Australian Government
Defence

Future Energy Strategy

August 2023

Defending Australia and its national interests in order to advance Australia's security and prosperity
www.defence.gov.au

LIMITATIONS

Energy assessment outcomes based on the Energy Resilience Framework are not recommendations. The Framework has been developed to illustrate the most suitable alternative fuels based on current and predicted future potential. Detailed engineering and technical assessments of alternative fuels for specific platforms and equipment need to be completed prior to adoption.

Foreword

Assured access to reliable sources of the energy required to fuel Defence's warfighting capabilities is critical for achieving our mission to defend Australia and its national interests.

Currently, fossil-based fuels power our deployable capabilities. We are reliant on imported crude and refined fossil fuels that are transported through supply chains that are vulnerable to disruptions caused by geopolitical or environmental factors. Moreover, the global availability of fossil fuels is predicted to decline over the next two decades.

The Australian Government has joined with over 70 other nations, including our closest allies, in committing to reduce carbon emissions to net-zero by 2050. As the Government's largest user of fossil fuels, Defence has a significant role to place in achieving this commitment.

The Australian Defence Force must, therefore, transition from fossil fuels to alternate renewable energy sources in order to maintain preparedness, sustain operations, and reduce our carbon footprint.

The transition from fossil fuels to alternate energy sources for our deployable capabilities presents significant opportunities to improve our energy security, preparedness and resilience. Alternate energy sources that are wholly generated in Australia through sovereign capabilities are highly attractive to Defence.

Our transition to alternate energy sources must be undertaken in a coherent, measured manner that builds interchangeability with our allies and partners, and within our Joint capabilities. We must be careful to ensure that our future energy mix is not overly complicated and that it is sustainable in both logistic and environmental terms.

Defence must also demonstrate leadership in the transition away from fossil fuels. This requires us to work with industry, academia and other Government departments to support the development of sovereign and regional renewable capabilities.

The Defence Future Energy Strategy provides the framework for Defence to take a measured and coherent approach to transitioning to future energy sources for our deployable capabilities. It is critical that we invest in its implementation so that we can maintain our operational capabilities and improve our preparedness while we do so. This will enable Defence to continue to defend Australia and its national interests while contributing to a net-zero emission future.

Greg Moriarty
Secretary for Defence

3 August 2023

Angus J Campbell, AO, DSC
General
Chief of the Defence Force
3 August 2023

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Executive Summary

CONTEXT

The predicted reduction in availability of fossil fuels in the next 10 to 15 years represents a significant challenge to Defence achieving its mission of defending Australia and its national interests. This is due to a reduction in oil reserves and global action on climate change with the Australian Government joining over 70 countries in committing to reducing carbon emissions to net-zero by 2050. Oil companies are responding by taking deliberate action to transition to more enduring income streams.

Defence must take action to assure energy supply for warfighting capabilities throughout the transition to new and emerging energy types. Concurrently, Defence has an obligation to identify appropriate pathways in accordance with the Government's commitment to decarbonisation while maintaining or enhancing our warfighting and support capabilities.

Key allies are also implementing decarbonisation strategies in line with their own government expectations. It is important that Defence takes advantage of this work to ensure interoperability is maintained.

THE NEED FOR A STRATEGY

As Defence reduces its reliance on fossil fuels, an evolving and diverse range of new energy sources will be required. Iterative analysis must be conducted to ensure Defence energy requirements and opportunities are understood as new solutions become technologically and economically viable.

The Defence Future Energy Strategy (DFES) and associated Implementation Plan provide the framework for a central programmatic approach to Group and Service energy transition activities. This is critical to ensuring Defence takes full advantage of the opportunities to:

- Collaborate with military allies and industry partners regarding the adoption of alternative energy types to maintain interoperability.
- Enable sovereign alternative energy production capabilities, thus strengthening national energy security
- Maximise value-for-money by transitioning from increasingly expensive fossil fuels to emerging commercial alternatives over the longer term
- Link alternative energy adoption to the One Defence Capability System (ODCS) to ensure integration and compatibility, and minimise sustainment complexity.

The DFES is the first step in enabling the critical decisions that will equip Defence to maintain capability and interoperability, while contributing to the government's decarbonisation commitments.

THE FUTURE STATE OF DEFENCE ENERGY

The DFES energy assessment has identified Renewable Diesel (RD), Sustainable Aviation Fuel (SAF), and Electrification for land as likely alternative energies over the short to medium term, with Hydrogen, Uranium, and Electrification for selected Air and Maritime domain applications identified as long term alternative energy options. Conventional fossil fuels are expected to remain part of the Defence energy mix beyond 2050, albeit at a reduced proportion, but immediate action will start to mitigate interoperability, supply, and financial challenges associated with long term exclusive reliance on fossil fuels.

DEFENCE FUTURE ENERGY STRATEGY

MISSION

Defence maintains warfighting capability and interoperability while adopting low carbon energy sources in line with government policy and industry

VISION

- Maintain or enhance warfighting capability and ongoing interoperability with coalition partners
- Enhance resilience through diversified, secure energy supply and reduce reliance on fossil fuels, imported and domestic.
- Collaborate with industry to adopt and secure access to low-carbon energy
- Support the Government commitment to achieve net-zero carbon emissions by 2050

MEASURED BY

- Increase in Defence uptake of alternative energies with no reduction in operational capability
- Increase in percentage of Defence energy consumption sourced locally
- Reduction in time between market and Defence uptake of alternative energy
- Reduction in Defence emissions from the use of fossil-based fuels

DELIVERED BY FIVE LINES OF EFFORT

1. **Understand and set future energy needs**
   Defence's future energy profile will change as the organisation, assets and market evolve. Defence will need to have ongoing clarity of its future energy needs to enable general planning, set achievable energy and emission reduction targets, assess fleet and infrastructure changes, and inform energy procurement requirements.
2. **Influence the future energy industry**
   The alternative energy market within Australia is evolving with current geo-political tensions emphasising the need to drive domestic market activation to support overall energy security. Defence will influence the future energy industry and end-user requirements in collaboration with Government, industry, research organisations, and Defence allies.
3. **Design and develop the future workforce**
   Defence will design the future workforce required to support and manage its emerging energy mix from transition through to sustainment. Defence will work with industry, education, and research institutions to develop training pathways that enable its workforce and the broader industry to bridge the technology gap between today and future requirements.
4. **Prepare platforms and the network for the emerging energy mix**
   Current Defence platforms and infrastructure will need to be centrally reviewed to inform compatibility with alternative energies that are not drop-in replacements, and the potential need to invest in future modification or replacement. This encompasses the extant and planned platforms, the Defence Fuel Network (DFN) and other key functions such as asset data management.
5. **Develop processes for transition and develop governance**
   Defence will have the right level of governance and performance management in place throughout, and after, the adoption of alternative energies, including standardisation of processes for Defence energy adoption and clarity over roles and responsibilities. Considerations for non-fossil based energy will be incorporated into the ODCS.

Defence Future Energy Strategy Scope

Transitioning Defence Materiel from fossil based energy to sustainable energy sources without detriment to capability.

Aim

The DFES provides a framework and direction to transition Defence Materiel energy sources in ways that enhance operational effectiveness, reduce dependence on vulnerable supply chains, retain interoperability with key partners and reduce Defence's environmental impact.

The DFES is sponsored by Chief of Joint Capabilities and focused on platforms rather than the Defence Estate.

Interdependencies

The DFES has been developed in line with the 2023 Defence Climate Change Policy.

The DFES complements Security and Estate Group's Defence Net Zero Strategy (DNZS) which will focus on an Estate led approach to reduce emissions by delivering sustainable and renewable energy sources.

The DFES supports the Government's decarbonisation commitments, notably net-zero emissions by 2050.

Applicability

The DFES is applicable to all personnel with capability management and support responsibilities, including acquisition, testing, sustainment, operating, enabling and support functions.

The Defence Energy Transition Office (DETO) will centrally implement the DFES and ensure adherence to its principles to assure integration and compatibility by minimising sustainment complexity.

The DFES acknowledges that an energy transition on the scale required to achieve net zero emissions by 2050 will be a long pathway spanning generational periods, using undiversified technology and maintaining legacy technologies that require some form of fossil-based fuels for the foreseeable future.

It acknowledges that Defence Material cannot transition to sustainable energy alternatives in isolation of the supporting training areas and facilities, and that a coordinated approach is required to assure Defence's energy resilience and the ability to contribute to the Government's decarbonisation commitments.

The DFES focusses on the activities that must be undertaken to support the transition of Defence material to use sustainable energy alternatives in a staged approach without detriment to warfighting capability and interoperability.

In conjunction with Security and Estate Group's DNZS, the DFES will enable critical decisions that equip Defence to assure its warfighting capabilities through an energy transition on the scale of what is expected over the coming decades.

Assuring Warfighting Capability and Interoperability

Defence will adopt future energy options in a staged approach without detriment to warfighting capability and interoperability.

Assuring warfighting capability and interoperability with key coalition partners is essential. Defence needs to keep these two factors at the forefront of any decision to adopt future energy options.

Complementing this is enhancing energy source resilience by reducing Defence reliance on imported fossil fuels and supporting commitments to achieve net-zero carbon emissions by 2050.

With over $570 billion in planned investments as part of the 2020 Defence Strategic Update, Defence is delivering large-scale critical capability acquisition and sustainment programs which rely on the consumption of conventional fossil fuels.

The average in-service life of many of these platforms may overlap with an evolving Defence energy mix. As a result, individual platform energy requirements must be flexible and compatible with the shifting energy composition.

Capability acquisition and sustainment activities for current and future platforms will be impacted by the energy transition.

The energy assessment identified RD, SAF, Hydrogen, and Electrification as future energy options for Defence.

Each of these options can provide benefits to different warfighting capabilities. When acquiring or upgrading warfighting capabilities, Defence will consider all factors associated with adopting future energy options.

This includes an assessment of available proven technology over the life of type of the platform, the energy sources of similar platforms operated by coalition partners and the supply chain maturity of the energy source.

Even as Defence adopts new energy types, fossil fuel reliant platforms will need to be sustained using drop-in substitutes, such as blended bio and synthetic liquid fuels.

This is due to the high costs and engineering challenges associated with modifying platforms to enable the use of non-drop-in alternatives, such as hydrogen.

Alternatively, Capability Managers could be faced with potentially costly choices for fossil fuelled capability. This may include reducing lifecycle extensions, accelerating decommission dates for non-critical platforms and prioritising the reduction of fossil fuels use.

