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H.1 MINIMUM ENERGY AND WATER PERFORMANCE REQUIREMENTS

H.1.1 DESIGN PHILOSOPHY FOR ENERGY AND WATER EFFICIENCY

Design and construction teams must follow the following guiding principles for the design of new buildings and the renovation of spaces from the energy and water efficiency point of view:

- Whole-system design: optimising the whole system instead of optimising individual components independently, to minimise energy and water use for the whole system,
- Lifecycle thinking: considering the implications of design decisions on energy and water use over the lifetime of the building or space (including embodied energy and water), and
- Quality of spaces: so to achieve high levels of occupancy comfort and productivity.

In summary, UNSW buildings must offer the best environment for the occupants to work in a safe, practical, and comfortable space, whilst achieving the highest sustainability credentials in its construction and operation.

In general terms, UNSW requires new buildings and major refurbishments to achieve a minimum of 5 Green Star rating and 5.5 NABERS Energy and Water ratings (when NABERS can be applied), or 20% energy and water reduction on an annual basis compared to an all-electric reference building compliant with the energy efficiency requirements of the Australian National Construction Code (NCC), in alignment with UNSW Environmental Sustainability Plan. Energy and water efficiency targets must be demonstrated in the design stage of each project by ESD reports or the use of building modelling tools.

Furthermore, UNSW set carbon reduction targets in 2020 using the Science Based Targets Initiative (SBTi) methodology to reduce total (scope 1, 2, and 3) emissions in accordance with a 1.5°C global temperature increase limit as per below:

- 30% reduction in emissions by 2025.
- 50% reduction in emissions by 2030.
- Net zero emissions by 2050.

This means reducing operational scope 1 and 2 emissions related to gas and electricity use for all building and construction projects in line with these targets, by implementing energy efficiency activities, deep energy retrofits, clean electrification, and meeting minimum energy/water intensity requirements outlined later in this document.

This document provides a guide to achieving the design goals expressed above in terms of reaching world leading levels of energy & water efficiency in the construction and operation of new buildings and renovations. Design teams are expected to work closely with UNSW Estate Management (UNSW EM) team to achieve the best outcomes for each project.

H.1.2 ENERGY AND WATER INTENSITY TARGETS

UNSW has a long history of energy & water efficiency initiatives and of pushing the boundaries of building design for sustainable goals. As such, UNSW has a comprehensive historic energy & water use record that has been used in this guideline to inform new designs.

To monitor the energy & water performance of UNSW buildings and campuses, UNSW EM uses energy & water intensity metrics, whereby the total energy (in kWh) & water (in kL) use of each building or campus is divided by the total gross floor area (GFA in m^2) of the building or campus. The building GFA data is available in the UNSW property management system called Archibus, while the historical energy/water data is available in UNSW Energy Management and Control System (EMACS), which incorporates interval data for the main building meters as well as hundreds of submeters.

Using the method explained above, UNSW has established the following baselines using NGERS reporting boundaries and 2018 as the base year, for the total energy and water intensity of Kensington, Paddington, and Randwick campuses:

- Total Energy (electricity and gas) intensity baseline: 199 kWh/m^2/year.
- Total Water intensity (potable and bore water) baseline: 0.95 kL/m^2/year.

As per the Environmental Sustainability Plan 2022-24, the target is to reduce the total energy and water intensity of the campuses by 5% in 2025. In other words, all new buildings, and renovations (large and small) must be designed, constructed, or altered (i.e., using energy/water efficiency initiatives) to help UNSW to achieve or exceed the following Campus level energy and water intensity values:

- 2025 Energy Intensity target: 189 kWh/m^2/year.
- 2025 Water intensity target: 0.90 kL/m^2/year.

Hence, all new buildings and retrofitted areas, must be designed to have energy and water intensities below these targets. In other words, as mentioned in section H1.1, these targets will be accomplished by achieving a minimum of 5 Green Star rating and 5.5 NABERS rating in all new buildings and renovations, or a 20% reduction against reference building levels when NABERS is not applicable.

H.1.3 NATIONAL CONSTRUCTION CODE (NCC)

This design and construction standard should be considered as a complement to the current NCC, particularly to Section J of the code. Use of this standard does not waive the requirement of Section J compliance. If for any reason, the NCC and this guideline appear to be in conflict, the design team should obtain further clarification from UNSW. Note that across this standard, UNSW requires energy and water use reduction of 20% against an NCC reference building if no other benchmark is defined.

