Low-Carbon Energy Development from an Islamic Perspective: Technological Opportunities, Environmental Implications and Ethical Considerations

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ABSTRACT

Malaysia's electricity supply remains dominated by fossil fuels, while national policy envisages a large expansion of low-carbon generation. Choices among low-carbon technologies are usually framed in technical and economic terms, and their ethical and religious dimensions are rarely examined systematically. This conceptual, literature-based study examines four technologies relevant to Malaysia: solar photovoltaics, wind and hydropower (renewable), and nuclear power (low-carbon but not renewable). It compares them on lifecycle emissions, land and water use, cost, dispatchability and grid integration, and proposes an Islamic ethical assessment framework of eight principles (*khalifah*, *amanah*, *mizan*, *israf*, *fasad*, *maslahah*, *maqasid al-shariah* and *la darar wa la dirar*), each expressed as an assessment question and graded supports, concern, mixed or unresolved. The framework is applied, as an illustration and not as validation, to the Bakun hydroelectric project in Sarawak. No technology is superior on every criterion, and Bakun shows how a project can deliver reliable electricity while concentrating costs on local communities and ecosystems, leaving several ethical questions unresolved. The study offers a transparent, interdisciplinary tool for energy decision-making, with implications for impact assessment, public participation, compensation, monitoring, waste management and long-term accountability. The framework is a normative aid and not a fatwa or Shariah ruling, and the paper reports no experimental or simulation results.

Keywords: low-carbon energy; Islamic environmental ethics; maqasid al-shariah; hydropower; nuclear power; solar photovoltaics; Bakun dam; Malaysia

1. INTRODUCTION

Electricity systems must expand supply, reduce emissions and remain affordable at the same time, and Malaysia faces this challenge from a fossil-fuel base. In 2021, coal supplied 45.0% of the country's electricity, natural gas 34.2% and hydropower 17.8%; these are the latest official Energy Commission figures available to the authors, and Malaysian statistics are dated by reporting year throughout [1]. The fuel base is also finite: crude oil and condensate resources fell from 5.907 billion barrels in 2015 to 4.430 billion in 2021, and natural gas resources from 100.413 to 76.032 trillion standard cubic feet [1]. If depletion continues, the cost falls on future generations, which makes prudent electricity use an ethical as well as an economic question.

Islamic teaching addresses this directly. In Pickthall's translation [2], Q 17:27 calls the squanderers "brothers of the devils". Commentators place the verse within teaching on moderate spending, defining the squanderer as one who spends where it is not fitting [3] and treating the verse as concerned with wealth [4]; the related prohibition of extravagance (*israf*) appears in Q 7:31. Applying either verse to electricity is the authors' extension by analogy. Islamic sources also encourage reflection on creation and its benefits, as in Q 2:164, which the commentary reads as a proof of God's oneness, noting that the sea carries ships so that people can trade [3]. The verse is not a statement about energy technology, and is cited only to show that the beneficial use of natural resources sits within an Islamic worldview, bounded by the ethical limits discussed in Section 6.

Four sources have high potential in Malaysia's power sector: solar, wind, hydro and nuclear energy. The first three are renewable. Nuclear energy is low-carbon but not renewable, because it depends on a finite fuel, mainly uranium; it is retained as a comparative case because it raises the sharpest questions of trust, risk and responsibility to future generations. The Twelfth Malaysia Plan states an aspiration of net-zero greenhouse gas emissions as early as 2050, and the National Energy Policy 2022–2040 and the National Energy Transition Roadmap (NETR) guide the energy sector [5, p. 13]. The main NETR target is a 70% renewable share of installed capacity by 2050, together with no new coal power plants [5, pp. 19, 32]. These are targets and aspirations, not achievements.

Energy planning is usually framed in technical and economic terms. For a Muslim-majority country where religious values inform public discourse, this leaves a gap: the ethical questions raised by each technology (who bears the harm, who is accountable, and what is owed to future generations) are seldom examined systematically in the light of Islamic sources. General studies of Islamic environmental ethics exist [6], [7], [8], but, to the authors' knowledge, work connecting them to the choice among specific low-carbon generation technologies remains limited [9]. This paper therefore (i) compares solar photovoltaic (PV), wind, hydropower and nuclear generation on lifecycle emissions, land and water use, cost, dispatchability and grid integration, using figures only where their system boundaries are comparable; (ii) develops an Islamic ethical assessment framework that translates principles from the Qur'an, Hadith, legal maxims and *maqasid al-shariah* into assessment questions; (iii) illustrates it with one documented Malaysian case, the Bakun hydroelectric project in Sarawak; and (iv) draws out implications for Malaysian energy policy. The contribution is conceptual: the paper rests on published literature, reports no experimental, simulation or stakeholder data, and is neither a systematic review nor a validated framework. Section 2 sets out the method, Section 3 the technologies and Malaysian context, Sections 4 and 5 their limitations and comparison, Section 6 the Islamic analysis, Section 7 the Bakun case, and Sections 8 to 10 the policy implications, contributions and conclusions.

2. METHODOLOGY AND CONCEPTUAL FRAMEWORK

2.1 Research Design and Sources

This is a structured conceptual literature-review study. The approach suits a question that spans engineering performance, environmental and socioeconomic effects, the Malaysian policy setting and Islamic ethical reasoning, the last of which rests on textual and juristic sources and not on measurable variables. The aim is to integrate published evidence from these domains into a transparent analytical framework. The study does not test a hypothesis or generate new empirical data, and it is not a systematic review or meta-analysis (no PRISMA-style screening was performed, so no screening counts are reported). Its framework is conceptual and normative, and the Bakun application in Section 7 is an illustration, not an empirical validation.

Peer-reviewed technical, environmental and policy literature was identified by keyword searching of academic sources using terms on renewable and low-carbon energy in Malaysia, the sustainability and environmental impacts of each technology, Islamic environmental ethics, *maqasid al-shariah*, jurisprudence, *amanah*, *khalifah* and *maslahah*. Official statistics and policy documents were taken from the issuing bodies (the Energy Commission, the Ministry of Economy, the Sustainable Energy Development Authority Malaysia, the International Renewable Energy Agency and the Intergovernmental Panel on Climate Change). Sources were included if they addressed the four technologies, Malaysian energy policy, or Islamic environmental ethics, jurisprudence or *maqasid*; were peer-reviewed articles, official reports, recognised academic books or primary or classical Islamic texts; reported data clearly enough to place figures within a defined system boundary; and were written in English, Malay or Arabic. Unattributed web content, figures without a stated year, unit or boundary, and contested religious claims presented as settled rulings were excluded. Classical Islamic texts and standard textbooks carried no date limit.

Authority among Islamic sources was judged by type. The primary sources were the Qur'an, read in the Pickthall translation [2] with the classical commentaries [3], [4], and the hadith collections [10]. Hadith in the two *Sahih* collections are relied on directly, and narrations graded weak by recognised hadith scholars are used only as corroboration of a Qur'anic text, never as independent evidence. Secondary sources were modern works on jurisprudence, legal maxims and *maqasid* [11]–[14] and contemporary Islamic environmental

scholarship [6], [7]. Institutional statements were used only where the primary document could be identified, and searches for Malaysian rulings on the choice among energy technologies were limited to publicly accessible sources and were not exhaustive (Section 6.5). Every statistic is given with its reporting year, and historical data, forecasts, policy targets, installed capacity and generation are kept apart and not combined into a single series.

