Improving Energy Literacy

The Commonwealth Sustainable Energy Transition Agenda

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The Commonwealth

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Introduction

This report identifies a path to improving energy literacy across the Commonwealth, with a particular perspective on the needs of small states and developing countries. The objective is to identify a path to improve overall awareness and literacy that will underpin a transition to diminished climate impacts from energy production and use supported by decision-makers and consumers. 'Energy literacy' in this report reflects not only improved understanding of the role and operation of energy 'systems', but support for public and private investment in the long-term transition to climate-friendly technology that continues to support consumer demand and economic growth.

The nature of the energy system demands large investments in generation technology as well as delivery networks that are land intensive, all of which imply continuous operational oversight and management. In other words, energy is an ongoing, never-ending commitment to the acquisition of fuels, maintenance, and upgrading of both supply and demand elements from providers to consumers.

Literacy in this arena implies an understanding and awareness of the costs, both direct and indirect, of providing and using energy, but also the benefits of using and conserving energy – currently and over time. The challenge for distilling and conveying this knowledge in clear and useful ways falls primarily on the public sector, where long-term decisions about system design and investment are made. The challenge for interpreting and living with the characteristics of this system falls on consumers, who typically make decisions at infrequent intervals (when purchasing appliances or other durable goods) or build them into routines that reinforce conservation at a personal level (in terms of heating and cooling temperatures, lighting etc.).

Improving energy literacy is a fundamental precursor to changes in energy systems, whether at the local or regional level. However, a more informed and focused type of energy literacy, organised around investments in new reliable and high-performance technology, will be necessary at the policy-making and regulatory levels, and must be delivered with the support of the consumers – who will ultimately bear the costs of this endeavour.

In the following sections, we identify the nature of assessing and improving energy literacy in both categories and highlight the challenge of adapting existing systems in terms of policy, consumer incentives and regulatory institutional design. Commonwealth countries vary considerably in terms of economic and demographic characteristics but share a desire to design responsive and affordable energy systems that minimise associated climate impacts.

The primary tools we highlight are the sequential improvement in understanding energy systems' performance and costs for decision-makers and consumers, followed by planning criteria for investment, and ultimately operation of transitional and hybrid systems where consumer support is critical.

Overview – Literacy and Public Support

There is a clear link between literacy and public support. The nexus is that there is a critical link between that support to policy changes, investment in system design and finally, consumer action both passively (behavioural changes) and actively (willingness to pay higher rates or support public debt) for policy changes. Over the years and through different contexts, several tools and institutional relationships have been used to increase literacy. In broad terms, they include:

- educational institutions
- public sources of information and education
- utility education programmes
- utility consumer awareness briefs (billing and data)
- billing incentives and disincentives
- public service announcements.

It is difficult to ascertain successes and failures of each tool individually, although combining groups and cross-industry/government collaboration has demonstrated a higher level of trust and success. Timing, context and execution affect the impact of such campaigns. Nevertheless, in our recommendations, we analyse the potential of various tools and techniques with specific focus on illustrative examples. The aim is to suggest a roadmap that includes best practice and guidance for broad-scale integration into different economic systems.

1. Energy and Energy Literacy

While energy may be ubiquitous, the systems that supply energy in its countless forms are complex and dependent on a network of science, engineering, economic markets and public regulation to satisfy demand and develop and maintain physical structures and supply capability. Consumers primarily see price signals, but not the connection between sources of energy (fuels) and the technology that delivers energy or the direct benefits of either conservation or the connection of energy to shifts in climate.

Inevitably, finding ways to satisfy consumer demands while reconciling competing interests and challenges falls under the purview of government officials. The nature of literacy in this context is similar but distinct between public decision-makers and consumers.

In the simplest terms, 'energy literacy' is 'an understanding of the nature and role of energy in the world and in our lives' (EERE, no date). Energy literacy is also the ability to apply this understanding to answer questions and solve problems. Accordingly, an energy-literate person:

- can trace energy flows and think in terms of energy systems
- knows how much energy they personally use, for what and where that energy comes from
- can assess the credibility of information about energy
- can communicate about energy and energy use in meaningful ways
- can make informed energy and energy-use decisions based on an understanding of impacts and consequences
- has developed tools to continue to learn about energy throughout their life (EERE, no date).

In general, energy literacy for consumers is based on whether households can make a trade-off between long-term savings from energy efficiency investments and the upfront investments that are required to achieve improvements in energy efficiency. However, at the societal level, energy literacy is embedded in the choices decision-makers and investors make for system design and operation.

For instance, the average electricity price in a given country not only reflects the *system* operating costs, but the operating costs of appliances, the savings potential of lighting technology as well as individual behaviour in the context of energy efficiency.

The outcome, then, is that the four main components of energy literacy are basic *knowledge about energy and energy production*, *attitudes about energy*, *behaviour change* and *financial knowledge*.

Efforts to increase energy literacy are not abstract or theoretical. A more energy-literate society will ultimately lead to tangible change in core technology and ongoing impacts to lower carbon emissions and local or regional climatic conditions. The benefits overall can be more informed decisions for policy-makers and consumers, improved security and reliability of operations, and improved economic conditions. Unfortunately, the transition to more climate-friendly technologies and fuels can lead to higher consumer costs and a concomitant demand for more responsive conservation in energy demand.

Humans make individual, community, national and international energy decisions. In the case of technology-centric energy systems, past decisions by governments, corporations and individuals define the efficiency of the existing system and the limits to adjusting climate-affecting impacts. Investing in alternatives is expensive and involves long-term commitments of investment (for technology, land, fuel contracts etc.) and consumer support.