H.1.4 BUILDING RATING SYSTEMS

UNSW expects that design teams will use complimentary building rating systems to guide the design process, as they include sustainability initiatives beyond energy efficiency, which contribute further to improving the occupant's wellbeing and comfort and reduce the campus' environmental impact. UNSW's preferred rating system is Green Star, and the minimum design target is 5 stars. Furthermore, the use of operational rating tools is also expected, so to monitor the real building performance during its lifetime. While Green Star Buildings is considered mandatory for all the new buildings, the use of Green Star Performance rating is highly recommended for the existing building and continuous improvements and/or when it comes to refurbishments plans.

H.2 RECOMMENDED ENERGY & WATER EFFICIENCY INITIATIVES

Specific guidelines are provided below for component and system level design and optimisation of energy and water systems. Other resources for energy and water efficiency, like the guidelines available in https://www.energy.gov.au/, https://www.sustainability.vic.gov.au/, https://www.energy.nsw.gov.au/, and https://www.dcceew.gov.au/, should also be considered.

H.2.1 MINIMUM EQUIPMENT AND APPLIANCE RATING

Products selected must meet the minimum energy performance criteria set out in the Equipment Energy Efficiency (E3) program (https://www.energyrating.gov.au/). For all the regulated products with an energy rating label available (e.g., single phase air conditioners, dryers, washing machines, monitors, dishwashers, refrigerating appliances, etc.), UNSW minimum standard is a 5-star rating. However, it is recommended to reuse existing equipment and appliances in projects if they have an energy standard above 3 stars.

Similarly, for all products regulated under Water Efficiency Labelling and Standards (WELS) scheme (i.e., taps, showers, dishwashers, washing machines, lavatory equipment, urinals, flow controllers)- https://www.waterrating.gov.au/, UNSW minimum standard is 5-star rating.

H.2.2 CLEAN ELECTRIFICATION

UNSW has recently developed a clean electrification strategy which aims to minimise scope 1 emissions in its campuses. The strategy is to replace assets using fossil fuels (like boilers for space heating) with electric assets powered by renewable electricity, to achieve UNSW net zero emissions targets.

This means that all new buildings and refurbished spaces must be fully electric, including all services and retail or tenanted areas. UNSW is implementing a systematic and planned electrification of all its assets across all campuses, and synergies with specific projects are encouraged.

H.2.3 LOW GLOBAL WARMING POTENTIAL (GWP) REFRIGERANTS

Furthermore, Australia agreed to phase down refrigerants with high GWP as part of the Kigali amendment (2016) of the Montreal Protocol. Hence, part of UNSW clean electrification strategy includes the transition to low GWP refrigerants, using the following traffic light system:

Red	GWP above 1,000 is not accepted (unless there is no other viable option)
Yellow	GWP below 1,000 is currently accepted
Green	GWP below 500 is strongly preferred

Furthermore, UNSW has a strong preference for using natural refrigerants with low GWP (like R774 and R290) instead of HFOs refrigerants.

H.2.4 RAINWATER HARVESTING AND WATER RE-USE

UNSW encourages the installation of rainwater harvesting and water re-use system for all new buildings and buildings undergoing significant refurbishment, in line with UNSW sustainability policy. The goal of these systems is to reduce the building's reliance on mains water supply.

Rainwater re-use may be used for the following applications, subject to UNSW EM approval:

- Irrigation,
- Urinal and WC flushing,
- Cooling tower supply water.

For more information about rainwater harvesting and water re-use systems please refer to section E.1 – Hydraulic Services of UNSW Design Standards.

H.2.5 STEAM SYSTEMS

All steam generators must be electrified when possible and steam demand must be reduced, for example, by changing process steam requirements, or by using local steam generators and equipment with its own steam generating ability that are only operated when needed, instead of using centralised steam systems. A centralised building system with steam reticulation will only be considered where it can be demonstrated to be advantageous in terms of capital and an operational costs and efficiency over the lifecycle of the system.