2.2 Islamic Ethical Assessment Framework

The framework was built in four steps: candidate concepts were taken from the Islamic environmental-ethics literature [6], [7], [8] and legal theory; a concept was retained only if it had an identifiable textual or juristic basis and a defined scope; each retained concept was expressed as an assessment question that can be put to any energy project; and each question was linked to evidence from the technical assessment, so that an ethical judgement can be traced to a stated fact. The result is eight principles (Table 1). *Maqasid al-shariah* is treated as one principle, within which the protection of life (*hifz al-nafs*) and of wealth (*hifz al-mal*), the objectives most directly engaged by energy decisions, are assessed as two sub-questions. Intergenerational responsibility is a cross-cutting consideration assessed against every principle and asked explicitly as a final question, because it follows from *amanah* and *khalifah* and, on some contemporary readings, from *hifz al-nasl* (protection of progeny), and has no independent classical basis of its own (Section 6.4).

Table 1. Islamic ethical principles, their basis and their translation into assessment questions.

Principle	Textual and juristic basis	Operational meaning for energy decisions	Assessment question
***Khalifah* (stewardship)**	Q 2:30; hadith on responsibility of the shepherd [10]	Delegated responsibility to develop resources for human welfare without corrupting the conditions that sustain life	Does the option demonstrate responsible stewardship of land, water, ecosystems and energy resources?
***Amanah* (trust)**	Q 33:72; hadith on responsibility [10]	Resources are held in trust for present and future generations; decision-makers answer for consequences	Are decision-makers identifiable and accountable for long-term consequences, including waste, decommissioning and harm?
***Mizan* (balance)**	Q 55:7–9	Creation is ordered and measured; interference should not upset that order irreversibly	Does the option maintain ecological balance, or does it impose changes that cannot be reversed or compensated?
***Israf* (waste and excess)**	Q 7:31; 6:141; 17:26–27 (*tabdhir*)	Avoid waste in supply and use; restraint in demand	Does the option encourage efficient resource use, and is capacity matched to genuine need?
***Fasad* (corruption, destruction)**	Q 30:41	Avoid avoidable damage to land, water and living things	Does the option cause avoidable environmental destruction, given the alternatives?
***Maslahah* (public interest)**	Legal theory [11], [12]	Reliable, affordable supply and development, fairly distributed	Does the option deliver equitable public benefits, and are costs and benefits shared fairly?
***Maqasid al-shariah* (including *hifz al-nafs* and *hifz al-mal*)**	Classical objectives [12]	Protection of life (*hifz al-nafs*) and wealth (*hifz al-mal*) as the objectives most directly engaged by energy	Does the option protect human health and safety, and use economic resources responsibly?
***La darar wa la dirar* (no harm, no reciprocal harm)**	Hadith [41]; legal maxim [11]	Harm should be prevented where possible and removed where it exists	Is harm to people and the environment prevented or removed, and are those harmed compensated?

Each assessment question is answered from the technical evidence (Section 5) and graded, with the reasoning stated, as *supports* (the evidence indicates consistency with the principle), *concern* (it identifies an adverse impact or a significant ethical issue), *mixed* (it shows both positive contributions and significant adverse consequences) or *unresolved* (it is insufficient for a reliable assessment). Absence of documentation is graded *unresolved*, not *concern*, unless the sources identify an actual adverse impact. The decision criteria (environmental sustainability, economic feasibility, energy security, social justice and intergenerational responsibility) are then considered together. No numerical weights or scores are assigned, because weighting is a value judgement for decision-makers and could be examined in future multicriteria analysis. The grades are the authors' reasoned judgements from published sources and have not been tested with other assessors.

2.3 Conceptual Framework

Figure 1 summarises the framework. The alternatives (solar PV, wind, hydropower and nuclear) enter a technical, environmental and socioeconomic assessment; these facts are then interpreted through the eight principles and graded; and the graded questions and the technical evidence are weighed together under the decision criteria, because economic feasibility and energy security are not ethical judgements alone. The outcome sought is a transparent, ethically informed energy strategy for Malaysia, and the dashed arrow shows monitoring, review and public participation feeding back to earlier stages.

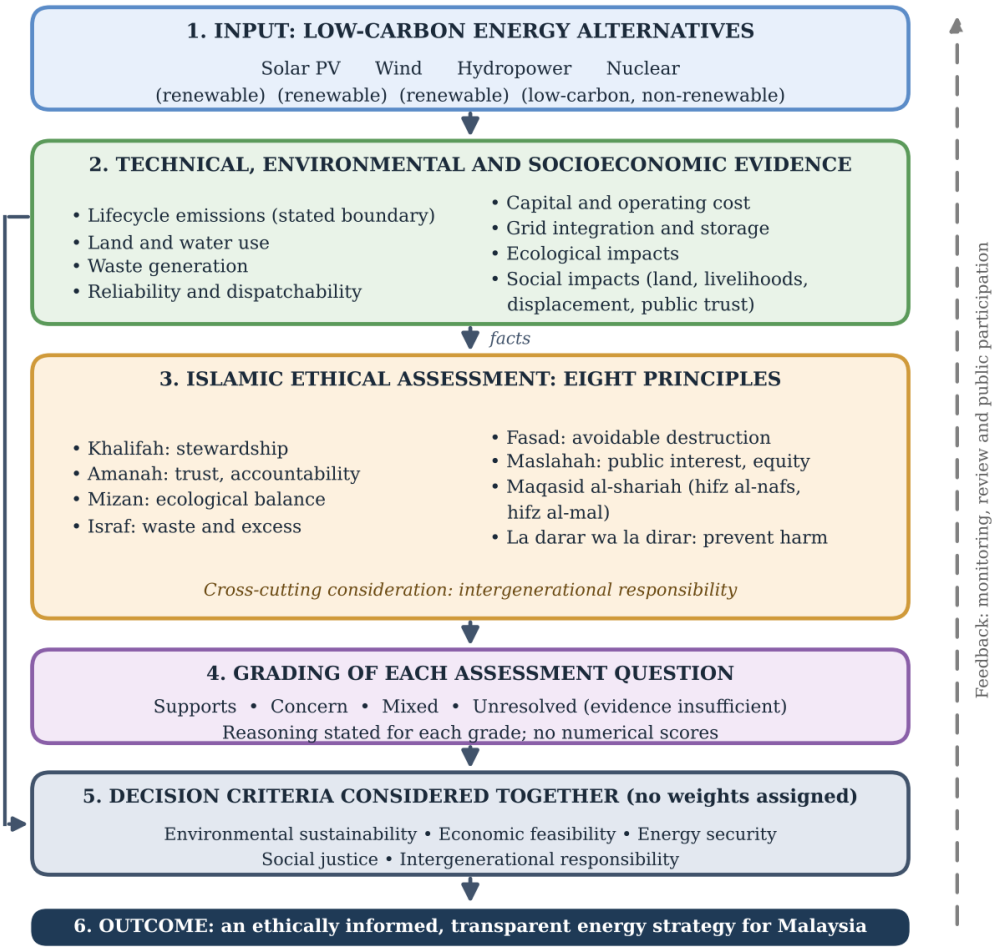


Figure 1. Conceptual framework for the Islamic ethical assessment of low-carbon energy development (authors' own).