Future Defence Energy Landscape

The energy assessment identified Renewable Diesel, Sustainable Aviation Fuel, Hydrogen, and Electrification as future energy options for Defence

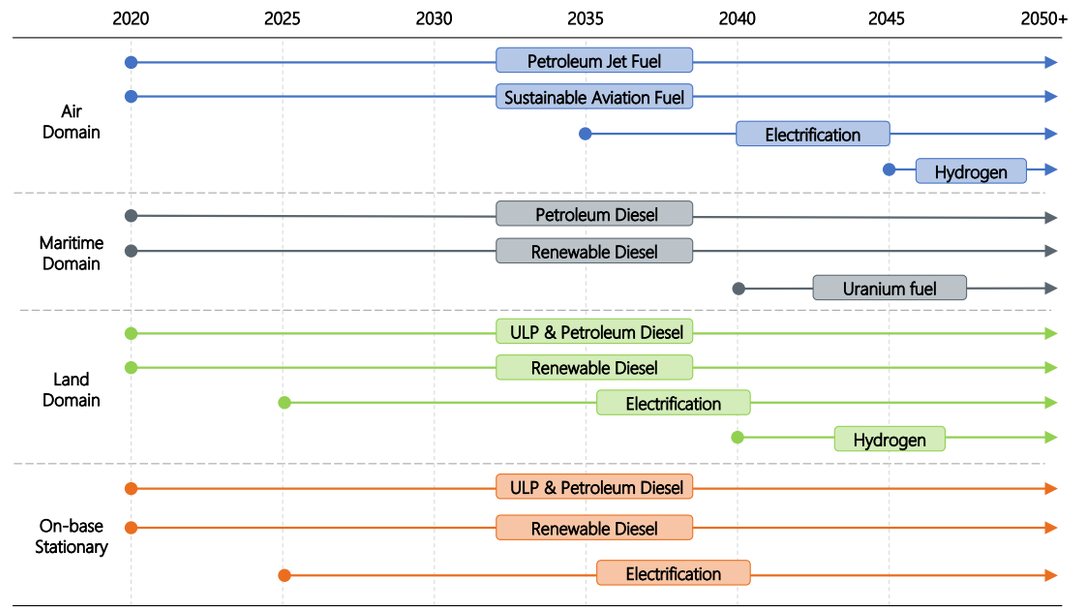
Defence's transition to alternative energy types presents opportunities to enhance supply security for warfighting capabilities, interoperability and to reduce price volatility, reinforcing the importance of Defence commencing its energy transition journey. As Defence reduces its reliance on depleting fossil fuels, capabilities will rely on emerging energy types. The energy assessment of future alternative energy sources is based on an 'Energy Resilience Framework' and provides a point-in-time view of the energy transition roadmap for Defence. It assumes that Defence will undertake this transition in line with industry and allied militaries in the adoption of alternative energies, while considering the unique requirements associated with Defence's military operations.

The assessment identifies RD, SAF and electrification as the priority future energy options for Defence in the short term, with hydrogen, uranium and further electrification for select air platforms as other long term alternatives.

While Defence will transition away from legacy fossil fuels, it is expected to support the transition and remain in the Defence energy mix in a reduced capacity or blended with alternative fuels beyond 2050. The transition roadmap should be periodically reviewed every 1 – 2 years to ensure it captures rapid shifts in timeframes arising from technology advancements, accelerated market and allied adoption, or changes in Government policy.

The Defence future energy mix roadmap illustrates projected market availability of Defence's alternative energy options. Defence's adoption of specific energy types will depend on the results of an infrastructure assessments and maturation of future energy technologies. The energy roadmap consists predominantly of alternative drop-in liquid fuels with similar chemical properties to conventional fossil fuels, such as RD and SAF. Drop-in replacements fuels have little to no impact on the Defence platform or infrastructure. Defence first operated using drop-in replacement fuels in 2012, where a Seahawk helicopter flew on a SAF blend, and the Great Green Fleet Rim of the Pacific (RIMPAC) exercise in 2016 using renewable diesel F-76 in the participating RAN ships. Electrification and Hydrogen will also be suitable for select platforms, but will not replace liquid fuels entirely due to limitations around range, survivability, and infrastructure requirements.

Defence future energy mix transition roadmap



Emerging energy types, such as Alcohols, Ammonia, and Hydrogen are likely to be adopted across industry in larger capacities as part of the global energy transition. However, some of these energy types present unique challenges to Defence due to the nature of its operation. Challenges include, reduced energy density resulting in lower range, or the need for larger storage tanks, compromised survivability with hydroscopic Alcohol and Ammonia fuels, and damage to platform propulsion systems. These will be worked through to cohere the balance between capability effect and risk.

The energy assessment identified that a more ambitious update approach results in greater energy security and cost savings in the future

Future state demand and emissions profile

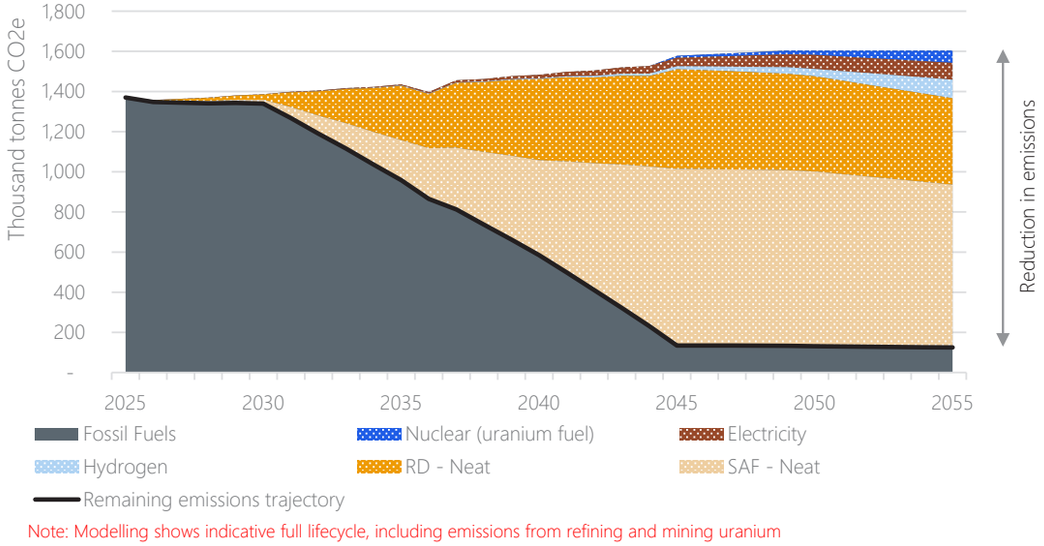
Defence's annual fossil fuel requirements are forecast to grow to 487 mega litres (ML) by 2050. However, if Defence transitions to a more diverse mix of alternative energy, demand profiles will become increasingly complex. This is a result of variations in energy density between different alternative liquid fuels and the introduction of solid state power such as batteries. A more tangible approach is to measure the future energy demand profile of Defence as the proportion of future fossil fuels displaced by alternative energies. Under the balanced adoption scenario below, almost all of the future fossil fuel demand is predicted to be displaced by alternative energies by 2045, or as early as 2040 under a more ambitious scenario. In addition to increasing Defence's energy security, it will meet government requirements to reduce carbon emissions.

If Defence transitions in line with these estimates, it has the potential to reduce its lifecycle assessment (LCA) emissions by 86 - 99% in 2050. Under a balanced adoption scenario, emissions are estimated to be reduced by 92% in 2050, noting a small volume of embodied emissions remain from alternative technologies, particularly battery technology.

While the adoption of renewable fuels will result in a higher cost over the short to medium term, from the mid-2040s it is anticipated that Defence will start to see a (relative) reduction in fuel costs. This is a result of the expected reduction in price of renewable fuels as the industry scales and the expected rise in crude oil prices over the long-term.

A more ambitious uptake approach from a large user like Defence signals to industry to invest faster and create greater economies of scale. This results in greater (relative) cost saving in the long term (noting that this scenario also assumes a level of lower price points for fuels and, like all scenarios, excludes O&M or infrastructure costs).

Defence projected emissions impact by future fuels type (Balanced adoption scenario)



Note: Modelling shows indicative full lifecycle, including emissions from refining and mining uranium

Science and technology requirements to support the Defence future energy mix

The future Defence energy mix, which may include emerging fuel types such as hydrogen and electrification, will require the maturation of technology. Not limited to energy production, the technological advancements required include platform propulsion systems, energy storage systems and supporting delivery systems particularly as it relates to safety in high-risk environments. This modelling is based on existing technology (e.g. lithium ion batteries) with projected improvements, noting it is subject to change as technology evolves (e.g. flow batteries).

Closing the gap between science and technology today and what will be needed to support the Defence energy mix of the future will require collaboration between Defence, industry, academia and research and development (R&D) organisations. As Defence navigates the energy transition, existing relationships with CSIRO and other established R&D institutions will play a key role in addressing future science and technology requirements.

Implications for Acquisition and Sustainment

Capability acquisition and sustainment activities for current and future platforms will be impacted by the energy transition.

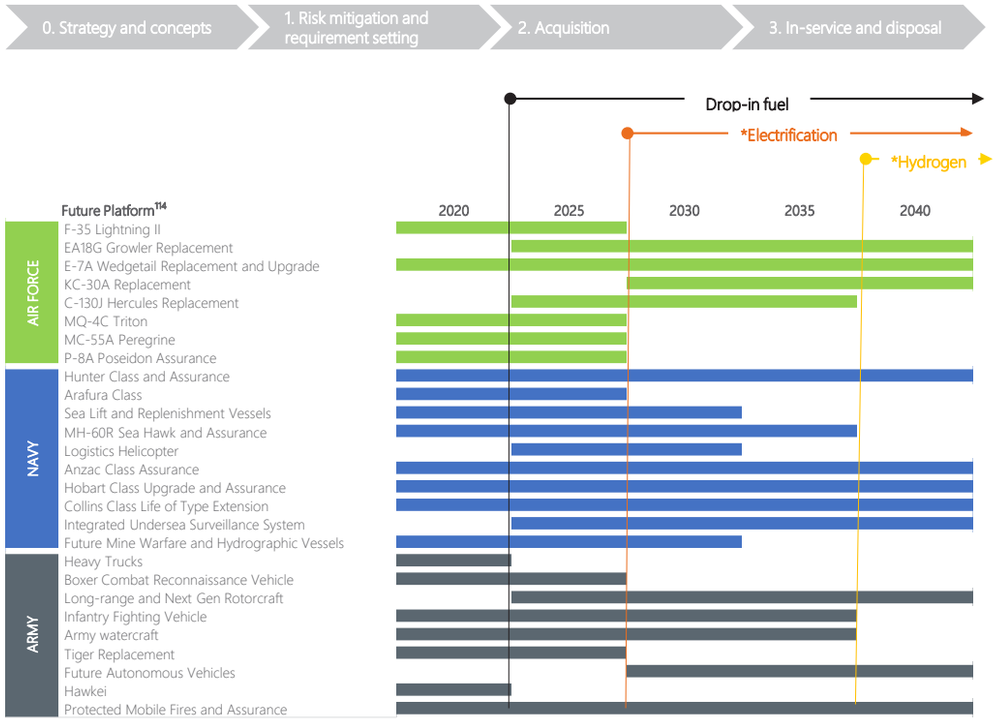
A future energy focused capability acquisition and sustainment strategy

The impact of the energy transition on the Defence environment stretches beyond the end-to-end energy supply chain. As Defence adopts additional energy technologies over the medium to long term, a clear understanding of cost and supportability in all elements of the Fundamental Inputs to Capability (FIC) will be critical to developing, managing, sustaining and supporting Defence platforms. Defence must incorporate future energy considerations into the ODCS to assure Integrated Investment Program decision making.

