries in the International Maritime Organization to adopt a goal of achieving zero emissions from international shipping by 2050 REF
 <p>Aviation</p>	<p>11%</p>	<ul style="list-style-type: none"> Reduce aviation emissions by 20% by 2030 when compared to a business-as-usual scenario Achieve net-zero GHG emissions from the U.S. aviation sector by 2050 Catalyze the production of at least three billion gallons of SAF per year by 2030 and ~35 billion gallons by 2050, enough to supply the entire sector REF

- The 2021 United States Aviation Climate Action Plan [REF](#) describes a whole-of-government approach to achieve net-zero emissions in the U.S. aviation sector by 2050. The plan builds on individual and sector-wide commitments

The SAF production industry is still developing, a trend spurred on by the SAF Grand Challenge. That partnership among the federal government, the airline industry, and partners established a goal of increasing U.S. SAF production to at least 3 billion gallons per year by 2030. This would put the U.S. on a path to produce and use about 35 billion gallons of SAF by 2050, which would decarbonize the aviation sector almost entirely [REF](#). SAF production will also be aided by the new tax credits and a competitive grant program the IRA established.

Guidance Document Excerpts

II. Climate Goal and Approach

To be effective, a goal should be clear, achievable, and ambitious with specific actions and milestones that can be taken to achieve it. The goal outlined below contributes to the broader objective to achieve net-zero GHG emissions economy-wide by 2050.

***U.S. Aviation Climate Goal:
Net-Zero GHG Emissions* from the U.S. Aviation Sector** by 2050***

* Aviation GHG emissions include life cycle carbon dioxide (CO₂), nitrous oxide (N₂O), and methane (CH₄) emissions. Aircraft engines produce negligible amounts of nitrous oxides and methane, so this plan has a focus on aviation combustion CO₂ emissions and well-to-tank life cycle GHG emissions (CO₂, N₂O, and CH₄). The U.S. Aviation 2050 Goal is based on emissions that are measurable and currently monitored. Research is ongoing into the climate impacts of aviation-induced cloudiness and the indirect climate impacts of aviation combustion emissions (see section 7 for details on the climate impacts of aviation non-CO₂ combustion emissions).

** This U.S. aviation goal encompasses CO₂ emissions from (1) domestic aviation (i.e., flights departing and arriving within the United States and its territories) from U.S. and foreign operators, (2) international aviation (i.e., flights between two different ICAO Member States) from U.S. operators, and (3) airports located in the United States.

Guidance Document Excerpts

2018 Initial IMO GHG Strategy

The IMO Initial Strategy on the reduction of GHG emissions from shipping sets key ambitions. This is a policy framework. The main goals are:

- Cut annual greenhouse gas emissions from international shipping by at least half by 2050, compared with their level in 2008, and work towards phasing out GHG emissions from shipping entirely as soon as possible in this century.
- The Initial GHG Strategy envisages a reduction in carbon intensity of international shipping (to reduce CO2 emissions per transport work), as an average across international shipping, by at least 40% by 2030, pursuing efforts towards 70% by 2050, compared to 2008.

The Initial Strategy will be revised by 2023.

What does the initial IMO GHG strategy say?

The initial GHG strategy envisages, in particular, a reduction in carbon intensity of international shipping (to reduce CO2 emissions per transport work, as an average across international shipping, by at least 40% by 2030, pursuing efforts towards 70% by 2050, compared to 2008); and that total annual GHG emissions from international shipping should be reduced by at least 50% by 2050 compared to 2008.

Guidance Document Excerpts

The first Energy Earthshot, launched June 7, 2021—Hydrogen Shot—seeks to reduce the cost of clean hydrogen by 80% to **\$1 per 1 kilogram in 1 decade** ("111").

Guidance Document Excerpts

Sustainable Aviation Fuel Grand Challenge



A commercial jet with biofuel tank. Photo courtesy of istock.com.

The SAF Grand Challenge is the result of DOE, DOT, and USDA launching a government-wide Memorandum of Understanding (MOU) that will attempt to reduce the cost, enhance the sustainability, and expand the production and use of SAF while:

- Achieving a minimum of a 50% reduction in life cycle greenhouse gas emissions compared to conventional fuel.
- Meeting a goal of supplying sufficient SAF to meet 100% of aviation fuel demand by 2050.

The SAF Grand Challenge and the increased production of SAF will play a critical role in a broader set of actions by the United States government and the private sector to reduce the aviation sector's emissions in a manner consistent with the goal of net-zero emissions for the U.S. economy, and to put the aviation sector on a pathway to full decarbonization by 2050.