3. LOW-CARBON ENERGY SOURCES AND THE MALAYSIAN CONTEXT

The Malaysia Renewable Energy Roadmap (MyRER) set a target of a 31% renewable share of national installed capacity by 2025 [33]; the sources available to the authors do not establish whether it was met. At 31

December 2021, installed capacity was 37,422 MW: natural gas 40.1%, coal 35.5%, major hydro 16.2%, solar 4.5%, biomass 1.1% and mini hydro 0.4%, including 909.4 MW of large-scale solar. Generation in 2021 was 174,231 GWh, of which coal supplied 45.0%, gas 34.2%, hydropower 17.8%, other renewables 2.4% and oil 0.6% [1]. Capacity and generation differ because plants run at different capacity factors, so installed capacity should not be read as energy supplied. Table 2 collects the Malaysian figures by reporting year and type; newer official Energy Commission data may exist and, if so, should replace the 2021 rows before publication (Section 10.1).

Table 2. Malaysian energy indicators used in this paper, by reporting year and type.

Indicator	Value	Year	Type	Source
Total installed capacity	37,422 MW	31-Dec-21	Historical official, installed capacity	[1]
Installed capacity shares	Gas 40.1%; coal 35.5%; major hydro 16.2%; solar 4.5%; biomass 1.1%; mini hydro 0.4%; remaining categories about 2.2%	2021	Historical official, installed capacity	[1]
Large-scale solar in operation	909.4 MW (859.4 MW Peninsular; 50.0 MW Sabah)	2021	Historical official, installed capacity	[1]
Electricity generation	174,231 GWh; coal 45.0%; gas 34.2%; hydro 17.8%; other renewables 2.4%; oil 0.6%	2021	Historical official, actual generation	[1]
Renewable capacity installed	Just over 9 GW	2023	Baseline of the roadmap, installed capacity	[5, p. 32]
Technical renewable potential	Almost 290 GW, of which solar PV about 269 GW	2023 roadmap	Potential estimate	[5, p. 32]
Primary energy demand; fossil-fuel reliance	95 Mtoe to 102 Mtoe; 96% to 77%	2023 to 2050	Forecast	[5, p. 8]
Renewable share of installed capacity	70% by 2050; no new coal plants	2050	Policy target	[5, pp. 19, 32]
Renewable share of installed capacity	31%	2025	Policy target	[33]

Malaysia lies close to the equator, with high temperatures, humidity and rainfall and weak, variable winds, conditions that suit photovoltaics and hydropower and offer only limited, site-specific wind potential. The NETR estimates technical renewable potential at almost 290 GW, of which solar PV is about 269 GW, against just over 9 GW of renewable capacity installed in 2023 [5, p. 32], and projects primary energy demand rising only about 0.2% a year, from 95 Mtoe in 2023 to 102 Mtoe in 2050, with fossil-fuel reliance falling from 96% to 77% [5, p. 8]. Electricity is not the dominant form of final energy: in 2021 it was 23.3% of final consumption, behind petroleum products (41.8%) and natural gas (31.1%) [1]. Regional transition analyses [34] and studies of household rooftop-solar adoption [35] give further context. The international performance data cited below are not Malaysian measurements, and their transferability is noted where it matters.

3.1 Solar Energy

Solar PV converts sunlight directly into electricity in cells, while concentrated solar power (CSP) uses mirrors to concentrate direct sunlight and drive a turbine. Total solar irradiance at the top of the atmosphere is about 1,361 W/m² [15], but surface irradiance depends on latitude, season, cloud and atmosphere. CSP needs strong direct-beam sunlight, which is scarce in humid, cloudy Peninsular Malaysia, and this helps explain why PV

dominates deployment there. Tropical sites offer year-round daylight, but heat lowers PV efficiency and cloud causes short-term fluctuation. Output follows sunlight and cannot be dispatched, so high solar shares need storage, flexible generation, demand management and grid upgrades [16], [17]. The Qur'an presents the sun as a sign of creation and a benefit to people (Q 10:5; 25:61); the commentary [3] reads these verses as praise of God, and they invite reflection on creation without speaking of solar technology (Section 6.1).

3.2 Wind Energy

A wind turbine converts the kinetic energy of moving air into electricity. The power available rises with the cube of wind speed, so resource assessment is critical: a small difference in average speed changes output greatly [18]. Malaysia's equatorial wind resource is generally modest, so opportunities are likely to be local or seasonal, for example at some coastal and island sites, and not large-scale. Output is variable, and integration needs mirror those of solar PV [16], [17]. The Qur'an presents the winds as heralds of God's mercy that also let ships sail (Q 30:46) [3]; the step from this benefit to turbines is the authors' own reading. Q 51:1 is the first of a series of oaths by winds, clouds, ships and angels in a surah on the Hereafter [3], [4], and is not used as evidence on wind power.

3.3 Hydro Energy

Hydropower converts the potential energy of water held at height into electricity. Reservoir schemes provide storage and dispatchable output; run-of-river schemes have little storage and lower reservoir impact but depend on river flow; and pumped storage works as large-scale energy storage and not as a primary source. Reservoirs can emit greenhouse gases from decomposing organic matter [23]. Hydropower is significant in Sarawak and Peninsular Malaysia: at the end of 2021 major hydro capacity was 3,452.0 MW in Sarawak, 2,536.1 MW in Peninsular Malaysia and 72.0 MW in Sabah, and hydropower supplied about 17.8% of the country's electricity [1]. Q 21:30 describes water as the origin of every living thing [3]; the authors read it as grounds for care in water use and protection, which they apply to hydropower schemes, and the verse does not address dams.

3.4 Nuclear Energy

Nuclear power plants use controlled fission of heavy atoms, typically uranium-235, to release heat that drives a steam turbine [19]. Nuclear power can supply large amounts of low-carbon, continuous electricity from a small land area; its main concerns are spent-fuel and radioactive-waste management, reactor-accident risk, security and proliferation, and high capital cost and long construction times. Malaysia has no nuclear power project, so the discussion of nuclear power in this paper is comparative and conceptual. Q 10:61 refers to "an atom's weight", but the commentary reads it as God's knowledge of and witness over every deed [3], [4] and does not link it to atomic physics, so no inference about nuclear energy is drawn from it.

4. BENEFITS AND LIMITATIONS OF LOW-CARBON ENERGY

Solar, wind, hydro and nuclear power emit little or no carbon dioxide in operation compared with coal and gas, with the exception of some hydropower reservoirs (Section 5). Replacing coal and gas also reduces particulates and sulphur and nitrogen oxides, which benefits public health, and domestic sources reduce exposure to fuel-price volatility and import dependence while bringing industry, jobs and technology capacity. Small solar and micro-hydro systems can reach remote communities in Sabah and Sarawak, as a techno-economic study of an off-grid hybrid system on Malawali island, Sabah, illustrates [36].