Future energy sources, which are not drop-in replacements for current fuel types will also have strategic implications for capability acquisition. Given the lengthy capability development processes for complex platform systems, an informed view of the Defence energy transition is essential to accurately inform the early parts of the One Defence Capability, particularly phase '0. Strategy and concepts', to ensure future platforms have propulsion systems compatible with Defence's future energy mix.

The One Defence Capability System

The first non-drop-in replacement fuels are predicted to be introduced into Defence from 2025 (electrification). Defence requires a centrally coordinated approach to the consideration and adoption of non-drop-in replacement fuels to ensure ADF interoperability within itself and its partners. Integration is critical to supportability, therefor the adoption of new energy types must consider the strategic acquisition and sustainment implications of changes in the energy mix. The ODCS must incorporate centrally led coordination and guidance to ensure ADF interoperability and minimise complexity in the future energy environment, which may be multi-source. Ensuring compatibility and carefully managing the integration of new energy types and supply chains will be critical to supportability and effective logistics management.



Planned Defence investments into future platforms across the services overlayed with when alternative energies are expected to be phased into the energy mix.
**Note these are illustrative only and subject to further detailed feasibility and technical analysis.*

Implications for the Defence Fuel Supply Chain

The energy transition and subsequent changes in Defence end-user energy requirements represent major implications for the existing fuels value chain

Impacts to the Defence Fuel Supply Chain (DFSC)

The DFSC encompasses all activities, organisations, resources and technologies that participate in the provision of liquid fuel to Defence. It begins with procurement and contract management for inbound supply, storage, management and distribution. Moreover, it includes suppliers of products, equipment and additional support services to Defence and its fuel suppliers. As Head of the DFSC, the Commander of Joint Logistics (CJLOG) is responsible for the safe, integrated and effective design and operation of the DFSC, commensurate with industry standards to ensure the safe and resilient supply of fuel to meet the needs of Defence capability, at optimal value for money for the Commonwealth.

The impact of the adoption of alternative energy types on the end-to-end DFSC must be understood to enable Defence to prepare for the opportunities presented by the transition. A full impact assessment of each potential alternative energy should be conducted to define process changes and determine the precise technology, infrastructure and personnel investments required to ensure the DFSC remains operable throughout the energy transition.

Defence Fuels Value Chain (Level 1 & 2)

A: Capability Requirements	B: Planning	C: Supply	D: Execution	E: Asset Management	F: Compliance & Assurance	G: Other Support
A1: Preparedness management	**B1:** Network planning	**C1:** Sourcing and contract management	**D1:** Receipt and store	**E1:** Asset acquisition	**F1:** Governance & performance management	**G1:** Competency training
A2: Requirements definition	**B2:** Inventory planning	**C2:** Procurement operations	**D2:** Issue	**E2:** Asset maintenance	**F2:** Enterprise risk & assurance	**G2:** Financial management
A3: Demand planning	**B3:** Supply planning	**C3:** Supply logistics	**D3:** Use	**E3:** Asset divestment	**F3:** Work Health and Safety management	**G3:** Information technology management
					F4: Environmental management	
					F5: Product stewardships	
					F6: Security management	

Introduction of alternative energies into the Defence fuels mix impact A: Capability Requirements and B: Planning

A1: As Defence commences a transition towards adopting lower carbon alternatives, the overall composition of the Defence fuel mix and the nature in which it's supplied will need to be reshaped. **A2**: Requirements definition will expand to include decarbonisation. **A3**: Demand planning will become more complex as the proportion of energy types changes over time. **B1**: Network planning, as demand changes and supply becomes more diversified. **B2**: Inventory planning and **B3**: Supply planning will need to adapt

Changing procurement requirements through the energy transition impact C: Supply

Procurement processes will change as Defence signals to the market a desire to introduce lower emissions alternatives into its energy mix. **C1**: Sourcing and contract management and **C2**: Procurement operations may need to be adapted as end-user requirements change, ensuring existing contracts stipulate, or can be modified to include the supply of alternative energy types. New contracts and changes to existing contracts should detail the requirement to provide the predicted energy requirements within the contract timeframe. **C3**: Supply logistics will alter and expand to enable new energy providers to enter the DFSC.

Network changes impact D: Execution, E: Asset Management, F: Compliance & Assurance and G: Other Support

As Defence transitions to alternative energies, changes to the DFN will be influenced by the energy types adopted. Drop-in replacement fuels can utilise existing infrastructure without the need for modification, however, the introduction of non-drop-in replacements such as hydrogen or electric will present fundamental changes to the DFN. Warehousing and distribution systems will require upgrades to manage storage, distribution and issue requirements. Changes may include asset modifications, new infrastructure and additional training requirements across all aspects of **D**: Execution, **E:** Asset Management, **F:** Compliance & Assurance and **G:** Other Support.

Lines of Effort

The future state of Defence energy will be achieved through five Lines of Effort (LoE)

Five lines of effort have been defined which prioritise Defence effort in the medium to long term. These efforts will position Defence to maximise opportunity value as it adopts emerging alternative energies.

Understand and set future energy needs

Defence's future energy profile will change as the organisation, assets and market evolve. Defence will need to have ongoing clarity of its future energy needs to enable general planning, set achievable energy and emission reduction targets, assess fleet and infrastructure requirements and inform energy procurement requirements.

Influence the future energy industry

The alternative energy market within Australia is emerging, however current geo-political tensions have highlighted the need to drive domestic market activation to support overall energy security. Defence will influence the future energy industry and end-user requirements at both a sovereign and global scale in collaboration with Government, industry and allied partners.

Design and develop the future workforce

Defence will design the future workforce and organisation required to support and manage its emerging energy mix from transition through to sustainment. Defence will work with industry, education, and research institutions to develop training pathways that enable its workforce and the broader industry to bridge the technology gap between today's and future requirements.

Prepare the network for the emerging energy mix

Current Defence platforms and infrastructure will need to be centrally reviewed to inform compatibility with alternative energies that are not drop-in replacements, and the potential need for investment in the future for change or replacement. This encompasses the extant and planned platforms, the DFN and other key functions such as asset data management.

Develop processes for transition and establish governance

Defence will have the right level of governance and performance management in place throughout, and after, the adoption of alternative energies, including standardisation of processes for Defence energy adoption and clarity over roles and responsibilities. Considerations for non-fossil based energy will be incorporated into the ODCS.

01

Understand and Set Future Energy Needs

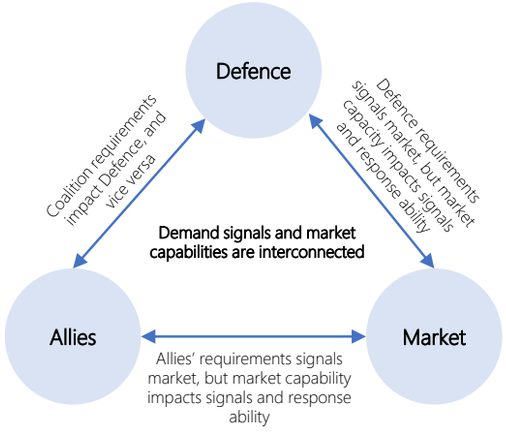
STRATEGIC INTENT

DEFENCE SHOULD HAVE A CLEAR UNDERSTANDING OF ITS FUTURE ENERGY NEEDS THAT ARE REQUIRED TO MEET ITS ONGOING STRATEGIC AND OPERATIONAL OBJECTIVES

Understand Defence's future energy needs

Understanding Defence's energy needs aligns closely to the requirements setting phase of the ODCS and requires continuous input from a broad spectrum of stakeholders. These stakeholders include coalition allies to ensure interoperability and alignment, market and industry participants to understand changing equipment requirements and availability of energy types, and Defence Groups and Services as end users (Navy, Army and Air Force and Capability, Acquisition and Sustainment Group (CASG) for acquisition and sustainment of platforms with defined energy needs.

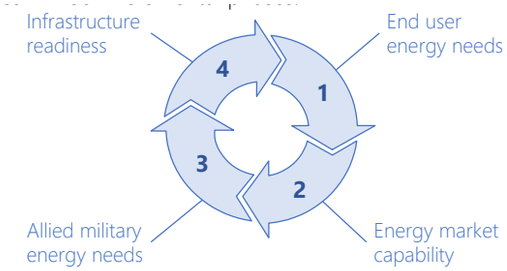
In setting future energy needs, Defence will impact the below stakeholder feedback loop.



Interoperability requirements imply that at least some of Defence's future energy needs and timing will be shaped by the future energy needs and in-train initiatives of coalition partners and vice versa. Defence future energy needs will influence market availability and capability through incentivising industry engagement and participation. However, should demand signalling be insufficient to generate enough market investment or production, Defence will be limited by market availability, which may impact or alter readily available energy types.

Similar dynamics apply to the relationship between allied military partners and the market participants and are required to satisfy future energy requirements.

Driven by this stakeholder feedback and dependency loop, Defence's understanding of its future energy needs will occur in four incremental phases:



Phase 1. Understand end user needs

Defence must have a strong understanding of its future fuel requirements. In FY20/21, Defence's total fuel consumption was ~310ML (dominated by liquid petroleum fuel), which equated to a emission footprint of ~890 tonnes CO2 equivalent.

An accurate projection of future fuel demand will enable Defence to understand the desired fuel mix, determine future alternative fuel demand and shape future carbon emissions profiles.

This clear view on future energy requirements will develop through ongoing collaboration between Defence end users and capability planners, as well as equipment and energy market participants. Once future needs are sufficiently understood, Defence will be able to make strategic and informed decisions regarding the modes and phasing of transition towards lower carbon intensive energy sources.

Phase 2. Understand the energy market

A global transition away from fossil-based fuels to less carbon intensive energy sources is underway. This is evident in the actions of the government, allied partners and commercial sector and the broader energy supply industry. These changes create a need for Defence to understand the future trajectory of the energy market, including alternative energies and the corresponding technologies, infrastructure and policy to support them. This understanding will ensure continued alignment and targeted collaboration efforts with industry.

Defence will conduct regular market scans of Original Equipment Manufacturers (OEMs) and energy producers to maintain understanding of market trends and technology developments. This will build on the existing energy assessment and transition roadmap which identifies RD, SAF, hydrogen and electrification as the most suitable and likely future energies for Defence.

The effective transition of Defence's current fuel mix, supporting assets and platforms to incorporate lower carbon intensive fuels and energy sources will require strong understanding of market and governmental influences.
Ongoing review of the transition roadmap will enable Defence to make informed decisions throughout the transition process and ensure any shifts in timeframes as a result of new technological advancements, accelerated market or allied adoption and government policy changes are immediately captured.