In recognition of the critical role that drop-in synthesized hydrocarbon fuel from waste streams, renewable energy sources, or gaseous carbon oxides—or SAF—will play in addressing the climate change crisis, and its role for jobs and the economy, DOE, DOT, and USDA undertake the MOU to ensure the highest level of collaboration and coordination across the agencies.

Through the MOU, DOE, DOT, and USDA intend to accelerate the research, development, demonstration, and deployment needed for an ambitious government-wide commitment to scale up the production of SAF to 35 billion gallons per year by 2050. A near-term goal of 3 billion gallons per year is established as a milestone for 2030.

Guidance Document Excerpts

- **KR 1.6:** Department of the Air Force's installations portfolio is net-zero emissions by FY46, including a 50 percent emission reduction from 2008 levels by FY33.

Key Result (KR):

- **KR 3.1.1:** Operational energy intensity of Air Force flying missions increased 5 percent by FY27 and 7.5 percent by FY32 through standardized use of aircraft drag reduction technologies, modern software scheduling tools, and enhanced engine sustainment practices.
- **KR 3.2.1:** Completed successful pilot of drop-in compatible sustainable aviation fuel at two operational Air Force locations by FY26 where 10 percent of all purchased aviation fuels consist of sustainable aviation fuel blends at the same or less cost than traditional aviation fuel. The pilot project will validate operational, infrastructure, and logistical requirements for blending and quality control in the use of sustainable aviation fuel.
- **KR 3.2.2:** Completed successful pilot of micro-reactors by FY28 to demonstrate viability of this technology as a feasible alternative energy source.
- **KR 3.2.3:** 100 percent carbon pollution-free electricity on a net annual basis by FY30, including 50 percent 24/7 carbon pollution-free electricity.
- **KR 3.2.4:** 100 percent zero emission non-tactical vehicles by FY35, including 100 percent zero emission light-duty vehicle acquisitions by FY27 and aircraft support equipment by FY32.

Guidance Document Excerpts

ACS END STATE AND GOALS

The Army will be a resilient and sustainable land force able to operate in all domains with effective mitigation and adaptation measures against the key effects of climate change, consistent with Army modernization efforts.

- Achieve 50% reduction in Army net GHG pollution by 2030, compared to 2005 levels
- Attain net-zero Army GHG emissions by 2050
- Proactively consider the security implications of climate change in strategy, planning, acquisition, supply chain, and programming documents and processes

INTERMEDIATE OBJECTIVES:

1.1	Install a microgrid on every installation by 2035
1.2	Achieve on-site carbon pollution-free power generation for Army critical missions on all installations by 2040
1.3	Provide 100% carbon-pollution-free electricity for Army installations' needs by 2030
1.4	Implement installation-wide building control systems by 2028
1.5	Achieve 50% reduction in GHG emissions from all Army buildings by 2032, from a 2005 baseline
1.6	Attain net-zero GHG emissions from Army installations by 2045
1.7	Field an all-electric light-duty non-tactical vehicle fleet by 2027
1.8	Field an all-electric non-tactical vehicle fleet by 2035
1.9	Continue to advocate for an expanded Army Compatible Use Buffer

INTERMEDIATE OBJECTIVES:

2.1	Modernize existing Army platforms by adding mature electrification technologies
2.2	Field purpose-built hybrid-drive tactical vehicles by 2035 and fully electric tactical vehicles by 2050
2.3	Develop the charging capability to meet the needs of fully electric tactical vehicles by 2050
2.4	Develop predictive logistics that drive more precise and faster decisions
2.5	Establish policies that standardize contingency basing to increase resilience and reduce fuel requirements
2.6	Significantly reduce operational energy and water use by 2035
2.7	Achieve carbon-pollution free contingency basing by 2050
2.8	Adopt a Buy Clean policy for procurement of construction materials with lower embodied carbon emissions
2.9	Implement a revised energy key performance parameter
2.10	Attain net-zero GHG emissions from all Army procurements by 2050
2.11	Analyze all Army supply chain Tier 1 sources and contracts for climate change risks and vulnerabilities by 2025
2.12	Develop plans, policies, and contracts to ensure Army supply chain resilience by 2028

by land management decisions

science into stationing, construction, and fielding decisions

Guidance Document Excerpts



Net-Zero Planning by Militaries Across the Globe Summary of Findings

January 2023

POC: Jonathan Lussier, jonathan.lussier1@nps.edu

This document presents a summary of research related to commitments and plans to reach net zero emissions by militaries across the globe including findings, general trends, exceptions and countries with especially different strategies or timelines. The findings are followed by a table showing goals and strategies (when available) for 11 countries, including the U.S.