Other resources on energy efficiency of steam systems:
https://www.energy.gov/sites/prod/files/2014/05/f15/saveenergyinsteam.pdf
https://www.sustainability.vic.gov.au/energy-efficiency-and-reducing-emissions/in-a-business/plant-and-equipment-energy-efficiency/boiler-steam-and-process-heating
https://www.energy.gov.au/business/equipment-and-technology-guides/process-heat-and-steam.

H.2.6 COMPRESSED AIR SYSTEMS

A centralised compressed air system and its associated reticulation system will only be considered where it can be demonstrated to be advantageous both from a capital investment and an operational cost and efficiency basis. If a central system is chosen, then heat recovery must be implemented, to aid other processes in the building, like space heating or domestic hot water systems. In all other cases requirements for compressed air systems should be solutioned either by distributed/local equipment that can be operated only when needed or by equipment procured with its own compressed air generating ability.

A guideline on energy efficiency of compressed air systems can be found here:
https://www.energy.gov.au/business/equipment-and-technology-guides/compressed-air.

H.2.7 HVAC SYSTEMS

Heating ventilation and air conditioning (HVAC) systems account for up to 50% of a commercial building’s energy use and dominate peak electricity demand. In general, HVAC systems can be categorised as either; “house systems” which provide air conditioning to communal areas and people spaces, or “special use systems” which provide air conditioning to areas which have a particular requirement. Examples of special use areas include computer and server rooms, communications equipment rooms, clean rooms, PC2/3 laboratories, animal holding facilities, and areas with 24/7 operations. Special use areas generally require significantly higher air conditioning performance hence a need to be considered separately.

To avoid the energy inefficient solution of “over designing” house systems to provide conditioning to special use areas, local dedicated HVAC systems should be provided to cater for the enhanced requirements of those special use spaces. The local systems can be either stand alone or used to boost the house system. The final solution being dependent upon achieving best energy efficiency outcome and running costs. This local, dedicated solution can also prevent running house systems 24/7, as it is the case when house systems serve special use areas.

Outside air economy cycles must be considered for all ‘house systems’ and where possible in the ‘special use’ systems.

Classroom theatres and any other space requiring high volumes of fresh air should include dynamic delivery systems that can adjust airflow and fresh air amount depending on set conditions and measurements, and energy recovery systems. For example, outside air quantity and air volume of a classroom could be adjusted based on occupancy sensors or CO_2 sensors monitoring the space.

For the renovation of areas with existing HVAC systems, then a holistic HVAC strategy with the following hierarchy must be used: reduce demand, optimise the existing system, and finally upgrade to more efficient systems. The document “I am your optimisation guide” published by the NSW Government Office of Environment and Heritage is highly recommended in the design and optimisation of HVAC systems:
https://www.environment.nsw.gov.au/resources/business/150317hvacguide.pdf.

As mentioned in Section H.2.2, special attention must be made with regards to refrigerant selection for HVAC systems, so to avoid high GWP refrigerants.

H.2.7.1 SPACE HEATING

The University’s heating systems are to be fully electric and designed to comply with part J5 of the NCC. The preferred solutions for space heating include the use of high efficiency heat pumps and systems with heat recovery. If the space heating equipment is regulated under the Greenhouse and Energy Minimum Standards (GEMS) and has a MEPS value, then a 20% AEER improvement respect the most current MEPS value is required by UNSW (e.g., if the MEPS value is 2.9, then the minimum efficiency accepted by UNSW is 3.48 = 2.9 x 1.2). Please refer to Section E2.29 of UNSW Design Standards - Mechanical Services for more details on efficiency requirements of HVAC systems.

Treated bore water can be used to preheat fresh air or for operating heat pumps (water-to-water heat pump) where available, but the application must be compatible with the elevated water conductivity of the TBW used in Kensington Campus, of around 520 µ/s. Solar thermal systems can also be used to complement space heating requirements when appropriate.

The joint design of DHW and space heating solutions is encouraged, so one system is designed to deliver HHW and DHW to increase efficiency and reduce the number of system components.

H.2.7.2 SPACE COOLING

High efficiency chillers and cooling towers should be used, while pump and fan power should be minimised by reducing pressure loss in ducts, pipes, filters, and coils. If the space cooling equipment is regulated under the Greenhouse and Energy Minimum Standards (GEMS) and has a MEPS value, then a 20% ACOP improvement respect the most current MEPS value is required by UNSW (e.g., if the MEPS value is 2.9, then the minimum efficiency accepted by UNSW is 3.48 = 2.9 x 1.2). Please refer to Section E2.29 of UNSW Design Standards - Mechanical Services for more details on efficiency requirements of HVAC systems.