Phase 3. Understand broader energy needs

Maintaining collaborative relationships with international allies, partners and industry groups will ensure ongoing interoperability and continued awareness of international technological developments and global industry trends. Defence signalling intent will encourage industry and peer military alignment, collaboration and investment to meet future energy requirements.

Phase 4. Ensure infrastructure readiness (under LoE 4)

Current fuel infrastructure supports the liquid fuel needs of warfighting capability. An informed investment in strategic infrastructure is critical to sustaining and improving the resilience of liquid fuel/energy deliver and delivering enduring sustainment activities to in-service platforms. This could include Defence strategically investing in the alternative liquid fuel industry. Defence will seek to procure commercially available and viable fuel and energy sources. Defence will need to ensure the Fundamental Input to Capability (FIC) are considered to align with the strategic phasing in of future technology and infrastructure. This will support the integration of lower carbon energy sources to drive supply resilience, interoperability and ongoing sustainment.

Demand signalling

After identifying Defence's future fuel/energy requirements, Defence will leverage established communication channels and feedback loops to articulate changes in fuel and energy demand, and provide key inputs into supply management. These channels will support wider Defence innovation throughout the capability lifecycle and allow information related to fuel and energy advancements to be integrated with work that addresses capability gaps, risks, issues and opportunities. This linkage between requirement setting and operationalisation will ensure integration of technical and logistical data.

When communicating fuel and energy requirements, Defence will ensure a centralised and consistent communication approach is enacted by delegating the responsibility to a central coordinating body. The body will ensure consistent demand signalling and capability alignment throughout Defence, the Government and industry.

STRATEGIC EFFECT

DEFENCE HAS A CLEAR UNDERSTANDING OF ITS FUTURE ENERGY NEEDS AND IS ABLE TO PREPARE FOR MARKET AND COALITION CHANGES. DEFENCE IS ENABLED TO BE FORWARD THINKING, SEIZING OPPORTUNITIES TO INTEGRATE ALTERNATIVE ENERGIES INTO OUR NETWORK TO DRIVE INTEROPERABILITY, MITIGATE VULNERABILITIES AND IMPROVE SUPPLY SECURITY

02

Influence the Future Energy Industry

STRATEGIC INTENT

DEFENCE SHOULD LEVERAGE ITS UNIQUE POSITION TO INFLUENCE THE FUTURE ENERGY INDUSTRY AND, IN COLLABORATION WITH INDUSTRY, GOVERNMENT AND COALITION ALLIES, ACTIVATE AND SCALE UP AUSTRALIA'S SOVEREIGN ENERGY PRODUCTION CAPABILITY

Defence is uniquely positioned to influence the domestic alternative energy industry due to its credibility, strategic importance and focus on energy security. Defence can drive market activation through collaboration with industry, government agencies, allied militaries and other partners. Defence can disproportionately influence sovereign alternative energy production capability while supporting international energy capability.

Defence influence

The alternative energy market in Australia (and to a similar extent globally) has been active for more than a decade, but is still emerging in terms of broad market adoption, production scale and advanced manufacturing abilities. Australia currently lacks a large scale sovereign capability to supply lower carbon fuels, despite substantial domestic biofuel feedstock potential.
The global drive towards decarbonisation, sovereign manufacturing capabilities and resultant resilient supply chains potential provide Defence with a strong incentive to support the development of an sovereign fuel/energy manufacturing industry.

Defence is not a large user of fossil fuel in the context of the Australian market (~0.6%), but its criticality as a fuel user potentially carries substantial influence in establishing sovereign capability. As a capability-driven fuel user, Defence seeks to strengthen energy security and leverage opportunities to decarbonise fuel consumption. Defence is an uniquely positioned end user compared to typically commercially-driven industry users.

Defence is a major energy user of the Australian Government operations and can take initiatives to influence policy positions. Defence is a strategic ally, trusted and capable of enacting and enabling meaningful change within the policy landscape to support alternative lower carbon energy market.

Collaboration

In line with Australia's National Climate Resilience and Adaptation Strategy, Defence will leverage and build partnerships across all domains to drive coordinated action. All levels of government, the private sector, research institutions and the community need to collaborate to establish Australia's energy security which will build adaptive capability and drive persistent action.

The pathway to develop sovereign capability will require ongoing collaboration with key stakeholders. Due to the rapid evolution of the energy transition, Defence will also need to remain flexible to allow for reprioritisation based on new considerations, capability gaps and opportunities.

Government

Defence will work with other Government agencies and departments to advocate and provide support for the development and scaling up of Australia's alternative energy production capability. This will be done through inter-governmental alignment and the clear understanding of mutual benefits. Defence will leverage and build inter-governmental relationships, forums and initiatives to advocate, encourage policy discussion and collaborate to create industry incentives. Relevant agencies and departments include (but are not limited to):

- Australian Industry Capability (AIC): A sovereign alternative energy capability will build capacity and resilient supply chains. The sovereign capability will create a broader Australian security. Therefore, Defence will need to engage with AIC to explore potential support and collaborative opportunities.
- Clean Energy Finance Corporation (CEFC) and the Australian Renewable Energy Agency (ARENA): Collaboration on trials with CEFC, ARENA and commercial industry will facilitate the process from trial to commercialisation. There is opportunity to leverage the Future Fuels Program (ARENA) to conduct trials and demonstrations.
- Department of Climate Change, Energy, the Environment and Water (DCCEEW): As alternative fuels can contribute to meeting Australia's International Energy Agency (IEA) minimum stockholding requirements and bolster the electricity market, Defence will work with DCCEEW to explore increased monitoring and evaluation of stock availability and ensure alignment between civilian and Defence future fuel and energy standards.
- Other Federal, State and Territory Government organisations: A strong sovereign alternative energy industry will improve Australian capability and jobs/skills in clean technology and infrastructure development. Defence will explore collaborative opportunities on existing or new Commonwealth and State/Territory sustainability initiatives.
- Australia, United Kingdom and United States (AUKUS) Partnership: Defence can leverage AUKUS Pillar 2 to accelerate the development of lower carbon energy technologies and cohere fuel/energy requirements to deliver advanced military capabilities

Industry

Defence will need to work closely with industry partners to ensure strategic and operational energy needs are sustainably met and will seek to procure commercially available and viable fuel and energy.

Defence will lead and proactively participate in key industry groups (including public-private) and forums to influence decision making on alternative energy consumption and future industry capability. This will be done through leveraging existing Defence programs, contracts and initiatives such as the Fuel Services Contract (FSC), Advanced Strategic Capability Accelerator (ASCA) and the Australian Industry Capability Program where appropriate.

This will have the benefit of sending market signal that Defence is committed to supporting suitable lower carbon alternatives to fossil-based fuels, and will also enable Defence to have an clear understanding of market trends, technological advancements and investment activities.
Defence will work with industry to align future demand to maximise buying power and local market activation.

Defence has undertaken early stage public demonstrations of drop-in fuels trials to reinforce continued demand and commitment to alternative fuels while increasing awareness of the benefits of drop-in fuels such as SAF and RD.

Defence will also collaborate with OEMs to understand potential partnerships and investment opportunities to inform the future force design. This will enable Defence to consider its future energy needs early in the ODCS management process, leading to reduced retrofitting and enhanced transparency.

Allies

Collaboration and alignment with allies will enable Defence to maintain interoperability through continued awareness of allied military's targets, objectives and technological developments.
In particular, there is an opportunity for Defence to collaborate with the United States Department of Defense (US DoD) to lead the way in a combined energy transition agenda. The US DoD is well positioned in this area, leading fuel certification and setting the energy standard for allies.
This alignment opportunity and shared leadership in energy transition can consolidate market signalling to drive confidence. Interoperability considerations are broader than the energy type consumed, therefore, Defence and its allies will need to ensure platforms, supporting equipment, workforce capability and the relevant policies remain as complementary enablers.

Moreover, there is a potential to explore joint procurement opportunities with Defence's allies to secure more favourable contracts as a result of combined purchasing power.

STRATEGIC EFFECT:
AUSTRALIA'S ALTERNATIVE ENERGY PRODUCTION MARKET DEVELOPMENT IS ACCELERATED THROUGH PUBLIC-PRIVATE PARTNERSHIPS AND INVESTMENT. DEFENCE IS ABLE TO SOURCE ITS ENERGY NEEDS FROM WITHIN AUSTRALIA, PLACING LESS RELIANCE ON IMPORTATION TO MEET ITS DEMAND

03

Design and Develop the Future Workforce

STRATEGIC INTENT

DEFENCE WILL be STRUCTURED WITH THE ROLES AND CRITICAL SKILLS REQUIRED TO UNDERGO THE ENERGY TRANSITION AND MAINTAIN THE BUSINESS-AS-USUAL STATE

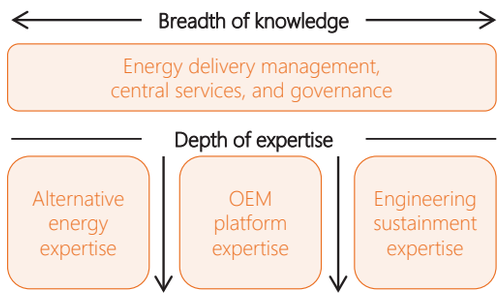
The immediate opportunities presented by the energy transition now are drop-in alternative fuels and electrification for select land and white fleet vehicles. Drop-in low-carbon fuels do not require significant changes to the existing infrastructure and workforce in near term. Defence must be prepared to adopt an emerging energy mix while maintaining and enhancing capability throughout the transition period. Defence must understand additional workforce implications with new skills for the maintenance of Defence capability using new energy technologies.

There will be a significant shift from the current business as usual of fuel procurement and provisioning. By expanding Defence's energy mix to include lower carbon intensive sources, the workforce will have an evolved purpose and must have the required skills and knowledge to ensure the energy transition is effective and adheres to existing capability needs.

Workforce structure and design

Defence will focus on structuring its workforce with a blend of generalist and specialist skillsets to meet operational requirements so that efficiency, consistency and quality through centralised management and assurance can be maintained, to ensure transition is successful. Changes to organisational structure and skill requirements will initially be minimal, but will gradually increase as long term energy alternatives that are substantially different to the current fossil fuels are adopted.

This will enable Defence to have a workforce model with the breadth of knowledge critical for strategic decision making and the depth of expertise required to execute the transition and operational employment at a tactical level.



While generalist and specialist responsibilities may be absorbed by existing positions in the short term, the long term transition will require an analysis of an expanded workforce with new lines of accountability to manage the diversified energy mix. The workforce may grow over time as the organisation transitions in phases to a new future steady state.

Leadership and ownership

Defence has not introduced a fundamentally different energy type into the energy mix since the transition from coal to crude oil. Effective implementation of the DFES will require strong leadership and ownership to ensure an effective transition supported by the entire workforce. Defence has an opportunity to shape the culture of the organisation through clear leadership, and a communication strategy which reinforces the importance of a cohesive and collaborative approach to the energy transition program.