2. The Nature of Energy and Energy Systems

Energy in all forms is fundamental to life at every level. Access to reliable, affordable and ultimately low-impact fuels and energy delivery is critical to continued economic resilience, comfort and security.

The nature of energy systems, however, is by nature and design complex. Ignoring this characteristic can result in inefficient, inadequate and overly costly investment decisions and consumer dissatisfaction. However, unnecessary or detailed conveyance of the system can result in confusion that undermines important decisions and changes to the technology necessary to transform and deliver energy to consumers at every level.

The challenge of achieving and sustaining high levels of understanding, literally improving the literacy of society, demands an understanding of the roles and potential for decisions and actions by both consumers and decision-makers or their representatives, such as regulators and utilities, and ultimately investors in critical technology and appliances.

Modern energy systems depend on *continuous* supplies of energy, whether it is from traditional hydrocarbon combustion or renewable resources such as hydropower, solar, wind or geothermal heat. In the case of depletable resources such as natural gas, this implies a continuous discovery of new sources and delivery to generators or consumers, while in the case of renewables, this implies a commitment to overcome periods of intermittency or changes in climatic conditions. All energy systems imply an environmental cost, whether in operation or in the construction and ultimate replacement of components, and in the case of renewable resources, a substantial investment in storage capacity. Finally, every energy system, especially hybrid operations that combine legacy technologies with newer lower-impact renewables, must be managed continuously by systems operators to ensure availability and reliability throughout the day.

This also means that systems of the future will be linked inexorably to open access to data regarding use patterns as well as costs for consumption, which in turn will reinforce the choices made at all levels from households to regional interconnection. Achieving broader social goals such as diminished impacts from use, and meeting climate-quality goals, will demand concomitant changes in technology and behaviour at all levels.

Consumers typically do not make changes in their demand in real time. They depend on the nature of installed appliances or in cases of transportation, on price signals for fuels that translate to overall impacts on flows of energy or indirectly on environmental impacts. At a social level, consumers depend on regulators and policy-makers to translate user preferences for access to getting energy in ways that are affordable, dependable and do not degrade the environment people live in.

Consequently, planning for energy supplies and system reliability depends on co-operation between decision-makers, investors, regulators, utilities and consumers themselves. Ultimately, consumer awareness, demand management and prudent long-term public investment determine costs and changes in behaviour and system performance. Obtaining, delivering and using energy wisely is a community-wide effort that *evolves* continuously over time. This process begins with the sharing of information.

Information in the form of data and experience underpins how consumers react to *choices* and costs of obtaining and using energy. A key source of this information is available in the bills for service supply (e.g. of natural gas, electricity, transportation fuels); however, the billing for monthly service charges is by definition lagged from use. Consequently, linking behaviour for any fundamental energy source (outside gasoline or diesel fuel purchases) is disconnected from actual use. Other consumer demands, such as for food, which internalise energy costs, are not *directly* associated with consumer behaviour. Key appliance purchases, such as washing machines or refrigerators, currently supply information about expected performance and cost. But once they are installed, they perform without intervention or change for long periods of time.

Thus, while energy is being consumed and paid for continuously, the link between the type of demand, the hours of use or the intensity of use, are difficult to connect directly to consumer behaviour. In many cases, awareness of the role of energy is only available or appreciated during changes in service level or quality, which can include severity of outages, changes in routine billing charges, or indirectly when air or water quality suffer from utility choices.

Ultimately, technology and wider regional controls will provide the keys for delivering the 'product', namely reliable, cost-effective and accessible energy supplies. These characteristics, matched to demographic, cultural and economic conditions within each of the member states, will ultimately dictate the design and the appreciation of the value of the various options available.

The challenge of meeting climate impacts through long-term changes in energy technology and consumer behaviour choices implies increased costs and focused investment in new technology, rights of way for transmission and storage capacity. A more detailed and technical discussion of energy development can be found in Appendix B.

3. Measuring Energy Literacy

The goal of addressing energy literacy is to increase awareness and knowledge of the basic dimensions of energy production and how transition impacts people's lives. The only way to track progress on energy literacy is to measure it over time. The practical outcome of this section will be a set of specific questions that have proved successful in measuring energy literacy and could be used to track progress.

3.1. End users and energy programmes

The availability of alternative programmes, subsidies, incentives or standards for technologies that offset or improve system operating characteristics are typically only broadly known or appreciated by consumers. A key reason for this lies in the fact that consumers, even those with time-of-use metrics or other tools, simply do not participate in moment-to-moment or day-to-day decisions about changing behaviour. In practice, this means that decisions to conserve or change ongoing behaviour impacts are made at the time of device purchase or point-of-sale, integrated into consumption patterns, and then operate autonomously until replaced or upgraded.

Many alternative programmes are available to control and measure energy use. These can have a dramatic and lasting effect on the billing, comfort and performance of consumer-scale demand. For instance, in many competitive markets, consumers may be offered a choice of generator or energy sources that reflect higher percentages of renewable energy sources, or less demand for imported fuels. Indirectly, consumers can influence their own demand patterns through the purchase of energy-efficient appliances, higher insulation of homes and businesses, and choice of low heat-loss windows, while public agencies can influence the adoption and enforcement of higher performance building standards.

This is also true for any utility-scale investment – such as in gas turbines, solar panels, wind turbines or geothermal wells. Once installed, they will continue to operate with the characteristics that reflect their level of performance as designed. Considering the nature of large-scale capital costs, replacement of these units does not typically occur until the end of their service lifetime, which can last 35–40 years or more. The consequence is that planning for system diversity is difficult and complex. Initially, it is limited to a high degree to fuels available or desired characteristics that are reflected in the choice of technology to serve current system demand while being flexible enough to serve future changes.