Low cooling loads should be serviced by low load chillers and not by running large chillers below their specified minimum output. Chiller choice and sizing must also comply with the requirements of the UNSW Mechanical Systems Design Guide. An example of a novel energy efficiency initiative already tested on Kensington Campus is the use of treated bore water (TBW) for precooling fresh air. Similar initiatives are encouraged, but note the application must be compatible with the elevated water conductivity of the TBW used in Kensington Campus, of around 520 µ/s.

H.2.7.3 HEAT AND ENERGY RECOVERY SYSTEMS

Energy recovery systems should be used where appropriate, particularly in systems that require large amounts of outside air and/or dehumidification.

H.2.7.4 DEHUMIDIFICATION

If dehumidification is required, then a dedicated dehumidifier must be considered as the preferred option. Dehumidification by the house system by over cooling and reheating shall be avoided.

H.2.7.5 AIR AND WATER RETICULATION

System pressure should be minimized by increasing duct or pipe size, reducing flowrate, and minimizing bends, fittings, and complexity in the reticulation.

H.2.7.6 VENTILATION

Fans and motors should be high efficiency and always have a variable speed drive (VSD) if the fan motor power is higher than 3 kW, or if it is operated 24/7. Electronically Commutated (EC) fans are recommended as a better solution to the standard VSDs/Fan combination.

Outside air intakes should be in areas with low solar heat gain and surrounded by light colour building fabric elements. Research has found that air intakes located near dark façade or roof elements, have air temperatures well above ambient, reducing the performance of the HVAC system. This can be even more detrimental on days of extreme temperatures, as the conditions will fall outside the HVAC design parameters.

H.2.7.7 FUME CUPBOARDS AND EXHAUST SYSTEMS

Fume cupboards and exhaust systems are responsible for a large portion of energy use in lab spaces, not only due to the energy use in the fans, but also because of the exhausting of conditioned air that must be replaced. Hence, the overall energy use of fume cupboards and exhaust systems must be minimised. Low flow cabinets, variable air volume exhaust, automatic sash, and local ON/OFF controls are some of the expected solutions for new buildings. Further novel solutions can include indirect energy recovery systems, or fresh air supply to the cabinets to reduce the amount of exhausted conditioned air, as long as the solution is compatible with Australian Standard AS/NZS 2243.8.

H.2.8 DOMESTIC HOT WATER

The preferred solution for domestic hot water application is to use dedicated air-source electric heat pumps with natural refrigerants (particularly R744) or refrigerants with GWP below 500. The system should demonstrate a minimum COP of 4 at 20°C ambient air for water outlets of 60°C. The use of storage tanks to reduce the size of heat pump should be considered. The ring main pump should come with a timer or controller so that the water circulation is blackout at off-peak hours or if the return temperature is high enough (i.e., the ring pump should activate only if the temperature difference between supply and return is more than 3°C).

The joint design of DHW and space heating solutions is encouraged, so one system is designed to provide both space heating and DHW to gain in efficiencies and reduce number of system components.

H.2.9 EQUIPMENT COOLING WATER (ECW)

In cases where ECW temperature can be kept at or above 18°C, use of treated bore water (TBW) should be considered, as local temperature data in the Kensington Campus shows a consistent temperature over the year fluctuating between 18°C to 19°C. However, the equipment must be compatible with the elevated water conductivity of the TBW used in Kensington Campus, of around 520 µ/s.

Generally, ECW systems should not be designed to deliver chilled water. Where specific laboratory equipment requires chilled water then it should be procured with a dedicated local water chiller with the ECW being utilized for heat rejection.

ECW cooling pipes should always be insulated throughout the building. Pump power should be minimized by reducing the system head for the designed flow rate.