Future workforce skills and responsibilities

The workforce will need the skills to manage a range of existing and new responsibilities. Some of these responsibilities include:

- Ongoing monitoring of the energy market, including The Government and Defence direction, allied military uptake, industry uptake and production trends
- Ongoing projections of energy requirements across a diversified fuel mix
- Target setting, projection and monitoring of carbon emissions profile
- Influencing and driving the establishment of a sovereign energy capability through collaboration, investment and demand signalling
- Management of new and/or increasingly complex contracts and supplier relationships
- Delivery of alternative energies to Services and Groups, ensuring capability is maintained and enhanced.

Workforce planning

Defence will invest in identifying personnel with strategic acumen to become effective and influential through the energy transition. This will help ensure skilled personnel are allocated to capability enhancing functions and foster the growth of an intelligent, curious, skilled and strategically-aware workforce. The workforce will be empowered to enable activities across the energy delivery system. These activities could be conducted by a body tasked with managing Defence's energy transition.

Responsibility for Defence Fuel Installation (DFI) operations and maintenance activities, fuel supply and strategic inventory and asset management is managed through strategic industry partnerships. The redundancy of these functions could be utilised for their detailed understanding of the assets and operations network to adopt lower carbon energy types. Additional workforce investment will be required to develop the complex skills needed to manage the Defence future energy environment.

Once the longer term energy transition begins to slow and the Defence energy mix reaches a steady state, the organisation will need to reassess the workforce needed to maintain Business As Usual (BAU) activities.

A business plan will need to be developed seeking initial funding to prepare the workforce to meet emerging energy requirements.

Workforce training

While new personnel will be required for long term due to technical, educational and certification requirements for specific alternative energy types, some of the requisite skills needed can be attained by upskilling and training the existing workforce.

Generalist and leadership training will be provided to ensure that a future focused, energy type literate and energy transition conscious culture is fostered across Defence. As emerging technologies become increasingly commercial, Defence will leverage universities (including the University of New South Wales (Australian Defence Force Academy) – UNSW-ADFA) to provide education and qualifications to shape Defence's technical expertise with the skills to navigate and shape the new capability effects. Areas of expertise with key value include alternative liquid fuels, hydrogen, nuclear and electric propulsion.

This will lead to the resilient, sustainable, and future focused workforce needed across the energy delivery network.

STRATEGIC EFFECT:

DEFENCE HAS THE LINES OF ACCOUNTABILITY, SKILLSET AND CAPACITY TO ADOPT, MANAGE AND DELIVER ALTERNATIVE ENERGIES THROUGHOUT THE ENERGY TRANSITION AND INTO THE NEW ENERGY FUTURE

04

Prepare the Network for the Emerging Energy Mix

STRATEGIC INTENT

DEFENCE will deliver, MANAGE and maintain alternative energies by A CENTRALLY CONTROLLED APPROACH TO identification AND INVESTMENT in EMERGING AND supporting technologies and infrastructure within the DEFENCE ENERGY network

The DFN will be faced with evolving energy requirements throughout the transition, and these changes cannot risk or impact continuity of support to ADF warfighting capability.
The transition must be centrally controlled to ensure interoperability, minimise complexity and maximise compatibility of energy sources. Significant investment in technology and network infrastructure is required to deliver and support the use of the future energy mix by end users, hence the removal of duplicate energy sources will be a key driver. New infrastructure and systems to store and maintain a range of new energy technologies and products must be 'Joint by Design'.
Defence must be prepared to adapt the deployment of existing assets and adopt rapid advancements in technology and infrastructure in parallel with the introduction of alternative energy types.

Embracing future network technology

Embracing innovation, conducting independent research, undertaking pilot studies and demonstrating the successful use of emerging technology are imperative to remaining competitive in a rapidly evolving strategic environment. Early investments in pilots are critical catalysts to integrating high potential alternative energies into the Defence energy mix.

As part of Lines of Effort 1, 'Understand and set future energy needs', Defence will monitor emerging technologies including energy types and propulsion systems to ensure it is ready to capitalise on energy opportunities as they arise. This will allow Defence to enhance capability in anticipation of government requirements and evolving threat environment.

Sovereign capabilities in critical areas have been highlighted or reassessed following the impact of the COVID-19 pandemic on global supply chains, rising geo-political tensions in the region and surging crude oil prices. Defence must embrace new sovereign energy technologies to reduce its reliance on oil imports and increasingly vulnerable lines of supply.

Defence must identify its future technology requirements and leverage relationships with

allies, the Government, industry and research organisations to prioritise where best to dedicate finite resources to build long term energy security and resilience.

Modifying existing network infrastructure

With the adoption of drop-in lower carbon alternatives such as SAF and RD which do not require infrastructure change, there is an opportunity to immediately incorporate the use of these fuels with existing infrastructure across the DFN.

However, as Defence transitions to other alternative energy types and begins to adopt new technology, the existing DFN must be modified to support an energy mix which will transition away from fossil-based fuels or lower-carbon drop-in alternatives. In loner term, future energy mix may include solid state power and gaseous energy sources which may require new infrastructure for storage, distribution and consumption. The means and scale of the transition will be determined by infrastructure assessments to ensure capability is maintained.

Shaping existing programs

Defence will conduct detailed infrastructure impact assessments across the entire DFN before the adoption of alternative energies to develop investment and implementation plans for site modifications. This will help ensure Defence is prepared to deploy integrated alternative energy at scale, when and where required. These recommendations will inform and shape current projects such as the Defence Fuels Transformation Program, the Estate Works Program and the Integrated Investment Plan.

STRATEGIC EFFECT:

DEFENCE IS ABLE TO EFFICIENTLY, EFFECTIVELY AND SAFELY SUPPORT AN EMERGING ENERGY MIX ENABLED BY A FUTURE FOCUSED AND ADAPTED ENERGY DELIVERY NETWORK

05

Develop Processes for Transition and Develop Governance

STRATEGIC INTENT

DEFENCE WILL DEVELOP FUTURE STATE PROCESSES TO MANAGE, GOVERN AND DELIVER THE TRANSITION TO ALTERNATIVE ENERGIES AS PART OF THE BROADER DEFENCE FUEL MANAGEMENT SYSTEM AND DEFENCE FUEL SUPPLY CHAIN ASSURANCE FRAMEWORK

During the transition, Defence will need to ensure the establishment of appropriate governance mechanisms and processes to support and manage the future energy mix. This will ensure transparency and accountability is maintained across the energy management system.

Define governance structure

Defence fuel network operations are governed by the Defence Fuel Management System (DFMS), an integrated management system enabling all components of the DFSC to realise the immediate and evolving fuel requirements of Capability Managers and joint operations.

A clear governance framework is required to support the energy transition. Accordingly, Defence will need to ensure all relevant business units within the organisation have clearly articulated and understood roles and responsibilities.

This includes end users such as Navy, Army and Air Force, through to those managing capability regulation frameworks, such as Sea, Land and Air worthiness. As transition occurs, Defence should revise existing governance mechanisms and oversight responsibilities to support current and future energy systems. The revised governance structure will include functional accountability for performance management and will be supported by the organisational structure and workforce capabilities achieved through Lines of Effort 3. The revised governance structure will need to balance effectiveness, efficiency and resilience throughout the transition process.

Defence has not previously introduced a fundamentally different energy type into its energy mix since the transition to liquid fuels, effective change management mechanisms

will be needed to ensure the new governance arrangements are appropriately communicated and supported.

Defence will need to make strategic decisions on how best to make use of existing governance frameworks and forums to manage both the energy transition itself and future sustainment systems. Defence may leverage and adapt existing mechanisms such as the Defence Fuel Board to ensure the right level of governance and assurance arrangements is in place to manage the DFMS, drive the implementation of energy transition initiatives and embed a culture of continuous improvement in the future energy system.

Defence stakeholders will work with Fuel Services Branch and service providers to ensure appropriate representation at governance forums occurs to help govern the Defence energy network across fixed and expeditionary fuel capabilities. Defence will explore ways of working with FSC service providers to deliver the best value-for-money outcomes.

Define and monitor performance

Successful energy management requires a coordinated approach facilitated by the interaction between the various key stakeholders through effective governance arrangements. Defence will design and implement an energy transition performance management framework and metrics to enable evidence based evaluations of performance.

The full integration of Navy, Army and Air Force within the performance framework will include effective consultation to ensure processes and performance measures are appropriately tailored. Groups and Services will also implement tailored mechanisms and measures to assess the maintenance/enhancement of capability through the energy transition and into steady state sustainment.

To enable the monitoring of Defence energy management, a performance dashboard will be developed to ensure transparency for all stakeholders and decision makers involved in the end-to-end energy management value chain.

The appropriate data and enabling technology will be in place to support the measurement of performance in Defence's energy adoption and management.

Design future energy processes

The progressive adoption of lower carbon intensive fuels requires the establishment of future state processes to manage and deliver the transition. Defence will review and adapt existing processes to ensure a smooth transition, including the processes for:

- Certifying specific lower carbon intensive fuels: Certification and management of alternative fuels through a consistent portfolio wide process will provide individual capability managers with the confidence to endorse the revision of fuel standards. This process of certification could include ASTM International standards or the development of fit for purpose assessments to ensure safety and compliance in the adoption of alternative fuel types.
- Administering future fuels: An iterative process for administering future fuels should be adopted to afford Defence with the flexibility to review, adapt and improve the process as needed.
- Improving energy efficiency: Defence will undertake a lifecycle cost/benefit assessment of its facilities and infrastructure to identify potential energy efficiencies to be gained through the introduction of wind turbines, solar power, hydropower and/or other energy efficient mechanisms where appropriate. Defence will conduct an audit of current infrastructure and processes to determine whether energy gains can be made. Future platforms should be as energy efficient as possible without compromising their effectiveness. Energy efficient products will be managed as far as possible with regard to environmentally sound principles that are supported by extant policy.
- Acquisition: Defence will undertake an acquisition impact assessment to ensure sufficient understanding of the acquisition needs of adopting alternative energy types. This will include consideration of storage, usage and the environment.

- Sustainment: Existing sustainment processes must be tailored and adapted to the alternative fuel types to ensure lifecycle optimisation and to avoid unpredictable sustainment costs.
- Risk management: Existing risk management processes must be tailored and adapted to alternative fuel types to ensure risks are captured and appropriate risk-mitigation techniques are implemented.

Defence will embed the adaptive processes required for the transition, ensuring safety and regulatory compliance. There will be a focus on defining, measuring and tracking performance through clear governance arrangements to provide assurance of the energy delivery network.

Facilitate cultural change

Defence-wide leadership and cultural training, highlighting the importance of alternative energy adoption and the need for a sovereign energy capability will educate Defence's workforce, generate buy-in for the transition to alternative fuel types and support change management.

Similarly, review and alignment of Defence's internal corporate policies and targets will send signals to the workforce to reinforce the importance of alternative energy sources and a consistent approach to enhancing energy resilience.

Define funding requirements

Funding for fuel is currently allocated through Defence Group and Service budgets. Initially, the price for alternative energies, such as RD and SAF, will be higher than traditional energy sources. The energy transition may impact how funding is managed, requiring review and redesign of current funding management processes. Defence will need to ensure the Defence energy network has sufficient funding to meet agreed energy needs.