Because evidence of use is typically lagged (for example, bills for energy use may not be available for some time after billing periods end, which in turn are a reflection of decisions or weather patterns days or weeks past), matching behaviour to costs can be difficult. Worse, linking the choice of energy products to broad changes in weather, pollution or even indirect long-term concentrations of atmospheric agents such as CO_2 or methane, depends on information from experts or policy-makers that may be difficult to understand. The only proxy available is some cost reporting (billing) that also includes a measure of environmental performance. To the extent costs cannot be directly tied to negative environmental trends, some connection must be used that users understand and that will allow them to support or reward 'good' long-term changes in system design and operation.

Ultimately, this connection will only be established and maintained by sharing some measure of performance, or quality, that is routinely updated and reported to consumers who are bearing the cost, and enjoying the benefits of, energy availability. Technology and reporting tools are available to convey performance directly through devices such as time-of-use meters for electricity and gas consumption, and indirectly through programmes that encourage higher-performance building design, visible taxes or charges on polluting industries, or even subsidies and support for lower-impact appliances or vehicles.

3.2. The role of public support

Providing adequate, affordable and environmentally sustainable energy systems is a *process* that evolves and adapts over time. Often referred to as 'transitional', choices depend on records of past performance, changes in recent consumer behaviour, external impacts, decisions made in neighbouring or even distant regions, and forecasts of future needs. The costs imposed by these changes are accounted for in political and regulatory debate, subject to investment reactions and ultimately to consumer or public support for some intended future system. The process of identifying a path of transition and transformation of such a fundamental industry depends on unifying the diverse and often competing interests of actors from each of the above sectors, where information can be difficult to convey and understand.

There is no avoiding a complex discussion on energy, but there are established methods for introducing the concepts of energy resources and changes in technology. At the same time, energy systems of the future, whether built around improving existing technology or fuel choices, will rely on the integration of communication technology and energy availability. In short, technology and wider regional controls will provide the keys for providing the 'product', namely reliable, cost effective and accessible energy supplies. These characteristics, matched to demographic, cultural and economic conditions within each state, will ultimately dictate the design and appreciation of the value of the various systems that can be developed.

Emerging public goals broadly reflect a commitment to transition to longer-term, lower-impact fuels, waste disposal and responsive operation that still meet changing demands and consumer preferences. However, since installed energy systems of any scale are expensive and have long performance lifetimes, designs that emphasise future integration and utility prior to reaching the end of that lifetime will be supported much more readily than those demanding complete replacement of whole legacy installations.

As society weans itself from fossil-derived combustion turbines, replacement with alternatives such as renewable technologies demands innovation both in performance and in operation. At this stage, most renewable technologies do not monetise their environmental benefits, and consequently exhibit higher unit costs for their output. Convincing consumers that a change is appropriate, considering these costs, can be challenging.

This means that policy-makers must be the first movers and adopters of system designs and investments and must manage public literacy and support in such a way as to accept and adopt new designs and corresponding changes in demand behaviour.

Policy literacy is generally measured by policy knowledge or policy understanding (Jung 2008). In the existing literature, it is commonly hypothesised that *the greater the policy literacy of the public is on a given policy, the greater public support or acceptance there will be*. Policy-makers often rely upon public support to propose, and potentially adopt, certain policies. The argument is fundamental that the public's understanding of an issue will influence policy-making, both at inception or design, and finally in implementation.

There is a positive correlation between policy literacy and policy support. In the case of financial literacy, defined by the Organisation for Economic Co-operation and Development (OECD, 2011) as 'a combination of awareness, knowledge, skill, attitude, and behaviour necessary to make sound financial decisions and ultimately achieve individual financial wellbeing', this is in turn a key determinant of personal decisions regarding retirement, savings and investments. A related category of health literacy:

> *entails people's knowledge, motivation, and competence to access, understand, appraise, and apply health information in order to make judgments and take decisions in everyday life concerning healthcare, disease prevention, and health promotion to maintain or improve quality of life during the life course.*
>
> (OECD, 2011)

3.3. Measuring energy literacy

The goal of addressing energy literacy is to increase awareness and knowledge of the basic dimensions of energy production and how transition impacts people's lives. The only reliable way to track progress on energy literacy is to create a baseline and measure it over time.

It is evident from the body of knowledge about energy literacy, that creating a baseline and measuring change is key to successful future actions. While there is no common scale, methods of data collection were found to be similar. For instance, baseline surveys defining energy literacy in terms of knowledge, attitudes and behaviours are grounded in understanding the level of knowledge or awareness of basic systems available in each region or country, dominant uses of energy, costs of operation, and knowledge of the value or expected value of alternatives. Table 3.1 contains the set of characteristics and examples of common benchmarks in this area.

Ultimately, most analyses point to some positive links between literacy and policy support and even on behavioural change. Initiating and implementing transformational energy systems has varied in terms of design and success rates over the past

Table 3.1. A set of Considerations for Measuring Energy Literacy

Domain	General characteristics	Example of benchmarks
Cognition	1. Knowledge of basic scientific facts	- Definition/ forms of energy
	2. Knowledge of issues related to energy sources and resources	- Renewable and non-renewable resources
	3. Awareness of the importance of energy use for individual and societal functioning	- Society's need for energy
	4. Knowledge of general trends in a country and global energy resource supply and use	- Relative abundance of energy resources in a country/globally
	5. Understanding of the impact energy resource development and use can have on society	- Societal impacts related to energy resource development
	6. Understanding of the impact energy resource development/use can have on the environment	- Impact of developing energy on all spheres of the environment
	7. Knowledge of the impact individual and societal decisions can have related to energy resource development and use	- Importance of energy saving and improved efficiency of energy use
	8. Cognitive skills	- Ability to examine one's own beliefs and values
Affect	1. Concern with respect to global energy issues	- Values energy education
	2. Positive attitudes and values	- Prevention of societal problems related to energy use
	3. Strong efficacy beliefs	- Internal locus of control
Behaviour	*Predispositions to behave*	
	1. Willingness to work toward energy saving	- Considers energy impacts of everyday decisions
	2. Thoughtful, effective decision-making	- Evaluates pros and cons related to energy consumption
	3. Change advocacy	- Remains open to new ideas
	Behaviour	
	1. Willingness to work towards energy saving	- Exhibits energy-saving habits at home and in school
	2. Change advocacy	- Encourages others to make wise energy-related actions

