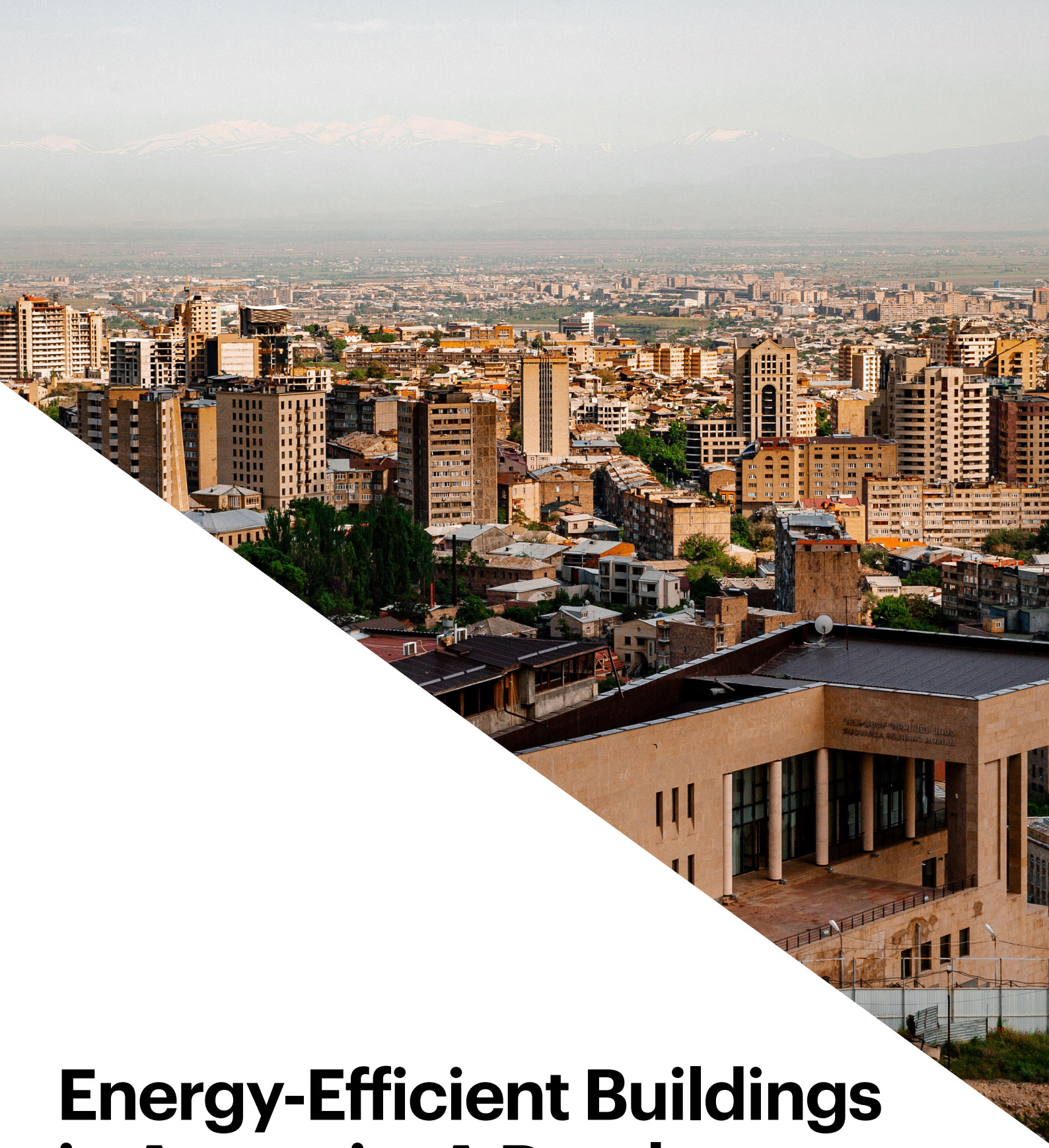

Energy-Efficient Buildings in Armenia: A Roadmap

Insights and pathways for better buildings 2020-2040

International Energy Agency

EU4Energy

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Executive summary

A tremendous opportunity

Improving building energy efficiency is central to the strategic development of the Republic of Armenia ("Armenia"). As Armenia's largest energy-consuming sector, buildings account for nearly 40% of the country's total electricity demand and more than 25% of its gas demand. Estimated energy-saving potential ranges from 40% to 60% across residential, public and commercial buildings, depending on interventions. This level of savings could translate into significantly lower household energy bills, greater energy security, improved thermal comfort in homes, offices and schools, and many other benefits.

The residential subsector especially holds significant energy-saving potential. Along with transport, the residential subsector consistently accounts for the highest share of Armenia's total final energy consumption (TFC), and this amount is projected to rise by up to 40% above the 2018 level by 2036 (see Figure 1). For public sector buildings, exemplar or "lighthouse" projects that build on past success and demonstrate leadership could stimulate the domestic high-efficiency building products and services market, with both local and international lenders providing project financing.