Each technology also carries costs. Large solar plants need land, and panels use energy and materials in manufacture and raise questions of end-of-life disposal and recycling [24]–[26]. Wind turbines can harm birds and bats [27], [28], and their siting can cause conflict and divide opinion on visual effects, which makes siting a matter for consultation; blade waste is an emerging concern that the sources cited here do not review. Dams change river ecosystems, flood forest and wildlife habitat, alter water quality and flow, trap sediment, block fish migration, affect downstream fishing communities and can displace people, and their reservoirs emit greenhouse gases [23]. Radiation damages body cells, radioactive waste is dangerous and costly to manage over very long periods, serious accidents, though rare, have long-lasting health, environmental and social

consequences, and nuclear facilities raise security concerns; decommissioning and uranium supply are further considerations that the sources cited here do not quantify. Solar and wind add intermittency and storage needs, and all four technologies need high initial investment and have impacts in manufacture, construction, operation and decommissioning, so their relative ranking depends on the assessment method and local conditions [24], [25].

5. COMPARATIVE TECHNICAL AND ENVIRONMENTAL ASSESSMENT

5.1 Basis of Comparison

Comparisons are meaningful only when figures share a boundary, so Table 3 keeps six distinctions apart: lifecycle emissions (manufacturing to decommissioning) against operational emissions, which are close to zero for all four technologies except for methane and carbon dioxide from some reservoirs; land occupation against total project area; water withdrawal against consumption; installed capacity (a rating) against generation (what is delivered); dispatchable against variable generation (solar PV, wind and run-of-river hydropower); and direct against indirect impacts, and short-term effects against long-term liabilities such as waste, decommissioning and sediment. Where no reliable comparable figure was found, a cell is qualitative or omitted. Direct impacts are tabulated, and indirect and long-term ones are discussed in Section 5.2.

Table 3. Comparative assessment of solar PV, wind, hydropower and nuclear generation.

Criterion	Solar PV	Wind	Hydropower	Nuclear
Lifecycle emissions (gCO_2e/kWh; median, range) [a]	Utility-scale 48 (18–180); rooftop 41 (26–60) [20]	Onshore 11 (7–56); offshore 12 (8–35) [20]	24 (1–2,200); upper end reflects some reservoirs [20]; reservoir emissions in [31]	12 (3.7–110) [20]
Land requirements	Utility-scale PV occupies land exclusively; rooftop PV needs none; intensity depends on whether panel area or site area is counted [42], [30]	Large project area, small physical footprint; land between turbines can often keep other uses [30]	Inundation is highly site-specific and among the largest per unit of electricity; Bakun flooded roughly 700 km^2 [30], [37]	Smallest site footprint per unit of electricity in comparative studies [30]; excludes mining and waste repository
Operational water consumption (m^3/MWh) [b]	Negligible: median about 0.004 (range 0–about 0.019) [29]	About 0 [29]	Reservoir evaporation dominates: median about 17 (range about 5–68), strongly site-specific [29], [43]	About 2.5 with cooling towers; about 1.0 once-through, with large withdrawals [29]
Waste generation	End-of-life modules; recycling feasible but still developing [24], [25], [26]	Composite blades are an emerging stream (not reviewed in the sources cited)	Little operational waste; trapped sediment and flooded biomass [23]	Small volume, but long-lived spent fuel and radioactive waste need very long-term management [19]
Dispatchability and grid integration	Variable; dispatchable only with storage; needs forecasting, flexibility, storage and network reinforcement [16], [17]	Variable; not dispatchable; resource weak in Malaysia; integration needs as for solar [16], [17]	Reservoir and pumped storage dispatchable and flexible; run-of-river depends on flow [23]; long transmission from remote sites	Firm continuous output; limited load-following in practice [19]; large single units need large reserve margins

Capital investment and levelised cost [c]	About US$758/kW and falling; levelised cost 0.044 US$/kWh [21]	Offshore costlier than onshore; levelised cost onshore 0.033, offshore 0.075 US$/kWh [21]	About US$2,806/kW; site-specific, long-lived assets; levelised cost 0.057 US$/kWh [21]	Very high capital cost, long construction and cost-overrun risk [22]; levelised cost not given by the same source, wide range [22]
Environmental and social impacts	Land-use change and habitat loss; manufacturing and end-of-life burdens; land access and compensation	Bird and bat collision risk [27], [28]; noise, visual effects and siting conflict	River fragmentation, inundation, sediment trapping, fish migration, reservoir emissions [23]; displacement, loss of livelihoods, indigenous rights [32], [37]	Radiological risk (accident, waste); thermal discharge; mining impacts; public acceptance, trust in regulators, intergenerational liability

Notes. [a] Medians and minimum–maximum ranges of the harmonised literature in IPCC AR5 [20], which gives medians of 820 gCO_2e/kWh for coal and 490 gCO_2e/kWh for natural-gas combined cycle; newer PV studies generally report lower values, but none has been substituted. [b] Operational consumption medians from United States studies [29], converted from gal/MWh (1 gal = 3.785 L): utility PV 1; hydropower 4,491 (range 1,425–18,000); nuclear 672 with cooling towers and 269 once-through. They depend on cooling technology and climate and are indicative only for Malaysia. [c] Global weighted averages for projects commissioned in 2023, in 2023 US dollars; not Malaysian figures, and excluding storage, grid reinforcement and system integration costs. Nuclear energy is low-carbon but not renewable.

5.2 Interpretation

Emissions. At median values all four technologies emit far less over their lifecycle than the fossil alternatives (820 gCO_2e/kWh for coal and 490 for gas combined cycle [20]); the differences among the four medians (11 to 48) are small by comparison and depend on assumptions such as the carbon intensity of the electricity used in manufacturing. Hydropower is the exception to the median comparison: its range extends to 2,200 gCO_2e/kWh, above both fossil medians, because reservoirs in warm, forested regions can emit substantial methane and carbon dioxide [31], [23]. In tropical Malaysia, the low end of the range cannot be assumed for a new reservoir.

Land, water and cost. Direct land use is lowest for nuclear and among the highest, per unit of electricity, for reservoir hydropower, with solar PV and wind between them and strongly dependent on the counting boundary [30]; rooftop PV, which Malaysian households are adopting [35], avoids additional land demand. Solar PV and wind consume almost no water in operation, nuclear plants with cooling towers consume several cubic metres per MWh (once-through cooling withdraws large volumes but consumes less), and hydropower is dominated by reservoir evaporation, which varies by site [29], [43]. The 2023 global averages place onshore wind, solar PV and hydropower within a narrow band of levelised cost [21], but levelised cost omits system costs: variable sources need storage, flexible generation and network reinforcement, and capital-intensive options are sensitive to the cost of capital. Nuclear new-build costs vary widely by country and have been subject to overruns [22]; no verified Malaysian levelised cost for nuclear power was available to the authors, and none is claimed.

Capacity, generation and dispatchability. Capacity factors differ between technologies; IRENA reports a global average of 16% for solar PV in 2023 [21], so a gigawatt of installed solar PV delivers much less energy than a gigawatt of firm capacity. Solar PV accounts for about 269 GW of Malaysia's almost 290 GW technical renewable potential [5, p. 32], so a high renewable share implies a large variable component and therefore storage, flexible generation, stronger transmission and demand management [16], [17]. Capacity is reported separately for Peninsular Malaysia, Sabah and Sarawak [1], and the flexibility of Sarawak's hydropower cannot be assumed to firm up solar output in Peninsular Malaysia without transmission between them. Nuclear

power would provide continuous output but requires legal, regulatory and human-capacity infrastructure and a long lead time.