STRATEGIC EFFECT:

DEFENCE WILL HAVE CLEAR EFFICIENT PROCEDURES FOR THE ADOPTION AND DELIVERY OF ALTERNATIVE ENERGIES WITH CONFIDENCE IN MEETING CAPABILITY AND PERFORMANCE REQUIREMENTS WELL INTO THE FUTURE

Background

Background

Defence will be expected to play a leading role in delivering the Government's commitment to net-zero carbon emissions by 2050

In 2022, the Australian Government has legislated Climate Change Act 2022 to reduce Australia's net greenhouse gas emissions to zero by 2050.[1] With the net-zero by 2050 commitment Australian Federal Government joined the alliance with over 70 countries.[2]

As the Federal Government's largest fossil fuel consumer, Defence will be expected to play a leading role in delivering the Government's commitment to net-zero carbon emissions by 2050. While Defence does not consume a significant portion of Australia's overall fuel demand (0.6%)[3], its influence is significant given the criticality of energy as a key capability enabler. However, this proportion may change as other sectors transition away from fossil fuels to meet decarbonisation commitments.

The ADF has no industry peer in Australia, where mission failure could be catastrophic for Australia's security. The ADF should investigate and learn from its near-peer militaries to reduce carbon emissions whilst maintaining operational capability. Of course, there are many domestic heavy industries, e.g. mining, road transport and aviation, which the ADF should forge strategic partnerships with to harvest knowledge and accelerate the appropriate adoption of low emissions technology.

Global market trend examples

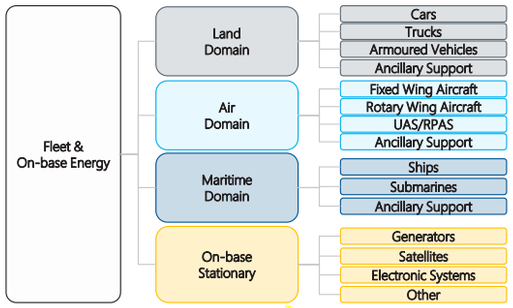
Fuel suppliers	Major oil companies are making transitions to decarbonise. Shell is targeting net-zero carbon emissions by 2050. Approximately 9.1 billion litres of biofuels formed part of international oil major Shell's global petrol and diesel supply in 2021, with continued investment in production and supply of biodiesel, bioethanol, renewable natural gas, RD, SAF, and fuel-cell to help lower carbon emissions from transportation.[4] BP has also set a net-zero carbon emissions target by 2050, and is active across multiple alternative energy activities, such as forming a joint venture that combines BP and Bunge's Brazilian bioenergy and sugarcane ethanol businesses.[5] In addition to these companies, there are a large number and diverse array of other companies trending towards the production of SAF and renewable diesel in the US, EU, UK and Asia.
Mining	Major mining organisations such as Fortescue Metals Group (FMG) are focussing on the development of battery and hydrogen-powered equipment and large-scale electrification. FMG has set a carbon neutrality target of 2030,[6] whilst BHP and Rio Tinto have set net-zero carbon emission targets by 2050, with interim milestone targets.[7] [8]
Commercial Aviation	Qantas and Virgin Australia have committed to achieving net-zero emissions by 2050. Qantas announced targets of 10% (2030) and 60% (2050) SAF uptake in the Group's fuel mix, executed SAF supply agreements and committed AUD$50 million to help establish domestic SAF production.[9] Qantas and Airbus recently announced up to US$200 million investment to accelerate a SAF industry in Australia. The agreement will see investment in locally developed and produced SAF and feedstock initiatives. Currently, Qantas sources SAF from the UK and US, but has identified that local production is required to meet its emissions targets.[10]
Aerospace	Boeing achieved net-zero carbon emissions in its operations in 2020[11] and has committed to deliver commercial aircraft capable and certified to operate on 100% SAF by 2030.[12] Airbus has committed to net-zero carbon emissions by 2050, aiming to develop the world's first zero-emission hydrogen propelled commercial aircraft by 2035.[13] Airbus aims to achieve certification of 100% SAF by 2030 and is currently conducting trial flights with 100% SAF.[14] Lockheed Martin has committed to reducing carbon emissions per dollar gross profit by 70% by 2030[15] and in 2021, its longstanding Go Green program delivered $22.5 million in energy use cost avoidance compared to 2016.[16]
Shipping	The International Maritime Organisation Initial Strategy, released in 2018, focuses on lowering CO^2 intensity by at least 40% by 2030 and pursuing efforts towards 70% by 2050 compared to 2008 levels.[17] Based on this strategy, key industry participants, such as Shell, have begun working with shipping customers and partners to help accelerate decarbonisation in this sector.[18]
Integrated logistics	DHL Group has announced an accelerated roadmap to decarbonisation across their land, air and shipping operations towards net-zero by 2050, including operating 70% of its own first and last mile services with clean pick-up and delivery solutions (e.g. Electric Vehicles or EVs) and investing €7bn in climate-neutral logistics out to 2030.[19]

Current Defence Energy Landscape

The Government commitment to reduce carbon emissions presents capability and sustainment opportunities due to Defence's largely fossil fuel based energy mix

Defence capability

Defence assets and platforms rely on ongoing and enduring energy supply to deliver Defence's mandate to defend Australia and its national interests. Defence's capability types can be broken down by domain as follows:



Energy mix and consumption

Defence's total fuel consumption in FY20/21 was ~310ML.[3] The current Defence energy mix predominantly consists of liquid fossil fuels centred around the three broad fuel categories of aviation fuel, Marine Diesel Fuel (MDF) and Automotive Diesel Fuel (ADF). These three fuel types account for almost 98% of total Defence fuel demand, which is expected to grow by ~23% over the next 30 years.[20]

Fuel Category	FY20/21 Consumption (ML)	Proportion
Jet Fuel	227.3	72.5%
Marine Diesel	66.2	21.1%
Automotive Diesel	18.4	5.9%
Unleaded Petrol	0.7	0.2%
Other fuel grades	1.1	0.3%
Total	313.7	100%

While Defence fuel consumption is a fraction of total domestic demand, the high level of importance placed on national security and the critical impact to capability which would be caused by disruption justify increased focus on establishing and maintaining a secure energy supply.

Carbon emissions profile from direct consumption

From its energy consumption (scope 1), Defence's total carbon emissions in FY20/21 were approximately ~889,636 tonnes of CO^2 equivalent. [21] While total Commonwealth Government emissions data is not readily available, comparable Defence forces typically represent 50-80% of total Government emissions, illustrating the scale of Defence's contributions to emissions. [22] [23] Of Defence's total carbon emissions from direct energy consumption, the Air domain contributes the greatest proportion, making up 66% of total emissions, with Maritime and Land accounting for only 28% combined. Fuel consumed on-site by equipment for Defence Groups accounts for the remaining 6% of scope 1 emissions.[21]

Domain	FY20/21 Scope 1 Emissions (tCO2-e)	Proportion
Air	587,322	66%
Maritime & Land	248,002	28%
On-site	54,312	6%
Total	889,636	100%

Carbon emissions profile from indirect consumption

Defence domains account for most direct scope 1 emissions. In contrast the Defence estate accounts for all scope 2 emissions, totalling 722,123 tCO^2-e exclusively from the consumption of electricity generated from fossil fuel. The *'Defence Net-Zero Strategy'* (DNZS) developed by Security and Estate Group (SEG) will focus on an Estate led approach to reduce emissions from Defence Estate. It includes plans to move secure and reliable renewable energy, and install micro-grids on all major bases as part of its net-zero by 2050. DNZS is complementary to the DFES in part due to the predicted future reliance on battery and EV technology in future Defence platforms.

The opportunity for Defence

One of the ways that Defence can progress towards the Federal Government's net-zero carbon emissions by 2050 target is to challenge the composition of its current fuel mix by assessing and adopting less carbon intensive alternative fuels and energy sources into its assets and platforms.

The alternative energy market is evolving and with the current national focus on energy security and prices, there is an opportunity for Defence to influence which energies are produced (type and specifications), where they are produced (strategic locations), and how they are produced (pathways). The impending transition presents a number of opportunities for to Defence:

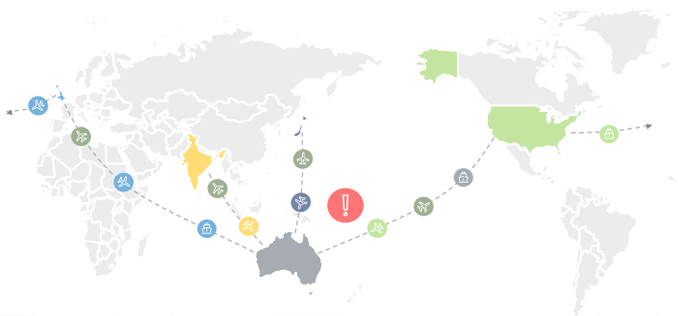
- collaborate on the adoption of alternative energies with military allies and industry to overcome the challenge of compromised interoperability
- strengthen our national energy security and sovereign energy production capabilities
- maximise value-for-money by transitioning from increasingly expensive fossil fuels in longer term to increasingly more commercial lower carbon alternatives
- enhance capability and link future energy adoption to the One Defence Capability management, transitioning away from fossil-based fuels which will have limited availability in longer term.

Strengthening Interoperability

The energy transition presents a significant and immediate risk to Defence with maintaining interoperability with its key military alliances

With the US, UK, India and Japan have all commenced their energy transition by investing in and piloting the use of alternative energies in their platforms. In September 2021, AUKUS, a trilateral security pact between Australia, the United Kingdom and the United States was announced for the Indo-Pacific region. Under the partnership, the US and UK agreed to assist Australia in acquiring nuclear-powered submarines. Existing alliances such as the Five Eyes Alliance, and the Indo-Pacific focused Quad partnership have focused on intelligence-sharing and broader regional collaboration. A Joint Leader's Statement released by the White House states that AUKUS '… in particular, will significantly deepen cooperation on a range of security and defence capabilities…'[24], emphasising the importance placed on opportunities to enhance interoperability within the alliance. Australia has previously signalled joint intent and demonstrated its ability to use alternative energy sources participating in the Great Green Fleet Demonstration in 2012. Defence signed a standing statement of cooperation on alternative fuels with the US Department of Defense and flew a Seahawk helicopter on a SAF blend. In 2016, RAN destroyers participated in the Great Green Fleet RIMPAC exercise running on a renewable F-76 blend.

Defence has an opportunity to invest in and enhance interoperability with its alliance partners by undergoing a collaborative transition, ultimately enhancing joint capability. Failure to pursue a joint energy transition aligned to our military allies exposes Defence to significant interoperability risks during joint operations, supporting infrastructure being non-interchangeable and unfit for purpose, as well as misaligned technical, certification and specification positions.



Investments and pilot studies conducted by our allies with alternative energy types such as hydrogen, SAF, and RD may leave Defence vulnerable due to the exclusive fossil fuel-based suppliers, operations, assets and systems across the DFSC.