H.2.10 BUILDING ENVELOPE

The building envelope is probably the most important design aspect of a building when it comes to energy performance. It regulates the heat transfer between indoors and outdoors, it controls solar gains, and it also controls the air exchange with the environment and infiltration. Hence, a well-designed building envelope not only ensures a good energy performance but also high levels of comfort for its occupants. The orientation of a façade will also influence the performance required from its design. North facing aspects are preferred as can be designed to have low solar gain in summer and high solar gain in winter, thus minimising the energy use of HVAC systems. However, north facing elements do require greater resistance to solar gain than other aspects across the year. West facing facades must be particularly optimized for summer days, as afternoon solar gains contribute to maximum demand loads and occupant's comfort. The notion of non-homogenous façade design where the performance of each aspect is optimised to its performance requirements must be used, as discussed in detail in the next sections.

A recent publication by the International Energy Agency provides a roadmap on energy efficient building envelopes[1]. Some key points are:

- Levels of insulation in walls, roofs, and floors, should be optimised through life-cycle cost (LCC) assessment.
- New office buildings should be fitted with integrated facade systems that optimise daylight while minimising energy requirements for heating, cooling, artificial lighting, and peak electricity use.

[1] https://iea.blob.core.windows.net/assets/2be63379-1185-42e7-9608-94e5d3682956/TechnologyRoadmapEnergyEfficientBuildingEnvelopes.pdf

- Exterior shading, proper orientation and dynamic solar control should become standard features globally in new buildings and can also be applied to existing buildings.
- Pilot projects have demonstrated that such systems can enable energy savings of up to 60% for lighting, 20% for cooling and 26% for peak electricity.

H.2.10.1 FAÇADE R VALUE

Each façade face should be designed independently; hence, the average R value of each façade should be calculated independently and comply with the minimum value as stated in the NCC or as optimized to achieve the target building energy performance. This is in addition to (and be compliant with) the standard Section J Verification method.

The effective average R value of each façade should be at least 2.8 K.m^2/W, this value must include all façade elements, including windows. Furthermore, individual façade elements, including windows, must have a minimum R value equal or above to 0.4 K.m^2/W (see Section H.2.10.2).

The designers will have to optimize the design to provide enough natural light while maintaining the façade performance. The window to wall ratio (WWR) of each façade plays a big role in this respect. It is recommended that the WWR is no more than 30% for each façade.

H.2.10.2 GLAZING

The U value and solar heat gain coefficients (SHGC) should be minimized while maintaining good visual light transmittance (VLT). The total glazing area in a façade should be optimized for the user's comfort and productivity, trying to harvest enough indirect daylight, without compromising the thermal performance of the building envelope. Recommended values below:

- U value must be below or equal to 2.5 W/K.m^2.
- SHGC should be kept below 0.30 unless other specific requirements are set.
- VLT should be at least 0.50 unless other specific requirements are set.

H.2.10.3 THERMAL BREAKS

Façade elements exposed to direct solar radiation should include thermal breaks to stop direct heat conduction to the inside of the building. Thermal breaks should be considered irrespectively of the compliance to R and U values, as they are included to stop localized heat transfer to façade elements. However, shading of exposed elements is the preferred solution and this can be a valid way to minimise the requirement for thermal breaks.

H.2.10.4 SHADING

Shading is one of the most important elements in a façade, usually overlooked when using 'high performance' windows. However, a low SHGC is not a replacement for good shading practice, as effective shading can block direct sunlight (therefore reducing direct solar gain) while allowing diffuse daylight into the building. Furthermore, good shading can allow higher SHGC levels if the glass is well protected from direct sunlight for most of the year.

UNSW has the following recommendations for each façade orientation:

- North façade: shading should allow direct sunlight only during late autumn and winter period (May to Aug). This can be achieved quite effectively by horizontal shading devices.
- East façade: direct sunlight is only allowed during early morning time on late autumn and winter months (May to Aug). This can be achieved by using vertical shading devices angled towards north.
- West façade: direct sunlight is allowed only during early afternoon time on late autumn and winter months (May to Aug). This can be achieved by using vertical shading devices angled towards north. Late afternoon sun, especially between October to March, must be avoided.
- South façade: normally the southern façade does not need shading. However, during late hours in summer important amount of direct sunlight can ingress the building via the southern façade. This can be avoided by using small vertical elements.

As discussed above, diffuse sunlight is welcome in the building to improve natural lighting and certain shading elements can help on this task. For example, some companies have developed horizontal shading elements that reflect diffuse light inside rooms. This can be used on tall windows where the reflection can be orientated towards the ceiling.