Indirect effects and trade-offs. The figures in Table 3 mostly capture direct and near-term impacts. Supply-chain mining, grid reinforcement, sediment accumulation, spent-fuel storage and decommissioning are long-term or indirect, only partly quantified in the sources cited, and the impacts most likely to fall on future generations; they are addressed through *amanah* and *khalifah* in Section 6 and not through the numbers. The evidence therefore shows trade-offs, not a ranking. Solar PV is cheap and uses little water but is variable and land-demanding; wind has low lifecycle emissions but a weak Malaysian resource; hydropower is dispatchable but can impose the heaviest local social and ecological costs; and nuclear is firm and compact but carries long-lived waste, accident risk, high capital cost and an infrastructure burden. A coastal island with no grid may favour solar and storage [36], a forested valley inhabited by indigenous communities makes hydropower far more costly in social terms, and the weight given to long-term liabilities determines how nuclear power is judged. The choice is therefore not settled by engineering data alone: it depends on how criteria are weighted and whose interests are counted, and an explicit ethical framework can make that weighting transparent.

6. ISLAMIC ETHICAL ANALYSIS

This section distinguishes five levels of authority: what the Qur'an states, what Hadith report, how classical scholars interpreted both, what contemporary scholars argue, and, weakest of all, what the authors infer in applying these principles to modern energy systems. None of the texts discusses solar, wind, hydro or nuclear technology, so every application below is analogical and is labelled as the authors' reading.

6.1 Qur'anic Foundations and the Diversity of Tafsir

Humankind is described as *khalifah*, a trustee placed on earth (Q 2:30); resources are an *amanah* held for present and future generations (Q 33:72); creation is ordered and balanced, *mizan* (Q 55:7–9); and Q 2:195 and 30:41 warn against self-inflicted ruin and *fasad* (corruption and destruction). In the authors' application, stewardship means developing resources for human welfare while preserving the conditions that sustain life; the trust supports transparent decision-making, impact assessment and accountability when projects cause harm; balance is upset by excessive exploitation; and pollution, deforestation and ecosystem destruction fall within *fasad*. Some environmental disruptions have natural as well as human causes, so claims about the human contribution to a particular disruption should rest on scientific evidence and not on scripture. Table 4 sets out, for each verse, its context in the commentaries consulted, the ethical concept it supports and the authors' application; only the last column is the authors' extension.

Table 4. Qur'anic texts used in this paper: original context, ethical concept and the authors' application.

Verse	Original context in the commentaries	Ethical concept	Authors' application to energy
2:30	Humankind appointed *khalifah*; the angels' question and God's reply [3]	Stewardship, responsibility	Decision-makers hold delegated responsibility for developing resources
0.19722	Signs in creation as proof of God's oneness [3]	Reflection on creation and its benefits	Invites study of nature; not a statement on technology
0.21875	Spending in God's cause; avoiding self-ruin [3]	Avoiding self-inflicted harm	General warning against irreversible environmental harm
21:30	Heavens and earth parted; water as the origin of life [3]	Water as the source of life	Care in water use and protection in hydropower schemes

17:26–27; 7:31; 6:141	Spending, eating and the use of crops without squandering or excess [3], [4]	*Tabdhir*; *israf*	Demand restraint and efficient use of electricity
30:46; 51:1	Winds as heralds of rain and for sailing (30:46); an oath by the winds in a surah on the Hereafter (51:1) [3], [4]	Gratitude for natural blessings (30:46); none used (51:1)	Responsible use of wind; no direct statement about turbines; 51:1 not used as evidence
10:5; 25:61	Sun and moon for reckoning time; the "great lamp" is the sun [3]	Reflection on creation	Responsible use of the solar resource; no statement about technology
30:41:00	Corruption has appeared on land and sea through what people's hands have earned; commentators differ on the meaning of corruption [3]	*Fasad*; consequences of human action	Prevent ecological destruction; human contribution to any given disruption must rest on scientific evidence
55:7–9	Balance set in creation; do not transgress the balance; commentators differ on distribution [3]	*Mizan*	Ecological balance and fairness in distribution
33:72	The trust offered to heavens, earth and mountains and borne by humankind; commentators differ on what it comprises, Ibn 'Abbas reading it as obedience [3]	*Amanah*	Accountability of those who decide
5:8; 60:8	Standing firmly for justice even towards those one dislikes [3]; kindness and justice towards non-Muslims who have not fought the believers, a verse some early authorities held abrogated or limited and most held in force [44]	*'Adl* (justice)	Duties of justice to all affected communities, whatever their religion

Commentators differ even on central concepts. On Q 2:30, al-Tabari [45] explains *khalifah* as one who takes the place of another and records reports that the jinn had inhabited the earth before humankind; al-Qurtubi [44] identifies the *khalifah* with Adam as God's vicegerent and uses the verse to discuss the obligation to appoint a leader; Ibn Kathir [3] reads it as people succeeding one another across generations; and contemporary writers extend it to delegated responsibility for the earth [8]. On Q 2:195, early authorities tie the verse to spending in God's cause [3], so extending "ruin" to environmental harm is a later analogical reading. On Q 7:31, Ibn Kathir [3] links the verse to circling the Ka'bah naked and to eating and drinking without excess, and treats Q 6:141 under extravagance, so the extension to electricity is again analogical. On Q 60:8, al-Qurtubi [44] records that some early authorities held the verse abrogated or limited to particular groups, while most held it in force. Where classical commentary is silent on a modern technology, the paper reasons by analogy from the principle and not from the verse.

6.2 Hadith Foundations

Hadith bear on the same concerns, and narrations are paraphrased with collection numbers and gradings as given on sunnah.com. Narrations from the two *Sahih* collections are relied on directly, and those graded weak serve only to corroborate a Qur'anic text. *Sahih al-Bukhari* 2320 and *Sahih Muslim* 1553 [10] report that when a Muslim plants a tree or sows a crop and a person, bird or animal eats from it, it counts as charity, linking stewardship with continuing public benefit. *Sahih Muslim* 35b [10] lists the removal of what is injurious from the path as the humblest branch of faith, supporting the removal of public hazards as an ethical duty. *Sahih al-Bukhari* 893 and *Sahih Muslim* 1829 [10] hold each person answerable, as a shepherd, for his flock, which grounds the accountability of those who decide. *Sunan Abi Dawud* 3477 [10], graded sound (*sahih*) by al-Albani on sunnah.com, describes Muslims as partners in water, pasture and fire; whether it extends to modern

energy infrastructure is the authors' analogy, suggesting at most that resources on which public life depends are not purely private goods. A narration telling believers to eat, give charity and dress without extravagance is reported by al-Nasa'i (2559) and Ibn Majah (3605) [10] and graded weak (*da'if*) by Darussalam on sunnah.com for both, so it corroborates Q 7:31 and does not stand alone; a narration often quoted to forbid wasting water even at a flowing river (Ibn Majah 425) carries the same grading and is not relied on. None of these hadith mentions energy technology, and their use here is by analogy.