Source: For general characteristics, Suryana et al (2020); for examples of benchmarks, DeWaters and Powers (2013).

three decades. Some examples include those discussed below.

California in the US represents the sixth largest economy in the world, supported by a vast and diverse energy system. The historic investment in this system has favoured hydrocarbon-sourced electricity, natural gas for heating and power generation, and both gasoline and diesel fuels for transportation. Recent legislation and regulatory incentives have focused on changing this calculus, emphasising a combination of reduced demand for energy by adopting energy-efficiency standards, incentives for electric cars to displace liquid fuelled vehicles, and a commitment to renewable electricity technology.

In this state, electric system restructuring begun in 1998 created a more competitive electricity market, introducing both consumer choice and opportunity for new merchant investment in generation and a system of incentives for integrating renewable fuel technologies and energy efficiency programmes. The ultimate goal was to lower prices and begin a transition to lower-carbon impacts and expand the information for consumers to improve behaviour behind the meter. Gradual improvements throughout the 'system' have resulted in more transmission capacity, higher renewable capacity in various regions, and general diminishment of higher-emission hydrocarbon generation, both domestic and embedded in imports.

Notable tools and techniques that have formed the basis of a commitment to de-carbonise the energy sector include the option of net-metering for self-generation of renewable electricity and **time-of-use meters** to improve user control of consumption. California has emphasised the **display of appliance performance** data (through Energy Star labelling) to allow greater choice in technology that is the base of long-term demand for electricity in buildings. Recent advances in wire technology have allowed greater use of integrated telemetry in power lines, adding support for investment in upgrades and expansion of the electric transmission system. This has ultimately increased the ability of the system operator to both utilise and firm-up renewable energy generation from remote areas.

California has designed and initiated several carbon content and energy-efficiency measures, many of which have been adopted by a combination of the federal government and selected states. These include the Corporate Average Fuel Economy (CAFÉ) rule for fuel efficiency in vehicles, the CARB (California Air Resources Board) fuel standard for gasoline and the LCFS (the Low Carbon Fuel Standard to regulate the carbon content of fuels), which is the basis for a carbon market trading scheme that supports exchanges between California and Ontario, Canada.

Texas is the number one US state in both crude oil and natural gas production. The state accounted for a staggering 41 per cent of America's oil production in 2019 and a quarter of its marketed natural gas output. Texas relies on fossil fuels for most of its power. Wind power increased in total capacity within the state. Texas produced about 28 per cent of all the US wind-powered electricity in 2019, according to the EIA, a significant point since almost a quarter (23 per cent) of the power in Texas in 2021 was generated by wind power, whereas combined cycle natural gas (40 per cent) and coal (18 per cent) generated more than half of the state's power in 2020, according to the state energy operator. In addition, Texas gets about 11 per cent of its power from nuclear (see Minton 2020).

The state of Texas is primarily an independent power grid (run by ERCOT, the electric reliability council of Texas), a decision made in the 1930s to keep the state clear of federal regulation. This isolation means that it avoids direct federal regulation, but also this unfortunately prevents the state from importing electricity during periods of high demand. This characteristic of independence is reflected in the ability of the state to focus on areas of renewable energy capacity, and direct incentives toward them to encourage development of technology and transmission capacity.

One outcome from the combined need for new capacity and a desire to limit carbon emissions has been the development of a concentrated area of wind turbine capacity in the eastern regions of the state, supported by a new network of transmission capacity. This has reduced average user costs, although it has not eliminated the need for storage and firming capacity, largely from natural gas.

As a result of trying to keep carbon emission rates low, the state was not prepared for freezing weather. In February 2021, the Texas electric grid failed during a cold wave, despite a concerted effort to integrate significant wind and transmission capacity in the eastern region of the state.

In other regions of the state where insolation intensity is high, incentives for distributed solar PV (photovoltaic) capacity have offset much of the core demand for natural gas and coal-fired electricity generation. However, a residual need for firming capacity means that wholesale replacement of legacy thermal generation means, as a practical matter, that this capacity is either idled or put in reserve status for periodic restarting.

Mexico is a large country combining a wide and diverse range of urban, suburban and rural population areas. The energy system has historically relied on hydrocarbons for primary energy use, which includes electricity, natural gas and transportation fuels. Recent emphasis on expanding the renewable energy capacity has focused primarily in the electricity sector, with the largest contribution from solar and wind, followed by regional investments in geothermal power and biomass conversion with a limited contribution from nuclear power in southern Mexico.

Mexico's 2012 Reforma (still in effect), or General Law on Climate Change, currently commits the country to generating at least 35 per cent of its power with clean technologies by 2024 and to reduce emissions by 30 per cent by 2020 and 50 per cent by 2050 when compared to 2000. However, current revisions to that legislation being advocated today intend to reverse the trend toward renewables in favour of native hydrocarbon-based generation and could increase Mexico's carbon emissions by 26–65 per cent.