United Kingdom Ministry of Defence

- In 2020, the UK Army began testing hybrid technology on the Army's MAN SV Foxhound and Jackal vehicles following a £7m MoD investment.[25]
- In 2021, the UK Army launched their 2025 Strategy[26] with a focus on deploying electric batteries, sustainable energy and hybrid electric drive technologies across its entire vehicle fleet.[27]
- In 2021, the UK MoD released its *Climate Change and Sustainability Strategic Approach* signalling a call to action.

United States Department of Defense

- In 2016, the US Navy celebrated a full year of the Great Green Fleet using 77 million gallons of renewable F-76 in their Third and Second Fleets. Additionally, they used various energy conservation measures (ECMs) to reduce their total energy consumption.[28]
- Since 2017, US has been developing four hydrogen fuel cells technologies which include Unmanned Aerial Vehicles, Unmanned Undersea Vehicles, Light-duty trucks, and wearable power systems.[29]
- In 2021, the US DoD released their Climate Adaption Plan acknowledging the risk posed by climate change.

India Ministry of Defence

- India's Department of Biotechnology has been promoting R&D in Sustainable biofuels including Sustainable Aviation Fuel.[30]
- In 2021, Indian Ministry of Petroleum and Natural Gas (MoPNG) and the US Department of Energy (DoE) announced the launch of the India-US Task Force on Biofuels.[31]

Japan Ministry of Defense

- In 2020, Japan's "Green Growth Strategy through Achieving Carbon Neutrality in 2050" was released. It noted "Carbon Recycling" technology which utilises CO_2 as a resource, of which Japan is expected to be world-leading.[32]
- In 2021, Japan released a Defense white paper, noting efforts by the Defense Ministry and the Self-Defense Forces to introduce renewable energy.[33]

Establishing Supply Security

Currently, Australia is dependent on imported fossil-based fuel. Resource depletion and lines of supply disruptions leave Defence vulnerable

Meeting future Defence energy requirements

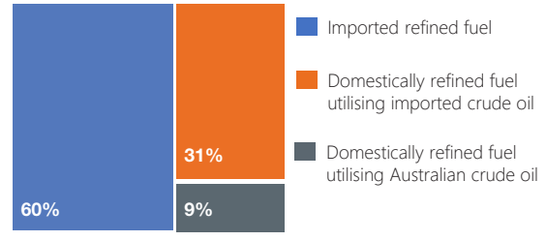
The Defence energy mix is currently derived entirely from crude oil, a globally depleting commodity. While predictions vary, the US Energy Information Administration (EIA) Annual Energy Outlook (2021) states that by 2040, cheap and accessible crude oil sources will begin exhausting before becoming entirely depleted by 2065.[34] This will result in significantly more expensive operations to extract oil in deeper reservoirs, only made economically viable as the price of oil rises.

As Defence's capability requirements grow, fuel demand is forecast to steadily rise in parallel with declining oil reserves. If current fossil fuel-powered capabilities are sustained, Defence may be faced with several challenges including unpredictable sustainment costs and the need make to make potentially capability compromising decisions on prioritising fuel use. This highlights the importance of maintaining alignment with industry and securing an ongoing supply of alternative energy beyond the exhaustion of crude oil in maintaining long-term Defence capability.

High reliance on imports & vulnerable supply chains

Defence is highly reliant on continuous 'just-in-time' fuel imports to satisfy its needs. In 2018, 60% of Australia's national fuel supply was imported, with the other 40% refined domestically. Of this 40%, only 22% was produced from Australian crude oil. This equates to 91% of total Australian fuel supply being import reliant, with only 9% being fully supplied through sovereign production and crude oil supply.[35]
Note: of the four refineries operating in 2018, two have since closed.

Import and domestic proportions of Australian fuel supply



Defence's reliance on fuel imports places a significant level of importance on Australian supply chains which are now becoming increasingly vulnerable, presenting risks to energy security and capability. Fuel supply chain disruptions, whether man made or natural, appear more likely considering the COVID-19 pandemic, the current conflict in Ukraine and increasing tension in the Indo-Pacific.

Sovereign energy capability in Australia

Australia is one of the only nations in the developed world with no mandated minimum reserves of liquid fuel for an emergency (a Minimum Stockholding Obligation is legislated). In April 2020, Australia announced the Government would establish a national oil reserve by spending $94 million to purchase 30 million barrels of crude (3 days of national supply) to be stored in the US for an initial period of 10 years.[36] While this oil is overseas, it counts towards Australia's International Energy Agency 90-day stockpiling commitment, a commitment the nation has struggled to meet. The need to store this reserve overseas exposes Defence to the risks associated with a lack of sufficient sovereign storage capacity.

Furthermore, Australia once had well established domestic crude oil refining industry, which is in steady decline. With the Australian Government $250m funding announcement in 2022, the last two domestic oil refineries i.e. Ampol's Lytton Refinery and Viva Energy's Geelong plant will operate to maintain Australia's sovereign crude oil refining capability until at least 2027.[37]

With insufficient storage capacity (particularly for aviation fuel) and a compromised refining capability, Australia currently lacks the sovereign capability to provide a reliable supply of petroleum-based fuel to Defence in the event of supply chain breakdowns.

An opportunity to invest in alternative energy

Countries around the world are now moving away from centralisation to sovereign manufacturing, seeking to move production closer to consumption to create supply security. Despite substantial domestic biofuel feedstock potential, Australia currently lacks the sovereign capability to produce alternative fuels. Defence has an opportunity to influence the establishment of an Australian alternative energy industry through its fuel demand, investments, and existing government partnerships, which in turn will enhance Defence's overall energy security. Defence has the opportunity to invest in and catalyse the establishment of a sovereign capability to supply alternative fuels and energy, utilising Australia's substantial domestic biofuel feedstock.

In longer term, fossil-based fuels may be unable to support all Defence capability. A high reliance on imported fuels and increasingly vulnerable supply chains reinforces the need of sovereign alternative energy manufacturing and distribution capability through greater industry partnership.

Ensuring Value-for-Money

Inaction comes with potential financial consequences for Defence, including potential pricing premiums, avoidable asset refit costs, and carbon offset costs

Uncertainty and dependencies

As governments and markets move towards less carbon intensive energy sources, Defence faces increasing financial costs if it does not keep up with the global energy transition trajectory. The financial significance of inaction remains uncertain, due to the dependency on the speed and manner in which the government and market responds to the net-zero target, and the multiple feedback loops within the energy landscape.[38]

In addition to unpredictable future policy responses and varied market appetite towards targeting net-zero emissions, technology also remains an uncertain dependency. Advances in renewable technology could lower the cost of alternative lower carbon energy and speed up the transition away from carbon intensive energy sources, whereas negative emissions technology could enable continued use of carbon intensive energy sources whilst producing net-zero emissions.[39]

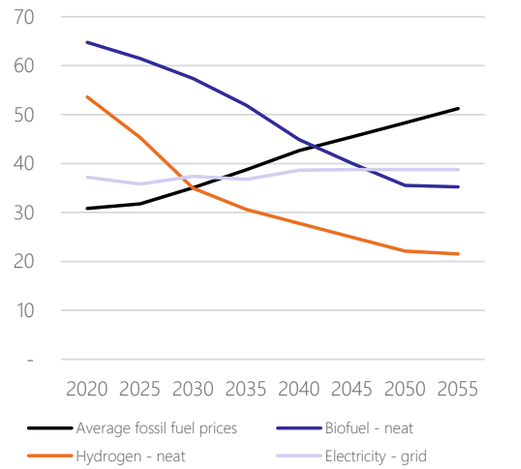
Modelling was conducted to assess the impact of adopting alternative fuels on Defence's total costs to procure fuel. Under a moderate scenario, adoption of alternative future fuels will result in a higher cost in the short to medium term. Projections indicate that from 2045, Defence will start to see direct energy and fuel costs decrease compared to the continued sole reliance on fossil fuels. This is a result of the expected fall in price of future fuels as technologies and uptake increases and crude oil prices rise in the long-term as supply depletes.

Trajectory away from fossil-based fuels

Currently, Australia does not levy an explicit carbon price.[40] Fuel excise taxes, an implicit form of carbon pricing, covered 22.4% of emissions in 2021, remaining unchanged since 2018.[41] Despite the absence of a national carbon tax, Australia will be impacted by any carbon tariffs introduced at a global scale, including the EU border tariff (Carbon Border Adjustment Mechanism - CBAM) which will be phased in from 2023. Following the CBAM introduction, it is likely that many of Australia's key trading partners, including the US, UK, Canada and Japan, will also follow suit.[42] In addition, increased competition for carbon offsets may put pressure on costs as industries that are difficult to decarbonise resort to carbon offsets to achieve net-zero by 2050.

Indicative alternative and fossil-based fuel pricing

Average indicative price of alternative fuels compared to fossil fuels



Maximising long term value-for-money

Using an illustrative guide of the projected fall in price of future fuels and the expected rise in crude oil prices in the long-term, we expect that Defence will overall benefit from alternative future fuels adoption due to lower long term fuel costs, despite facing higher short to medium term costs.

Impact on Defence from availability of fossil fuels

Operating Costs

- As the global price of oil increases, Defence will be faced with significantly higher operating costs for fossil fuel consuming capability.
- If net-zero emissions is achieved through carbon-offsets rather than adopting renewable energy sources, there will be offset costs associated with the transition.
- Increased operating costs may result in mandatory reduced operating hours (e.g. sea days) across these capability types; with strategic trade-offs required between critical platforms to achieve Service missions.
- As the largest consumer of fuel, Air Force is most likely to be impacted.

Acquisition Costs

- The viability of acquiring future fossil fuelled capability is likely to come under increasing scrutiny as global oil reserves continue to deplete and the costs of oil procurement continue to escalate.

Sustainment Costs

- As the global price of oil increases, Defence will be faced with a number of strategic choices for sustainment of fossil fuelled capability which, if not addressed, may include reduced activity periods or lay-up of platforms which compromises capability outcomes.

The Defence Future Energy Strategy

The DFES seeks to ensure Defence is prepared to capitalise on the opportunities associated with the energy transition

The Defence Future Energy Strategy

Defence must ensure it is well-positioned to capitalise on the opportunities presented by the energy transition under the context of both national and international commitments to achieve net-zero carbon emissions by 2050. Defence is compelled by the *Defence Climate Change Policy* to act now and prepare for the inevitability of a carbon-restricted future. While crude oil reserves face depletion from ~2065, the opportunities to enhance capability and address the risks of inaction exist not only in the long term, but can also be seized in the immediate term.

Defence will need to ensure it can maintain its capability while supporting the Australian Government's commitment to reducing emissions by adopting less carbon intensive energy sources. The transition towards alternative energies will not only reduce Defence's carbon output, but it will enhance capability ensuring that Australia remains interoperable with its key military allies. Defence can overcome the growing challenges associated with energy supply security and the rising costs of conventional fossil fuels and turn this into an opportunity.