6.3 Jurisprudence and Legal Maxims

Legal maxims (*qawa'id fiqhiyyah*), derived by jurists from the texts and from case law, guide reasoning and are not rulings, and each carries qualifications [11]. *La darar wa la dirar* (harm may be neither inflicted nor repaid with harm) is reported by Ibn Majah (2340) with a chain that Darussalam grades weak, and also by al-Daraqutni and, as a *mursal* report, by Malik in *al-Muwatta'*; al-Nawawi includes it as no. 32 of his Forty Hadith and describes it as *hasan* [41], and jurists treat it as a foundation of the law of harm. Its related maxim *al-darar yuzal* (harm is to be removed) supports removal and compensation, but the harm must be real or sufficiently probable. *Dar' al-mafasid muqaddam 'ala jalb al-masalih* (preventing harm takes precedence over securing benefit) applies when harm and benefit are of comparable weight and the harm is real. It is not a blanket precautionary principle: it argues for caution where harm would be severe, irreversible or long-lasting, as with radioactive waste, but does not by itself prohibit a technology whose harms are serious yet manageable and whose public benefits are large. *Al-mashaqqah tajlib al-taysir* (hardship brings ease) supports access and affordability, for example electricity for remote communities [36], but cannot justify avoidable harm to others. *Yutahammal al-darar al-khass li-daf' al-darar al-'amm* (a private harm is tolerated to prevent a public harm) bears on land acquisition and resettlement, but does not authorise uncompensated loss, because necessity, proportionality and fair compensation are conditions. *Maslahah mursalah* (a considered public interest not addressed by a specific text) is accepted with conditions chiefly by Maliki and Hanbali jurists and debated elsewhere [11]; the interest must be genuine, general and not contrary to a text, which supports decisions grounded in impact-assessment evidence. Table 5 shows how these maxims frame five recurring energy issues, and its qualifications column states the limits of each, so the table guides questions and does not issue verdicts.

Table 5. Application of legal maxims to five energy issues.

Issue	Principles engaged	Questions raised	Qualification
Land acquisition for solar farms	*La darar wa la dirar*; *maslahah*; private harm tolerated for public benefit	Is compensation fair? Were owners and users consulted? Is agricultural land or forest being displaced?	Public benefit does not remove the duty of compensation and consultation
Environmental damage from dams	*La darar wa la dirar*; *al-darar yuzal*; *fasad*; *mizan*	Is the damage avoidable? Has it been removed or compensated? Were less harmful alternatives weighed?	Depends on the scale and reversibility of harm and on the benefit gained
Wind turbine impacts on wildlife	*Fasad*; *mizan*; *la darar wa la dirar*	Can siting and mitigation reduce collision risk [28]?	Limited, mitigable harm may be proportionate to the benefit
Nuclear safety and radioactive waste	*Dar' al-mafasid*; *amanah*; *hifz al-nafs*	Can harm be bounded? Who is liable over very long periods?	Severity and irreversibility argue for caution; low emissions are a benefit; qualified scholars may differ
Energy affordability and access	*Maslahah*; *al-mashaqqah tajlib al-taysir*	Are access and tariffs fair, including for remote communities [36]?	Ease for hardship must not come through avoidable harm to others

6.4 Israf, Maslahah, Maqasid al-Shariah and Intergenerational Responsibility

The prohibition of wastefulness (*israf*, Q 7:31; *tabdhir*, Q 17:27) is the most direct link between a Qur'anic text and energy practice, and it remains an analogy: reducing unnecessary demand and improving efficiency are ethical as well as economic goals, and new renewable capacity does not justify wasteful use. *Maslahah* (public interest) asks whether supply is reliable and affordable, development is served, and health and environment are protected; a project that gains economic benefit by imposing serious, unfair harm on communities fails the test. The five classical objectives of Islamic law (*maqasid al-shariah*) are the protection of religion (*hifz al-din*), life (*hifz al-nafs*), intellect (*hifz al-'aql*), lineage (*hifz al-nasl*) and wealth (*hifz al-mal*), traced in legal theory to al-Ghazali and developed systematically by al-Shatibi, who classified interests as necessities, needs and refinements [12]; contemporary reformulations broaden their scope [13], [14]. Energy bears most directly on life (health, safety, air quality) and wealth (economic security), hence the two sub-questions in Section 2.2. Whether environmental protection is an independent additional objective is contested: some contemporary writers argue that it is a religious obligation rooted in the objectives of the law, while others treat it as a means of safeguarding the existing five [40]. This paper takes the conservative position and treats environmental protection as a dimension of protecting life, wealth and progeny. Likewise, intergenerational responsibility follows from the trust (*amanah*) and stewardship (*khalifah*) of Section 6.1 and, on a contemporary reading that some writers adopt, from *hifz al-nasl*; that reading of future generations' welfare is not part of the classical definition.

6.5 Contemporary Positions, Scholarly Diversity and Status of the Framework

No fatwa issued by the Malaysian National Fatwa Committee, a state fatwa authority or the International Islamic Fiqh Academy that specifically addresses the choice among solar, wind, hydropower and nuclear generation is cited or claimed; searches of publicly accessible sources found none, but fatwa portals were not searched exhaustively, so the absence of a ruling is not asserted. Broader documents exist: the *Islamic Declaration on Global Climate Change* [46], issued by Muslim leaders at a symposium in Istanbul in August 2015, calls on Muslims to take an active role in combating climate change and urges governments to conclude an effective climate agreement. It is a declaration, not a fatwa of a state or national body, and it does not settle the choice among technologies. Scholarly approaches also differ: textual approaches seek explicit evidence, classical jurists reason by analogy and maxims, *maqasid*-oriented scholars weigh outcomes against the objectives of the law [12], [13], and writers on Islamic environmental ethics stress stewardship and limits [6], [7]; some, such as Nasr [47], criticise the modern attitude to nature and technology, while others accept technological development under ethical constraints. For nuclear power, the authors distinguish in principle two analytical lines of reasoning, built from the maxims above and not documented positions of any institution: one stresses public benefit (*maslahah*) from low-emission firm power, the other prevention of harm (*dar' al-mafasid*) because of waste, accident risk and very long-term uncertainty. Neither follows automatically from the texts, and qualified scholars may reasonably differ. This diversity is why the framework poses questions and exposes trade-offs and does not issue answers: it is an analytical and normative tool, not a fatwa, a binding Shariah ruling or a substitute for qualified juristic deliberation, and its application to specific technologies is the authors' own reasoning, open to other readings.

6.6 Application to the Four Technologies

The principles bear differently on each technology, and the pairings below are the authors' application and not rulings. Solar power engages responsible use of an abundant resource (*khalifah*), fair treatment of land (*maslahah*, *la darar wa la dirar*) and manufacturing and end-of-life waste (*amanah*); wind engages care for wildlife and local communities (*fasad*, *mizan*); hydropower engages protection of water, forests and downstream livelihoods while securing supply (*la darar wa la dirar*, *fasad*, *amanah*, *maslahah*); and nuclear power engages the duty of care across generations for waste and safety (*amanah*, *hifz al-nafs*, *dar' al-mafasid*) against the benefit of low-emission, firm supply (*maslahah*). Nuclear power shows the difficulty most clearly: its low emissions serve *maslahah* and the reduction of fossil-fuel harm, but its waste and accident risks engage *amanah* and the protection of life across generations, and Islamic ethics does not settle this by itself. Recent work has also related Qur'anic environmental ethics to waste-to-energy technology [9].