Despite this, the adoption of the Deep Decarbonization Pathway in collaboration with other Latin American countries is providing a path to wean the country away from its strong state interest in hydrocarbons. Notable in this effort are attempts to adopt more energy-efficient building standards to lower demand from both rural and urban conurbations, and public investment in surface rail transportation to reduce automobile traffic. Traffic regulation in Mexico City has focused on rules that limit travel into and within the metropolitan area, and increased availability of charging stations and incentives for electric cars in the major cities. In northern Mexico, geothermal steam fields that are close to intertie connections with the US have been proposed for joint US/Mexico investment. These will provide electricity and grid support for the Southwest region of the US, offsetting high seasonal demand for natural gas-fired generation in the region.

Iceland is an island nation astride the Atlantic rift zone, with immense reserves of geothermal heat and hydropower capacity. The island imports gasoline and natural gas but is capable of using geothermal and hydroelectric facilities to meet most domestic consumption. However, in aggregate, per capita carbon impacts from energy use are high, in part because of the country's inability to meet all transportation needs with low-carbon fuels, and a limited role for regulatory solutions to price energy use in ways that influence demand and behaviour. Industries such as aluminium production that utilise geothermal electricity and then export the products, do not account for the carbon avoided in this production to the benefit of Iceland. Meanwhile, aircraft and marine vessels' fuel characteristics distort the impact of the base of low-carbon energy resources in the country.

Iceland's economy, ranging from the provision of heat and electricity for single-family homes to meeting the needs of energy-intensive industries, is largely powered by green energy from hydro and geothermal sources. The only exception is a reliance on fossil fuels for transport. Iceland offsets electricity demand for heating through direct heat delivered from geothermal power facilities using pass-through cooling water. In 2015, renewable energy provided almost 100 per cent of Iceland's electricity production, with around 73 per cent coming from hydropower and 27 per cent from geothermal power (Government of Iceland, no date).

Recent projects in Iceland are directed to managing the country's overall carbon footprint, which is driven primarily by vehicle fuels and emissions. This includes managing the use of the existing hydro and geothermal resources through the utilisation of reservoirs and pump storage facilities. Recent programmes to reinject carbon dioxide in silica-rich lava formations have created a new carbon sequestration market, as well as reduced the per capita impact of overall carbon waste.

The cities, and many of the outlying areas provide **convenient electric car chargers** and **enhance travel within the cities through on-demand electric scooters** that can be found widely available on most streets.

Canada represents a confederation form of government, with most governance issues, such as energy management, reserved to its ten provinces and three territories. Consequently, Canadian provinces generally operate energy facilities independent of each other; the incentives to develop fully integrated legacy hydrocarbon generation coincident with renewable technologies is limited. Most energy sales beyond domestic needs are exported to the US, exacerbating the maldistribution of cleaner resources such as hydroelectric generation, which is concentrated in the far west or east of the country. Carbon exchange is not consistently organised either between provinces or even across the country, where a notable example is the exchange agreement between Ontario (Canada) and California (US) based on carbon credits embedded in the Low Carbon Fuel Standard of California.

There are other lessons from these examples that address the combined challenges of meeting future demand with dependable systems that transition from hydrocarbon-based fuels to lower-impact renewable generation and lower-emission carbon grid technologies. In order to achieve any combination of these goals, and ensure consumer acceptance, the system itself must demonstrate a competitive ability for:

- **adaptability to local or regional conditions**
- **reliable and predictable performance**
- **scalability over time**
- **ability to overcome intermittency from solar and wind technologies**
- **ability to provide adequate storage and firming from more traditional technology**
- **ability to be dispatched to meet changing load characteristics**
- **ability to be seen as affordable when all benefits and costs are considered.**

This brief overview shows that many of the early examples/experiments listed above were not completely accepted or failed to perform technically. At least in part, this can be attributed to a factor that is difficult to control, namely the conflict between changing policy standards over time, and consequent reviews, revisions and redirection of regulatory standards that increase costs and uncertainty in financing incentives and support. Expanding access to energy systems (performance) and supplies (meeting demand) involves expansion and improvement of existing systems of fuel supply, technology, storage and delivery systems. To be successful, the evolution and transition to more modern technology and delivery capacity also depends on changes in behaviour and use patterns, and a general willingness to pay for more reliable or dispatchable supplies, matched with intelligent and timely conservation of the resource.

3.4. Outcomes of previous attempts to ensure energy literacy

A key driver of willingness to become literate or familiar with the challenges and availability of the next generation of energy systems ('the transition') is often driven by shortfalls in supplies, unreliable service, or sudden, unforeseen and sustained cost increases or surcharges. Transitions from older, less sophisticated energy systems have starkly affected public opinion, and corresponding responses from decision-makers, regulators and financiers or investors. The inception of change in virtually every instance cannot be described as complete, rather they provide an illustration that 'transition' and regulatory or policy liberalisation (competition allowed in former fully regulated and closed systems) are studies in process – literally a work in progress. A recognition that the introduction and deployment of new technologies, data for decision-making and behaviour modification, and charges for service are evolving continuously and will reflect the ability to change as well as the change itself. However, it is also clear that without an informed and willing consumer base, the transition from current to future systems, no matter how much improvement they represent, will fail to generate the policy and financial support needed.

Recommendations

A key objective for the Commonwealth member countries is to improve each states' energy literacy characteristics and use this resource to encourage a transition toward carbon-neutral energy systems. Energy literacy is an imprecise but widely acknowledged objective for achieving de-carbonisation goals. Uninformed decision-makers and consumers are not likely to support or sustain changes to traditional energy supplies without a demonstrated benefit that outweighs any substantial increase in costs.