Armenia could also address the energy consumption of specific building technologies (e.g. for lighting, heating and, increasingly, cooling). Not only would heating and cooling technology improvements raise energy efficiency considerably, they would increase warmth, comfort and indoor air quality to improve household health and wellbeing.

Emerging policy framework and early market development

Armenia has made some progress towards developing a basic building-efficiency policy framework, and further efforts are underway, including as part of the Comprehensive Enhanced Partnership Agreement (CEPA) with the European Union. As part of CEPA, energy efficiency standards and norms are being aligned line with the EU acquis established by laws such as the Energy Performance of Buildings Directive (EPBD) and Ecodesign.

Nevertheless, Armenia must finish establishing a comprehensive regulatory framework for building efficiency that allows laws to be fully implemented and enforced. Building codes and other efficiency requirements for new construction and reforms related to managing multi-apartment buildings (MABs) are examples of areas in which policies may exist, but capacity constraints and other issues limit their practical effectiveness. In the absence of well-enforced rules, opportunities to improve the efficiency of buildings are likely to remain disregarded.

As with many other countries, Armenia has a mixture of market barriers and other issues to address before it can make its buildings sector more efficient. These include general awareness about the benefits of efficiency investments and available options, data collection and quality, administrative and market capacity, and access to financing. Whole-building retrofits, for example, are particularly challenging to achieve in Armenia, where the market for comprehensive, project-based building interventions remains nascent.

Addressing challenges through international collaboration

Recognising the importance of raising building energy efficiency, several international organisations and lenders are working in Armenia alongside government officials, experts and other stakeholders to address persistent challenges and unlock the sector's potential. Successful building efficiency projects completed in the past decade provide demonstrable results and lessons for future efforts, and other countries' experiences and best-practice case studies can also inform efforts in Armenia.

In this context, roadmap development is an opportunity to take stock of the current situation and consider strategies for both the medium and long term (to 2040). This relatively brief document is therefore designed to provide an overview of Armenia's current buildings sector situation, with international case studies supplying the context and – when applicable – practicable insights. This roadmap is intended to support wider discussion among policy makers and experts working every day to advance building sector efficiency in Armenia.

Introduction

This roadmap is intended as a resource for policy makers, investors, representatives from development banks and international organisations, and other stakeholders working to advance building sector energy efficiency in Armenia. It may also be of interest to other countries at a similar stage of buildings sector efficiency improvements. Although specific energy, CO_2 or other reduction targets are not the focus, this roadmap's insights and information can be useful for both target-setting and goal achievement.

To understand Armenia's current buildings sector efficiency and to explore pathways for the future, this roadmap examines some of the key areas affecting the sector, including policy, market and technology issues, within five main sections:

1. buildings sector and energy-use indicators
2. influencing factors such as policies, financing and markets
3. energy-efficient technology deployment
4. emerging trends, including digitalisation
5. a summary roadmap containing insights from the text as well as guidance and recommendations for policy makers.

Rather than being an exhaustive and detailed study, this relatively brief document is intended to provide a high-level overview, offering insights based on international best practice as well as relevant examples and case studies. It is not meant to replace the detailed policy and project discussions taking place among dedicated experts working both in Armenia and internationally to advance progress on buildings sector efficiency.

Development of this roadmap for Armenia complements several notable ongoing and parallel efforts, including:

1. EU-led initiatives such as implementation of the EU-Armenia CEPA, dedicated funding streams and high-level dialogue with international financial institutions, featuring establishment of a board to steer progress on energy efficiency.
2. An International Energy Agency (IEA) in-depth review (IDR) of Armenia's energy policies.
3. Armenia's 3rd National Energy Efficiency and Renewable Energy Action Plan (NEEAP-3).
4. EU4Energy's Nearly Zero-Energy Buildings (NZEB) Roadmap, and its action plan to develop a calculation methodology for buildings' energy performance.
5. International organisation and international financial institution (IFI) efficiency and clean-energy programmes with buildings sector components and projects.

Status and key indicators

This section provides a brief overview of the status of Armenia's buildings sector as well as key energy-use indicators and trends. While its gross domestic product (GDP) has increased significantly since 2012, Armenia continues to face economic and social challenges, including high rates of unemployment and poverty as well as substandard building infrastructure. These factors impact the success of policies and other initiatives to improve the efficiency of Armenia's buildings.

Buildings sector overview

Most of Armenia's buildings are residential dwellings, whereby 52% are individual houses and 45% are MABs. Nearly two-thirds of Armenia's population of nearly 3 million live in urban areas. MABs dominate in cities such as the capital, Yerevan, where 37% of Armenians live.