Status of Net Zero Emissions for the U.S. Military

To comply with recent Executive Orders and goals set out for the Department of Defense (DOD) and the DON, all US Federal agencies are being called into action. In January 2021, Executive Order 14008 called for a government-wide approach for meeting climate related challenges in the U.S. and set goals for agencies. In December 2021, Executive Order 14057 set the specific goal of net zero emissions from overall federal operations, including DOD, by 2050 and a 65 percent emissions reduction by 2030. The NPS Pathways to Net Zero report is a broad study of strategies for the Department of the Navy (DON) to achieve net zero emissions by 2050. Across DOD, all branches have issued climate strategies including climate action goals and strategies.

General trends

Most EU, NATO and other allied countries have goals to become net zero by 2050 with public policies and statements showing a reliance on a combination of technologies and other strategies to reach the goal. There is little public documentation in many of these countries on military specific goals and technology strategies, but it is expected that a state's military is responsible to follow the government-wide efforts towards net zero, though there may be lag in implementation due to hard-to-decarbonize sectors. In general, most policies emphasize transferring ground installations and industry to net zero, via renewable energy and clean manufacturing. Little emphasis is placed on operational energy within the sea and air domain. While it is a significant source of military emissions in the U.S. military, in countries without large navies or air forces, it represents a very small part of total emissions. Some trends across allied countries can be observed and most countries are embracing net zero strategies like those under consideration and use in the U.S.

Summary Table

Country	Net Zero Goal Year	Military specific goals or policy documents?	Main Strategies	Notes
United States	2050	Yes	Differs by branch	<ul style="list-style-type: none"> Widespread investment across services, with many different technological paths Trends with technological investment show focus on installation decarbonization with renewables, electric vehicles, and alternative fuels Investment in hydrogen, microgrids, improved logistics and many other climate strategies/technologies continues within specific commands and programs in each service DOD: Tackling the Climate Crisis
Australia	2050	Yes, minimal	Solar, hydrogen	<ul style="list-style-type: none"> Very little military-specific information; military sources are considered small in terms of total emissions Mostly focused on grid and installation measures Aviation still a stumbling block, Fischer-Tropsch fuels are noted as a possible alternative Focus on hydrogen on a national level Australia's Long - Term Emissions Reduction Plan Australia's Bioenergy Roadmap Defending Australia in the Asia Pacific Century
Canada	2050	Yes	Renewables for installations, EVs	<ul style="list-style-type: none"> Focuses on reducing installation carbon footprint. Little information available regarding energy for aviation and marine operations While EVs are looked to as a replacement for light vehicle fleets, decarbonizing sea, air and armored land platforms is not addressed in depth Defence Energy and Environment Strategy Canada Emissions on Climate Action Tracker
China	2060	None found	None found	<ul style="list-style-type: none"> Lacking detail on plans to reach net zero by 2060 Emissions from China still increasing every year China Country Summary China's Pledge to Be Carbon Neutral As Climate Change Threatens China, PLA Is Missing in Action

Country	Net Zero Goal Year	Military specific goals or policy documents?	Main Strategies	Notes
Germany	2050	None found	Renewables, carbon neutral fuels	<ul style="list-style-type: none"> No specific military policy relating to net zero goals National focus on carbon neutral fuels for transport industry Assumption is that the defense ministry will follow the country's net zero goals Germany's current climate action status
India	2070	Sparse	None found	<ul style="list-style-type: none"> Broad goals on the military level to reduce emissions, but no specific plans Currently highly reliant on carbon-based fuels India Country Summary Approval of National Mission for a Green India Scheme
Italy	2050	None found	Renewables	<ul style="list-style-type: none"> Following EU guidelines, focused on renewable measures Biofuels looked to for hard to decarbonize industries Integrated National Energy and Climate Plan EU Country Summary
Japan	2050	None found	Hydrogen, ammonia, alternative fuels	<ul style="list-style-type: none"> Planning to reach net zero by solar, wind and electrification for most industries For sea-power, focus is on hydrogen and ammonia-fueled ships For air power, focus is on biojet fuel and e-fuel, with some electrification and hydrogen augmentation Close coordination with the U.S. Japan's Roadmap to "Beyond-Zero" Carbon FACT SHEET: U.S. - Japan Climate Partnership
Norway	2050	None found	CCS, hydrogen	<ul style="list-style-type: none"> Electrical grid almost completely renewable Nearly on track to hit net zero by 2050 Heavy investment in CCS and Hydrogen Future plan is focused on hard-to-decarbonize sectors Nothing specific on military emissions Norway 2022 - Energy Policy Review Norway's Climate Action Plan for 2021-2030

Decarbonization Research Consortium

Path Forward

Individual Meetings

April Meetings:

April 13, Noon – 2:30 pm ET: Virtual (in-person at Stanford)

April 24, 11 am – 1:30 pm ET: Virtual

May: Development of Draft Roadmap