In this case, the participating states represent a wide range of economic strength and political structure. Some member states have already invested in and made significant strides in alternative energy technology, including adoption of energy-efficiency programmes. Yet, even with similar goals, the objectives and capacity of any individual member country may vary significantly from the group.

As a result, measuring and using the metric of energy literacy as the basis for planning and implementing changes in investment and consumer behaviour is the most important first step. However, it is critical to understand that the metric of energy literacy represents far different characteristics for decision-makers and industry representatives than for consumers.

The logical starting point to stress about energy literacy is that the responsibility for it is shared in three distinct categories:

1. Consumers
2. Policy-makers and regulators
3. Investors and utilities

Any progress on improving public support for new decarbonisation programmes or investments should be measured and compared over time based on the four main characteristics of energy literacy:

1. Basic knowledge about energy – what is it?
2. Attitudes about energy – what it does, why it is important, why it should be preserved.
3. Behaviour change – what can be done practically and specifically about energy consumption and preservation?
4. Financial knowledge – what is the cost of energy production, consumption and preservation?

Energy literacy is a changing characteristic, reflecting perceptions about the environment people live in, expectations about system performance, costs to consumers and operators, and the level and clarity of information available to all actors in the system.

The recommendations below represent a continuum of steps beyond a common first step to establish, quantify and qualify levels of existing literacy. This should begin by establishing basic literacy characteristics within the separate member states, using a common survey design and using climate change as a variable associated with energy use. Such an instrument allows a base for understanding willingness to pay characteristics that will influence the nature of system changes in the future.

The creation of investment and system-wide improvements, time horizons for change and estimated costs can follow and be tested against this base understanding of public and decision-making awareness. Additionally, campaigns to improve literacy gaps can be focused, refined and implemented over time to improve and maintain public support.

A key starting point for understanding public literacy is to identify the common base of service and performance in each state. Changing system characteristics in order to achieve higher rates of de-carbonisation and in turn, influence regional or meta regional climate impacts must have a common platform by which to measure change. As stated above, some member countries have invested heavily in renewable energy technologies and will support variable levels of investment or behavioural change to reach new or modified climate goals.

With that in mind, the whole question of using energy literacy to support future system changes relies on building a system that supplies clear and updated data points for everyone, and which includes the following.

- An updated picture of systems (gas, electric, vehicle fuels) and demand for all consumers.

- A forecast of demand that involves consumers in the system tied to impacts associated with induced climate changes.
- Information that identifies the value of green energy, including programmes to subsidise or incentivise native or regional renewable or green energy resources.
- In an annual or biennial report to consumers, member states should identify the option to participate in a rewards and rebates programme, link it to carbon reduction and set goals that can be updated. They should make it a point of civic pride to be 'invested' in overall carbon reduction.
- A regular update to consumers at all levels regarding status, progress, upcoming investments and bills.
- Government should start building efficiency standards. Nothing gets the public more invested than grants and subsidies to upgrade homes, businesses, to retrofit, save costs, and increase comfort and utility.
- Matching system operations to consumer expectations and behaviour.

Managing energy sources, delivery and control of emissions can be challenging and typically is not always appreciated by consumers. One of the most contentious issues can be the dividing line between regulators, public or quasi-public utilities, and policy-makers. The difficulty stems from the actual roles of each party, combined with the fact that terms of office or even mission timing can vary widely in each group and within each constituency. For instance, regulators making long-term energy investment decisions imagine a timeline and financing scheme that will be measured in decades, while a policy-maker can be more interested in outcomes and costs in a far shorter period of time. For consumers, on the other hand, the impact of invested costs or new commitments to social goals results in changes of cost of monthly or periodic service bills. A consequence of making different technology or even appliance choices, is that investment and performance lifespans not only affect users differently but can be difficult to convey to all groups in a clear fashion.

Small States and ***developing countries*** present a wide range of different challenges when dealing with existential threats or processes such as carbon management or reduction from a social or individual base. The fundamental reason is obvious: the major impacts of energy use on environmental quality are found in air and water quality degradation, and are cumulatively experienced in broad-scale changes in climate, land and water productivity and ultimately, in economic activity.

The challenges then, emanate from the nature of the local economic, mineral and agricultural resources available, and the ability to integrate social preferences into daily or annual demand for and use of energy products. In a high proportion of small states, primary outputs are organised around production of cement or hydrocarbon extraction. Combined with embedded transportation systems, the current infrastructure does not lend itself to either replacement or intensive upgrades without putting a strain on national or even local finances. Some areas may already be dependent on contractual or historical links with neighbouring countries for resource or finished goods exchanges that are based on high-intensity energy use – with cement production offering a key example.

One key outcome is that for typical small states and developing countries, the burden of per capita carbon intensity reduction falls disproportionately on the poorer countries of the population.

Several small states and developing countries have already invested in renewable technologies such as solar PV and wind turbines but increases in the base production of (primarily electricity) have not kept pace with or exceeded the growth of population and overall demand. Given the cost of technology to support these industries, primarily interim storage capacity, this presents a key hurdle when the goal is to diminish reliance on older, less efficient and impactful technologies. In light of these constraints, it is important to convey to consumers and decision-makers the notion that once any given technology or process is chosen, its operating characteristics are effectively embedded over the lifetime of the technology. While some technologies such as battery storage can and will be routinely upgraded, the core technologies have predictable long-lived spans of service, and are likely to be replaced in the context of decades rather than annually.