The DFES defines the vision and mission for the future state of Defence energy, and the lines of effort required to realise that vison and mission. The DFES targets the following key outcomes:

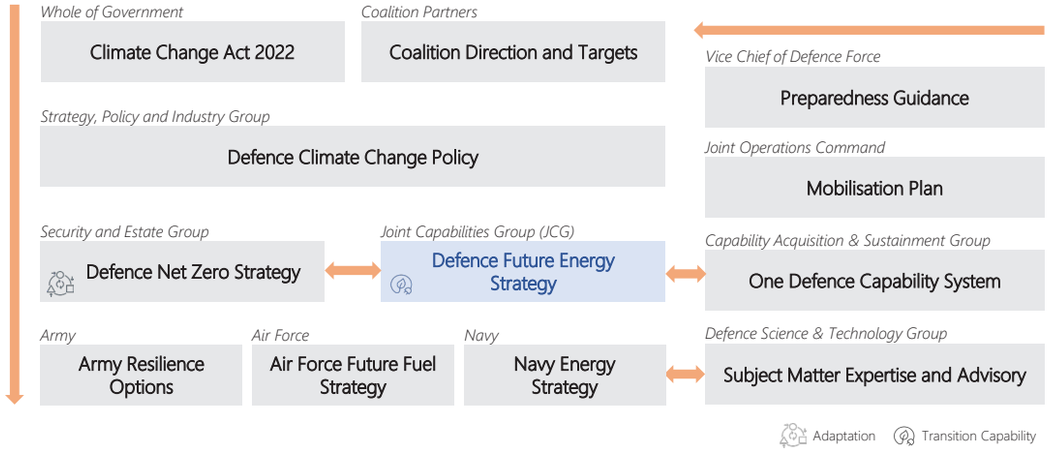
To ensure Defence enhances or maintains capability and interoperability with its allies and partners

- To prepare Defence to respond to the global energy transition journey in the short, medium and long term
- To retain and enhance the resilience of the Defence liquid fuel-consuming fixed and moveable infrastructure, and fleet as it looks to sustain its Force and capability throughout the energy transition
- To mitigate risks and seize opportunities that will emerge in transition.

The DFES Policy architecture

The DFES Policy Architecture diagram identifies the existing policy which the strategy nests within.

- The Defence Climate Change Policy was the original catalyst for the DFES development and sets the overarching direction for the strategy
- The DFES plays a complementary role to the SEG-owned DNZS, which focuses on adaption as opposed to transition
- The energy strategies of Defence Services will be directly informed by the DFES, and will be implemented and co-ordinated centrally via Joint Capabilities Group
- JLC-Fuel Services Branch is the single point of accountability for liquid fuel supply and management in Defence, and therefore CJLOG (as HDFSC) has been identified to take on the role of energy sponsor and owner of the DFES.



Glossary | Definitions

ASTM	The standards development organisation called ASTM International.
Biodiesel	A diesel fuel obtained by the esterification of oil derived from plants or animals.
Marine Diesel Fuel (MDF)	A paraffinic diesel used for the engines of HMAS ships. Also referred to as MDF, SOLAR, Marine Gasoline, and Marine Gasoil.
Renewable Diesel	Liquid fuel that is manufactured by chemically altering and hydrotreating (or equivalent) vegetable oils, animal fats, organic waste and other biomass, but also includes non-organic waste that cannot be reasonably recycled. It is not directly made from any fossil fuel.
Synthetic Diesel	Paraffinic diesel manufactured by chemically altering any feedstock. Also called Synthesised Paraffinic Diesel.

Glossary | NATO Fuel Types and ADF Equivalents

Category	NATO Code	Australian Equivalent	Description
Aviation	F34	F34	Primary aviation fuel used by Australian Defence used by land based military gas turbine aircraft. A military kerosene based aviation fuel with military additives, including fuel system icing inhibitor (FSII) and corrosion inhibitor/lubricity improver (CLI) . Also referred to as AVTUR/FSII or JP-8. F34 = F35 + additives.
	F35	F35	A military kerosene based aviation fuel equivalent to that used by most civil aviation operators of gas turbine aircraft. Also referred to as JET A-1 or AVTUR.
	F44	F44	Military high flashpoint kerosene type aviation fuel with FSII used by ship borne military gas turbine engine aircraft. Also referred to as AVCAT/FSII or JP-5.
Ground	F67	ULP	Unleaded petrol (gasoline) used in spark ignition engines. Interchangeable with commercial gasolines (95 RON)
	F54	ADF	Primary ground fuel used by Australian Defence. Military diesel fuel used in compression ignition engines. Also referred to as Diesel Fuel Military of DF-2.
Naval	F76	MDF (ISO 8217)	Primary naval fuel used in NATO. Australian Defence uses Marine Diesel Fuel equivalents but may also operate on F76. Also referred to as 'Fuel, Naval Distillate'.
	F44	F44	Military high flashpoint kerosene type aviation fuel with FSII used by ship borne military gas turbine engine aircraft. Also referred to as AVCAT/FSII.

Drop-in Jet Fuel Blend - A substitute for conventional jet fuel, that is completely interchangeable and compatible with conventional jet fuel when blended with conventional jet fuel. A drop-in fuel blend does not require adaptation of the aircraft or engine fuel system or the fuel distribution network, and can be used "as is" on currently flying turbine-powered aircraft.

Drop-in Jet Fuel Neat - A substitute for conventional jet fuel, that is completely interchangeable and compatible with conventional jet fuel. A drop-in neat fuel does not require adaptation of the aircraft/engine fuel system or the fuel distribution network, and can be used "as is" on currently flying turbine-powered aircraft in pure form and/or blended in any amount with other drop-in neat, drop-in blend, or conventional jet fuels.

Jet A-1 - Jet A-1 is a kerosene grade of fuel suitable for most turbine engine aircraft. It has a flash point minimum of 38°C and a freeze point maximum of -47°C.

Glossary | Abbreviations

AUKUS	Trilateralsecurity pact between Australia, the United Kingdom, and the United States
ADF	Australian Defence Force (‘Defence’)
ADF	Automotive diesel fuel
AIC	Australian Industry Capability
ARENA	Australian Renewable Energy Agency
AVCAT	Aviation Carrier Turbine
AVTUR	Aviation Turbine Fuel
BAU	Business as usual
CASG	Capability Acquisition & Sustainment Group
CBAM	Carbon Border Adjustment Mechanism
CEFC	Clean Energy Finance Corporation
CIC	Critical Infrastructure Centre
CJLOG	Commander Joint Logistics
CLC	Capability Life Cycle
CLCM	Defence Capability Lifecycle Management
CNG	Compressed natural gas
CO2e-	Carbon dioxide emissions equivalent
COP26	26thUN Climate Change Conference of the Parties
CRC	Cooperative Research Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DCDRP	Defence Climate and Disaster Resilience Policy
DFES	Defence Future Energy Strategy
DFI	Defence Fuel Installation
DFMS	Defence Fuel Management System
DFN	Defence Fuel Network
DFNMC	Defence Fuel Network Managing Contractor
DFSC	Defence Fuel Supply Chain
DISER	Department of Industry, Science, Energy and Resources (AU)
DNZS	Defence Net Zero Strategy
DoD	Department of Defence (US)
DoE	Department of Energy (US)
EIA	Energy Information Administration (US)
EV	Electric Vehicles
Five Eyes Alliance	Intelligence alliance between Australia, Canada, New Zealand, the United Kingdom, and the United States
FSB	Fuel Services Branch
FSC	Fuel Services Contract
FY	Financial year
GSE	Ground Support Equipment

HDFSC	Head of Defence Fuel Supply Chain
HED	Hybrid Electric Drive
IEA	International Energy Agency
IMOIS	International Maritime Organisation Initial Strategy
JCG	Joint Capabilities Group
JLC	Joint Logistics Command
JOC	Joint Operations Command
LCA	Lifecycle Assessment
LTH	Lipid-to-Hydrocarbon
LoE	Line(s) of Effort
ADF	Automotive Diesel Fuel
FT	Fischer-Tropsch
H2	Hydrogen
MBIE	Ministry of Business, Innovation and Employment (NZ)
MCA	Multi-criteria analysis
MDF	Marine diesel fuel
MoD	Ministry of Defence (UK, India, Japan)
MoPNG	Ministry of Petroleum and Natural Gas
NTV	Non-tactical Vehicles
O&M	Operations & Maintenance
ODCS	One Defence Capability System
OEM	Original Equipment Manufacturer
OHS	Occupational Health and Safety
PtL	Power-to-Liquid
Quad partnership	Network between Australia, Japan, India and the United States
R&D	Research and development
RD	Renewable Diesel
RIMPAC	Rim of the Pacific
SAF	Sustainable Aviation Fuel
SEG	Security and Estate Group
SP&I	Strategy, Policy and Industry
UAS	Unmanned Air Systems
UAV	Unmanned Aerial Vehicles
UGV	Unmanned Ground Vehicles
ULP	Unleaded petrol
UUV	Unmanned Undersea Vehicle
VCDF	Vice Chief of Defence Force
VFM	Value for money
WHS	Work Health & Safety
WHS&E	Work Health & Safety & Environment

Glossary | Summary of SAF

Short Term (2022-2030)

- Fischer Tropsch (FT) and Hydroprocessed Esters and Fatty Acids (HEFA) fuels are already certified and approved for inclusion in some commercial and military aviation fuel specifications. These are blends of synthetic and conventionally derived petroleum fuels. Technologies currently undergoing approval are Alcohol to Jet, Direct Sugar to Hydrocarbons and Pyrolysis which will likely become available for certification as blending components for use in military and commercial fuels.

Medium Term (2030-2040)

- In the medium-term (10 to 20 years), fuels derived from synthetic crude made via the FT and HEFA, ATJ, HFS-SIP, CHJ, and HHC-SPK processes will become more widely available on the market. The synthetic crude produced by these processes can be tailored and its composition like aromatics and lubricity can be adjusted to produce fuels to meet marine, diesel, and aviation engine requirements and specifications. These fuels are stable, have improved combustion characteristics, and would be excellent for military use.
- In the medium-term many new processes will come into use: pyrolysis, hydrothermal liquefaction, depolymerisation of plastics, microbial conversion of waste and biomass, and the production of synthetic aromatic materials. The certification of synthetically produced aromatic materials will facilitate the use of a 100% fully synthetic fuel containing both hydrocarbon and aromatics.

Longer Term (2040-2050)

- In the long-term (beyond 20 years), there will be a wide variety of technologies available. The Fischer-Tropsch process could be used to produce synthetic fuels from a wide variety of feedstocks; referred to as XTL (anything-to-liquid) fuel. Coal and gas reserves offer a feedstock to produce XTL fuels assuring a long-term security of supply. These coal based synthetic fuels would have a very poor carbon balance compared to a biomass feedstock. There are logistic concerns about gathering sufficient biomass and other concerns about energy crops displacing food production or causing rainforest deforestation which could limit the use of biomass. If sufficient XTL fuel becomes available in the long-term it could present an excellent opportunity to establish a single synthetic military fuel for air, land, and sea.

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