7. ILLUSTRATIVE MALAYSIAN CASE: THE BAKUN HYDROELECTRIC PROJECT

Three Malaysian cases were considered: large-scale solar, Sarawak hydropower and the nuclear feasibility debate. Bakun was selected because its technical, environmental, social and policy record is the most fully documented in the peer-reviewed literature available to the authors [37], [38], [39], and because hydropower is the largest renewable source in Malaysian generation [1]; large-scale solar is documented chiefly in programme statistics [1], and nuclear power has no Malaysian project to assess. The application illustrates how the framework works. It is not an empirical validation or a full project evaluation, rests entirely on secondary sources, and uses no community testimony or primary observation. It is organised around six questions on which a hydroelectric project can perform very differently: electricity supply and energy security, regional and national benefit, local environmental impact, displacement, compensation and procedural justice, and long-term ecological responsibility.

7.1 Supply, Energy Security and Regional Benefit

Bakun is a reservoir hydropower project on the Balui River in the upper Rajang basin of Sarawak, with a concrete-faced rockfill dam [37]. The project was halted in 1997 during the Asian financial crisis and later revived, and impoundment began in 2010 [37]. It was originally planned in part to supply Peninsular Malaysia through a long undersea link, which was not built, and was later tied to the Sarawak Corridor of Renewable Energy (SCORE), a strategy to attract energy-intensive industry to the state [38]. Its installed capacity is 2,400 MW, about 70% of Sarawak's 3,452.0 MW of major hydro capacity at the end of 2021 (Section 3.3) [1]. Reservoir hydropower of this kind is dispatchable and flexible, but its output depends on rainfall and its value on the demand it can serve. The supply and industrial-development benefits accrue regionally and nationally [38] and are real contributions to energy security, separate from the question of who bears the costs. Published analyses question whether projected demand justified capacity of this size at the time of planning [37], [38]; verified cost–benefit figures are not cited here, so the economic assessment remains partly unresolved.

7.2 Local Environmental Impact

The reservoir flooded roughly 700 km² of forest and river valley [37], with the consequences described in Section 4 for habitat, sediment, water quality and fish migration. Reservoirs in warm, forested regions can emit methane and carbon dioxide [31], [23], and none of the sources cited here reports measured emissions for Bakun; its carbon intensity is therefore treated as relatively low in principle but unverified, and the low end of the range in Table 3 cannot be assumed. The literature also records disputes about the adequacy of impact assessment, consultation and mitigation [37].

7.3 Displacement, Compensation and Procedural Justice

Many people from indigenous Orang Ulu communities were relocated to the Sungai Asap resettlement area [37], [39]. The literature documents loss of land and livelihoods, difficulties of adaptation and disputes over compensation [39]. The World Commission on Dams [32] recommends informed participation and negotiated outcomes in dam decisions, and the disputes recorded in [37] and [39] concern how closely those procedures were followed. Two questions are therefore distinct: whether compensation was adequate, and whether affected communities took part in the decision on fair terms. The affected communities are largely non-Muslim. This does not weaken the ethical analysis, because the Islamic principles of justice and prevention of harm apply to all people affected by a decision (Q 5:8; 60:8).

7.4 Application of the Framework

Table 6 applies the framework's ten assessment questions to the case: the eight principles, with *maqasid al-shariah* assessed through its two sub-questions on life (*hifz al-nafs*) and wealth (*hifz al-mal*), plus the cross-cutting question on intergenerational responsibility (Section 2.2). Each is graded from the evidence cited, using the definitions and the rule on undocumented evidence in Section 2.2. No numerical scores are used, and the grades are not additive.

Table 6. Application of the Islamic ethical assessment framework to the Bakun hydroelectric project.

Principle	Assessment question	Evidence in the case	Grade
Khalifah	Does the project demonstrate responsible stewardship?	Supplies dispatchable electricity from a domestic renewable resource [1]. Floods roughly 700 km² of forest and river valley [37]. Measured reservoir emissions are not reported in the sources cited [31], [23]	Mixed
Amanah	Are decision-makers accountable for long-term consequences?	Disputes over consultation and compensation are documented [37], [39]. Arrangements for long-term dam safety, sediment and decommissioning liability are not documented in the sources cited, and that part of the question is unresolved	Concern
Mizan	Does the project maintain ecological balance?	River regime, habitat and sediment are altered [37]. Reservoir emissions are possible and unmeasured [31], [23]	Concern
Israf	Does it encourage efficient resource use?	Published analyses question the match between capacity and demand [37], [38]. This is questioned but not established, and demand-side measures are not documented	Unresolved
Fasad	Does it create avoidable environmental destruction?	Forest flooding is documented [37]. Whether less damaging alternatives (other sites, smaller or run-of-river schemes, other sources) were weighed is not established in the sources cited	Unresolved
Maslahah	Does it deliver equitable public benefits?	Benefits (electricity, industrial development) accrue regionally and nationally [38]. Costs fall on a small group of relocated communities [39]	Mixed
Maqasid*: *hifz al-nafs	Does it protect human health and safety?	Dam safety record and health outcomes of resettlement are not documented in the sources cited. Adaptation difficulties are documented [39] but are not health-specific evidence	Unresolved
Maqasid*: *hifz al-mal	Are economic resources used responsibly?	Large capital commitment. Livelihoods lost [39] (assessed under *maslahah* and *la darar wa la dirar*). Verified cost–benefit data are not cited	Unresolved
La darar wa la dirar	Is harm prevented or removed, and are those harmed compensated?	Loss of land and livelihoods and disputes over compensation are documented [37], [39]. Negotiated outcomes are the recommended standard [32]	Concern
Intergenerational responsibility (cross-cutting)	Are future generations protected from unacceptable liabilities?	Long-lived asset, relatively low-carbon in principle but unverified [1]. Against this, reservoir emissions, sediment, lost biodiversity and cultural loss are lasting [37], [39]	Mixed

Three of the ten questions are graded *mixed*, three *concern* and four *unresolved*, and none is graded *supports*. This does not mean the project has no merits: where a benefit exists, the evidence also records an adverse effect or leaves a gap, so the benefit appears under *mixed* and not *supports*.

7.5 Overall Assessment

The project supplies dispatchable electricity from a domestic renewable resource, contributes to regional and national development, and has a long asset life. Against this, its costs are concentrated on relocated indigenous communities and on forest ecosystems; disputes over consultation and compensation are documented;

accountability for long-term consequences is not clearly documented; and the match between capacity and demand has been questioned. Climate benefit must be weighed against local ecological and social loss, regional benefit against concentrated harm, and early economic development against long-term liabilities, and evidence is missing on reservoir emissions, dam-safety arrangements, the consideration of alternatives and verified economics. The case shows why technical performance does not settle ethical acceptability: a project can supply reliable, relatively low-carbon electricity and still raise serious questions of justice, accountability and ecological responsibility. It also shows the reverse, that environmental and social costs do not by themselves make a project entirely unacceptable, and that the four unresolved questions call for further evidence.