Linking consumer support and behaviour at a local or regional level, based on improving the understanding of technology reliability, performance and lifespans, will result in 'ownership' and connection with regional systems. This will have a spillover effect on adoption of energy-efficient appliances and conservation-oriented use of both grid-based and individual demand for fuels, especially in the context of transportation fuels and in the future, grid supplied transportation recharging. In short, technology and wider regional controls will provide the keys for providing the 'product', namely reliable, cost-effective and accessible energy supplies. These characteristics, matched to demographic, cultural and economic conditions within nations and member states, will ultimately dictate the design and appreciation of the value of the various systems that can be developed.

Such literacy programmes should start in early childhood and comprise of several energy-related courses. They should encourage and promote positive environmental attitudes throughout the education cycle and beyond.

It should also be understood that there is an undeniable link between energy literacy and policy support. Accordingly, ***the greater the policy literacy of the public on a given policy, the greater the public support or acceptance of that policy***. This is particularly important because research has shown that when there is a gap between expert and popular opinion, policy-makers tend to go along with popular opinion – resulting in less-than-optimal policy choices. **Information should always be presented using concrete examples over abstract ones.**

Furthermore, we should build and expand on what has worked over time and in different contexts.

For example:

- energy-efficient standards
- incentives for behavioural change at the household level
- devices and data linked to consumer behaviour, such as time-of-use meters
- energy-efficient appliance standards
- comprehensive development of critical rights of way for transmission upgrades
- identification of energy storage options, including pumped hydro, compressed air storage, biomass resources and geothermal heat exchange
- regional incentives, including public transit linkages and ride-sharing
- carbon market exchanges to allow regional carbon targets to be more easily met
- regional and cross-border collaboration on renewable energy development
- availability of convenient electric car chargers
- enhanced travel within cities through on-demand electric scooters.

Finally, it is **essential to establish benchmark measures and then measure early and often.** As noted previously, the goal of addressing energy literacy is to increase awareness and knowledge of the basic dimensions of energy production and how transition impacts people's lives. **The only way to track progress on energy literacy is to measure it over time.**

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Appendix A: Definition of Key Terms Used in the Report

KEY TERMS	DEFINITION
Biofuel	A fuel produced from biomass – that is plant, algae or animal waste. Biofuel is a source of renewable energy.
Biomass	Biomass is plant-based material used as fuel to produce heat or electricity.
Chemical reaction	A process that involves changes in the structure and energy content of atoms, molecules or ions, but not their nuclei.
Commodity	A good for which there is demand, but which is supplied without qualitative differentiation across a market. The market treats it as equivalent or nearly so no matter who produces it.
Conservation of energy	Conservation of energy has two very different meanings. There is the physical law of conservation of energy. This law says that the total amount of energy in the universe is constant. Conserving energy is also commonly used to mean the decreased societal consumption of energy resources. When speaking of people conserving energy, this second meaning is always intended.
Fossil fuel	Fuel that is formed from fossilised, buried remains of plant and animals that lived millions of years ago.
Nuclear reaction	A reaction, as in fission, fusion or radioactive decay, that alters the energy, composition or structure of an atomic nucleus.
Oil	Greasy liquid substances from plant, animal or mineral sources that do not dissolve in water and are used especially as lubricants.
Power	This refers to the rate at which energy is transferred from one system to another. The rate is called 'power'.
Renewable energy	Energy obtained from sources that are virtually inexhaustible (defined in terms of comparison to the lifetime of the Sun) and replenish naturally over time.
System	A set of connected things or parts forming a complex whole. It is a set of things working together as parts of a mechanism or an interconnecting network. The place one system ends and another begins, is not an absolute, but instead must be defined based on purpose and situation.
Sustainable	Something able to be maintained at a steady level without exhausting natural resources or causing severe ecological damage, as in a behaviour or practice.
Work	Work in the simple model we are using is some activity done in order to achieve an outcome or result. Energy either enables or enhances the ability to complete that work.

Sources: Swaby et al (2016); Mirriam-Webster Dictionary (merriam-webster.com/dictionary); Sustainable Learning Partnership (no date); US Department of Energy (2017)

Appendix B: Energy System Overview

Background to Section 2: The Fundamentals of Energy and Energy Systems

To understand energy literacy is to get an elementary understanding of the basic concepts and vocabulary associated with energy production. In many ways, 'energy literacy' is a term of art, a proxy for the ability of various groups to intelligently participate in decisions or actions that affect personal and social outcomes in the energy system. Accordingly, it is important to spend some time explaining this foundational aspect of energy.

The term '*energy systems*' reflects a more formal interaction between consumers, fuel supplies, technological generation, operators and dispatchers, financial institutions, policy-makers, and regulators. Creating energy that can perform work for customers is a complex process using a wide variety of fuels or energy sources that is extremely capital intensive and requires continuous supervision and oversight. Every society at every level of income or education, whether urban or extremely dispersed and rural, needs energy in a range of sources and intensity to heat, light or otherwise enable labour, agriculture, transportation or the creation of industrial products. Advances in energy capacity, reliability and distribution are synonymous with social improvement and the creation of wealth. Simply put, human beings cannot exist without energy, and must make use of higher forms of energy to prosper and compete at scale with neighbours, regions or other nations. Energy literacy then serves as a symbol of consumers, the companies that deliver energy, and decision-makers who control competition and energy distribution being able to deliver cost-effective, reliable, useful energy in a timely and environmentally responsible manner.

As we discussed in the first section, there is an emerging consensus about what is energy literacy. Our proposed definition is like many others such as DeWaters and Powers (2011), who have provided a simple definition that we utilise to represent the broader character of literacy that is useful for understanding how investment, consumer behaviour and energy systems can evolve to improve economic and environmental stability. If we agree that 'energy literacy' is an understanding of the nature and role of energy in the world and daily lives, accompanied by the ability to apply this understanding to answer questions and solve problems, then an energy-literate person understands that energy reflects a flow of fuels that are transformed and delivered by wires or pipes that allow consumers to do work.