H.2.10.5 INFILTRATION

Infiltration when unmanaged, can greatly reduce the energy performance of the HVAC system in a building, particularly when extreme outdoor temperatures occur. Together with glazing, infiltration can be the weakest link in an otherwise well-designed façade.

All new building projects and major refurbishments are required to target a best practice air permeability rate of 3 $m^3/hr.m^2$ at 50 Pa, with a maximum allowable rate of 5 $m^3/hr.m^2$ at 50 Pa, as defined by section J1V4 of the NCC 2022. Solutions to reduce infiltration can include air traps, like double doors. Infiltration tests should be carried out in different sections of the façade to test the amount of air leakage at the rated pressure.

H.2.10.6 FLOOR AND ROOF INSULATION

Floor and roof insulation although important are probably less relevant for the whole building performance, when compared to other façade elements. For example, it is common to have plantrooms on roofs, which could reduce the need for high levels of insulation. However, minimum BCA values should be achieved and R value optimization for greater energy efficiency is encouraged. The floor should be insulated if hydronic floor heating is used.

H.2.11 BUILDING MANAGEMENT SYSTEM (BMS) AND ANALYTICS

Please refer to UNSW Design Standard Appendix 1 - Automation and Control Systems. All buildings must include a BMS to monitor and/or control their HVAC systems and sub-systems (as per Appendix 1, section 2.9), which must be integrated into UNSW central control system. From an energy management point of view, the BMS should be programmed and controlled to maximize energy productivity and avoid energy waste (Appendix 1, section 2.10). The use of an analytic platform is recommended to monitor the performance of the building and aid in the maintenance of the HVAC system.

H.2.12 LIGHTING AND NATURAL LIGHT

Natural light harvesting should be maximized without compromising thermal comfort. A maximum energy gain of 100 W per m^2 of window area due to natural light is allowed. An ideal level of 80% of daylight should be targeted.

All lighting should be controlled by a lighting control system integrated to the UNSW central lighting control server and be DALI 2 compatible. Efficient light sources and optics should be used, with a final lighting efficiency of at least 100 lumens/watt for a light fitting. When this light efficacy is not available for specific applications (e.g., architectural lighting), the design team must deliver a lighting solution with a maximum illumination power density (IPD) below NCC requirements, as per targets in Section H.1.1. The design team should bear in mind that some low-quality LED lights might not reach the required light efficiency, while some high efficiency CFLs might. It is however a consensus that efficient LED lights are currently a leading energy efficient solution. The standard colour temperature to be used in UNSW spaces is 4000 K with a minimum colour rendering CRI of 80. LM-80 reports must be provided to assess lumen maintenance. For more information check Section E.3.2 LIGHTING of UNSW Design Standards.

H.2.13 DEMAND MANAGEMENT (DM)

The building should have a demand management capability to reduce its electricity demand during peak demand periods. The demand management mode can enable the following elements:

- Local 'stand by' generator: normally a diesel generator that can be used in parallel with the grid (UNSW has experience on this type of systems with several generators already used for this function).

- Storage system: battery storage systems can be considered for demand management systems, as they can also provide other functions to the building, including but not limited to: PF correction, renewable energy smoothing, renewable energy firming, cost arbitrage, filtering, etc.
- HVAC demand management: it might be possible to reduce the level of service to non-critical areas during max demand events, without affecting the occupant's comfort, if it is done during small periods of time (1 hour maximum). This could include a wider temperature set point dead band, lower flow rates, or higher chilled water temperatures. Precooling or preheating are also valid strategies. However, HVAC DM is the less desirable option due to its potential negative impacts.

H.3 RENEWABLE ENERGY SYSTEMS

All new building and renovation projects must consider the use of renewable energy to reduce the energy reliance on the electrical grid. Rooftop Solar PV has shown to be the most cost-effective way to achieve this goal (as a reference, a 100 kWp system is the common minimum target), but solar thermal systems and building integrated PV (BIPV) systems should also be studied.

In some cases, maximising solar PV on buildings (BAPV and/or BIPV systems), can be explored as a potentially more cost-effective way to reduce energy use rather than other initiatives, and should be considered in the lifecycle costing of the final design. Some of the most common energy efficiency initiatives (like insulation) have diminishing returns, while solar PV doesn't, if the additional installed capacity is not shaded. A recommended guide to energy efficiency measures is the use of a MAC curve, which could be developed for a specific project.