The framework points to a review of compensation and benefit-sharing for affected communities, independent monitoring of reservoir emissions and sediment, published dam-safety and decommissioning arrangements, and support for restoring livelihoods. For similar projects it points to a documented comparison of alternatives, free, prior and informed consent where indigenous rights are affected, transparent impact assessment with independent review, demand justification, and a named body accountable for long-term liabilities. The assessment does not conclude that the project is Islamic or un-Islamic. Bakun is already built, and the practical questions are remediation, benefit-sharing, safety and lessons for later projects; the purpose is to show how the framework makes trade-offs visible so that decision-makers, affected communities and qualified scholars can discuss them openly.

8. IMPLICATIONS FOR MALAYSIAN ENERGY POLICY

The implications below follow from Sections 5 to 7 and are classified as technical, policy (regulatory or institutional) or ethical (value-based). Malaysian law requires environmental impact assessment for prescribed activities [48], but this paper does not claim that existing legislation requires an Islamic ethical assessment: the proposals are voluntary, normative complements to existing procedures, offered for consideration and trial because the framework is conceptual and unvalidated (Table 7). They fall into three themes. *Planning and assessment* (proposals 1, 2 and 5): rankings in Section 5 change with criterion and site, so planning based on technical and economic analysis alone leaves the weighting of values implicit, and making it explicit is the framework's main contribution. *Participation and justice* (proposal 3): the clearest Bakun concerns lay in compensation, consultation and concentrated costs (Table 6, *la darar wa la dirar* and *maslahah*). *Long-term accountability* (proposals 4, 6, 8 and 9): the liabilities with the longest horizons (dam safety and sediment, module waste and, if ever considered, radioactive waste) are those for which Table 6 found accountability least documented, and demand restraint belongs here because Section 6.4 treats efficient use as a first-order duty.

Table 7. Policy implications for Malaysia, by type.

No.	Recommendation	Type	Basis in this paper
1	Consider including Islamic ethical questions in national energy planning alongside technical analysis, with the participation of qualified scholars, initially as a pilot	Ethical; policy	Sections 2.2, 5.2 and 6; roadmap targets are technical and economic [5]
2	Improve environmental and social impact assessment: alternatives analysis, cumulative impacts, measured reservoir emissions, independent review	Policy	Sections 5.2 and 7; Table 6 (*fasad*, *mizan*)
3	Strengthen participation and community consultation, with free, prior and informed consent where indigenous rights are affected, fair land acquisition and compensation, and benefit-sharing; protect river ecosystems and communities through siting and alternatives	Policy; ethical	Sections 7.3 and 6.3; Table 6 (*la darar wa la dirar*, *maslahah*) [32]
4	Develop responsible solar PV recycling and waste-management systems	Technical; policy	Section 4 [24]–[26]; *amanah*
5	Improve grid integration and storage for variable renewable energy, including transmission between regions	Technical	Section 5.2 [16], [17]

6	Assign named accountability for long-term liabilities (dam safety, sediment, decommissioning, waste), and before any nuclear option is considered, assess waste, liability and regulatory capacity explicitly	Policy; ethical	Sections 5.2, 6.3 and 7.4; Table 6 (*amanah*)
7	Incorporate *maqasid*-oriented considerations into sustainable development assessments	Ethical; policy	Section 6.4 [40]
8	Pair supply expansion with demand-side efficiency, since new capacity does not justify wasteful use	Technical; policy; ethical	Section 6.4; Table 6 (*israf*)
9	Require independent environmental monitoring with public reporting, for example of reservoir emissions and sediment and of bird and bat collisions at wind sites	Technical; policy	Sections 4 and 7.5 [23], [27], [28]

9. THEORETICAL AND PRACTICAL CONTRIBUTIONS

The study contributes in four ways and does not claim to be the first of its kind. *Theoretically*, it connects four low-carbon technologies, one of them non-renewable, with Islamic environmental ethics, keeps the distinction between renewable and low-carbon sources explicit, and separates what the Qur'an and Hadith state, what scholars interpret and what the authors infer. *Methodologically*, it proposes a conceptual, normative framework in which each of eight principles has a stated textual basis, scope and practical question, graded on a four-category scale with the reasoning stated and absence of evidence recorded as *unresolved*, and with technical figures reported by year, unit and boundary. *Practically*, the Bakun illustration shows that a project can deliver reliable electricity while raising unresolved ethical questions, and the assessment questions can be put to any proposed project. *For policy*, it offers the nine voluntary proposals in Table 7. The framework has not been empirically validated or tested with other assessors.

10. CONCLUSION

This paper set out to compare four low-carbon generation technologies, develop an Islamic ethical assessment framework, illustrate it with the Bakun project and draw out implications for Malaysian energy policy. The comparison shows that solar PV, wind, hydropower and nuclear power all have much lower median lifecycle emissions than coal and gas but differ in land, water, cost, dispatchability and grid requirements, and no technology is superior on every criterion. For Malaysia, solar PV dominates the technical renewable potential and therefore raises storage and grid questions, wind is limited, hydropower raises the sharpest social and ecological questions in the case studied, and nuclear power, which is not renewable, raises the sharpest questions of trust across generations. The framework turns eight principles, with intergenerational responsibility as a cross-cutting consideration, into questions that can be put to any project; its value lies in making the weighting of values visible and in separating textual authority from the authors' application. The Bakun application returned a mixed profile, with benefits in supply and development, concerns over ecological balance, compensation and accountability, and several questions left unresolved for lack of evidence, and it reached no verdict on whether the project is acceptable. For Malaysia, the main implications are better impact assessment, fair compensation and participation, responsible waste management, grid and storage investment, independent monitoring and named long-term accountability, proposed as voluntary complements to existing procedures. Reducing waste in electricity use belongs to the same responsibility as building new capacity.

10.1 Limitations

This study is conceptual and depends on published secondary sources. It reports no primary stakeholder interviews and no empirical validation, and it did not use a systematic search, so relevant literature may have been missed. The framework's grades are the authors' reasoned judgements from published sources and have not been tested with other assessors, so another reader might grade some questions differently. Lifecycle assessments rest on varying assumptions, so the figures in Table 3 are indicative and, where the system boundaries of the sources differ, cannot be compared exactly; international figures do not necessarily describe Malaysian conditions. The latest official Malaysian capacity and generation data available to the authors refer

to 2021, and policy targets may change. Islamic scholarship is diverse: the interpretations offered here rest on selected sources and are open to other readings, no qualified jurist has reviewed them, and the Qur'anic translation used is dated in style. The case study rests on secondary sources and covers one project, and Malaysia has no nuclear project to which the framework could be applied.

10.2 Future Research

Future work could consult experts and stakeholders, including qualified Islamic scholars, engineers, regulators and affected communities, and test whether independent assessors grade the framework's questions consistently. Multicriteria decision analysis could test how different weightings change the ranking of options, and the framework could be combined with Malaysia-specific lifecycle assessment and cost analysis and applied to further Malaysian cases, such as large-scale solar and other Sarawak hydropower projects.

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