Fundamentally, an understanding of energy systems matters, reflecting the decisions we all make to consume or forego activities (conservation), choose technologies that benefit us (comparative choices), or to invest in alternatives. Without a basic understanding of energy, energy sources, generation, use and conservation strategies, individuals and communities cannot make informed decisions on topics ranging from smart energy use at home and consumer choices to national and international energy policy. This logic applies equally well to the decision-makers who affect the land use that allows technological investment in competing locations (from generation to transmission) and the companies or even municipalities that own and operate energy technologies.

Virtually all energy supplies reflect advanced technology and sophisticated delivery systems to make use of fuels to generate and deliver energy. We expect industry, commerce, regulators and policy-makers to exhibit a related sub-set of energy literacy to make responsible decisions on our behalf and refer to this as *technology literacy*. While not strictly synonymous with the broader category of *energy literacy*, applying energy literacy depends on the capability of systems operators to acquire and operate appropriate technological devices that are capable of turning a wide variety of fuels and resources into useful energy. The combined characteristics of literacy, then, is the ability of individuals, working independently and with others, to express their own demand responsibly, appropriately and effectively and to use technology tools to access, manage, integrate, evaluate, create and communicate information that is the basis for the design and use of any type of energy system.

In this vein, 'energy systems' is a relative term that does not distinguish the scale of any single or co-operative system. For this paper. it is sufficient to simplify components of any energy system by illuminating the core characteristics that must exist to provide energy efficiently and continually to consumers.

Any system must have *consumers who exhibit or demonstrate a demand* for energy to help them do work or achieve comfort and sustain life above basic existence values. This demand characteristic forms the basis for choosing various technologies, fuels and delivery hardware. Accordingly, any energy system will depend on a ***continuous source of fuel or resources*** to meet demand. This can take a variety of forms, ranging from mechanical energy (e.g., water wheels or wind turbines for crushing or transforming grains); chemical energy (e.g., combustible fuels from biomass); natural gas, geothermal heat and derivatives for direct combustion and heating; to various forms of hydrocarbon combustion (or wind or hydro) to turn turbines that deliver electricity; or sunlight for direct current electricity and geothermal or nuclear-derived steam for electric turbines. It follows that energy systems supplying more than a single household or business also need **transmission and distribution networks** that can deliver energy to points where it can be used. These delivery systems create a footprint over lands that demand agreement from owners, governments or nearby affected parties to operate over time. This in turn **requires a public process for permission to build and operate these facilities and to ensure environmental quality is not compromised**. Every energy system depends on various types of technologies to create the energy that is sold and distributed. This can range from large turbines or nuclear facilities at various scales, to pumped hydro dams or solar and wind facilities. The combined operation of dissimilar technologies demands a systems operator to ensure safe and timely dispatch, and to control properties of the energy available.

There is much more to be said about energy systems, but this brief overview is sufficient as an outline of how energy is produced and distributed and all the complexity it entails.

Appendix C: Sample Survey

The authors have conducted research in the past to gauge the level of understanding for various actors in the energy system. We include below an illustrative list of survey items that are useful in any attempts to measure energy literacy, in any context and, most importantly, comparable over time. After the initial baseline is established, it can be compared state to state, adjusting for demographic differences and, importantly, augmented with 'willingness to pay' qualifiers.

Potential measurement

Q. How much would you say you know about each of the following?

- Energy generation in (Insert Country)
- Energy distribution in (Insert Country)
- Energy use in (Insert Country)
- Energy conservation
- Management of the by-products of energy generation (waste)

Know a lot

Know a little

Heard of it but don't know much

Never heard of it

Q. How much do you agree or disagree with the following statements?

- 'I have a good understanding of energy issues in (Insert country)'
- '(Insert Country National) has a good understanding of energy issues in (Insert Country)'

Strongly agree

Somewhat agree

Somewhat disagree

Strongly disagree

Q. As far as you know, which <u>one</u> of the following is the major source of electricity generation in (Insert Country)?

- Coal
- Natural gas
- Hydro
- Wind power
- Solar power
- Nuclear

Q. How much do you support or oppose the increased use of each of the following in (Insert Country):

- Coal
- Natural gas
- Hydro
- Wind power
- Solar power
- Nuclear
- Strongly support
- Somewhat support
- Somewhat oppose
- Strongly oppose

Q. Overall, how concerned are you about the impact of energy generation on the environment?

- Very concerned
- Somewhat concerned
- Not too concerned
- Not at all concerned

Q. Which of the following activities are you already doing or have already done? Please check all that apply.

- Bought a more energy efficient vehicle
- Cut driving by at least 50%
- Taking public transit every day
- Replaced all light bulbs with energy-efficient light bulbs

- Reduced power consumption at home by at least 30%
- Keeping thermostat at 18 degrees Celsius or less during the winter and wear a sweater
- Spend less than five minutes in the shower, with no baths
- Reduced household waste by at least 50%
- Reduced air travel by at least 50%
- Buying local produce in season and can/store it for off season
- None of these

Q. Are you...

- Male?
- Female?
- Other

Q. In what year were you born?

Q. Including yourself, how many people currently live in your household in each of the following age groups?

- Children aged 12 and under
- Children aged 13 to 17
- Adults 18 and older

Q. What is the highest level of education that you have completed or the highest degree that you have received?

- Less than high school (Grades 1–8)
- High school diploma or equivalent
- College or other non-university certificate or diploma
- Undergraduate university degree, certificate or diploma
- Master's degree
- Degree in medicine, dentistry, veterinary medicine or optometry
- Doctorate
- None of the above
- Prefer not to answer

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