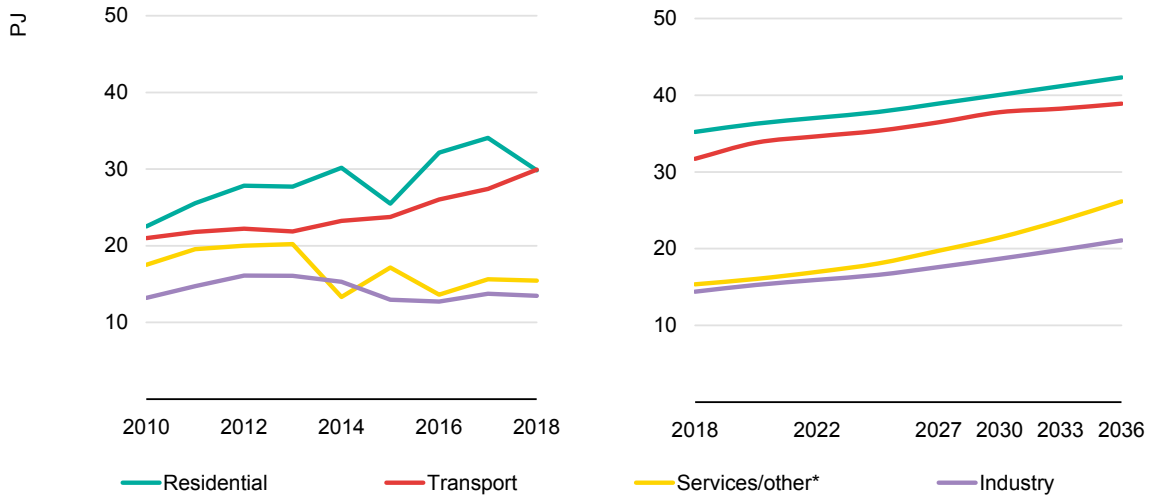
As of 2018, Armenia had just under 20 000 MABs with nearly 450 000 individual apartments. Houses, of which there are just over 400 000, are naturally more prevalent in rural areas, where just over 1 million Armenians live. Public and commercial buildings such as government buildings, schools, offices and shopping centres account for 12 15% of the country's total building stock (Armstat, 2019; UNECE, 2017). Only 6% of Armenia's total building stock is in "good" condition; 64% is "fair"; and 30% is "poor" (UNECE, 2015). Around 75% of the MABs were built during the Soviet era between 1951 and 1990, and they lack proper insulation (HFH, 2020).

From an energy efficiency policymaking perspective, residential buildings are a priority, assuming relatively high levels of energy consumption are a key focus of policy efforts (see Figure 1). Nonetheless, public buildings also offer significant potential for efficiency gains and, furthermore, energy efficiency programmes for public buildings can stimulate markets for energy efficiency services that can then be used in the residential subsector.

Energy-use indicators and trends

With the notable exception of transport, the residential subsector consistently accounts for the highest share of TFC in Armenia – higher than the industry sector and exceeding commerce and public services (which includes commercial and public building energy consumption). Furthermore, solid residential energy demand growth is expected over the next 15 years (Figure 1).

Figure 1 Total final energy consumption in Armenia by sector, 2010-36 (projected)



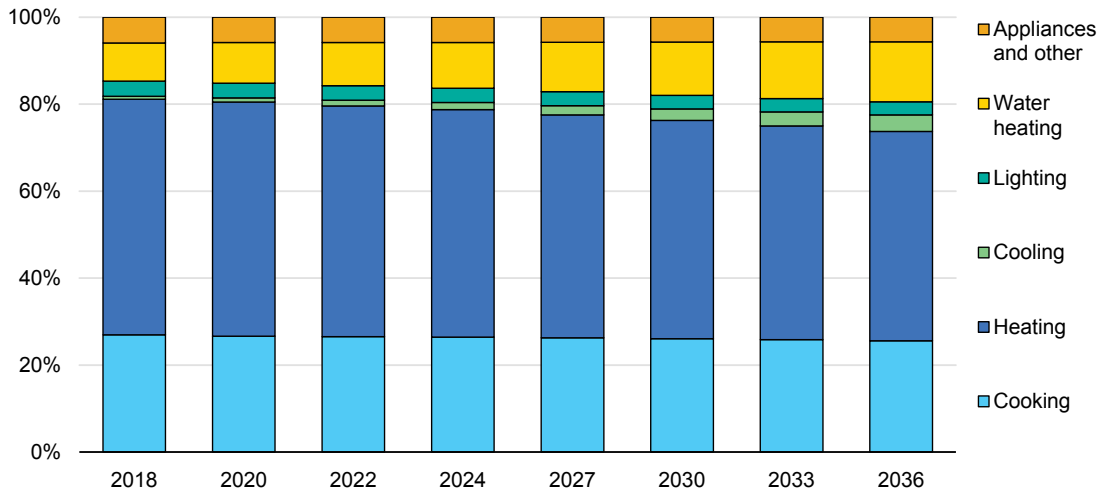
* Includes non-specified consumption of electricity and natural gas.

Notes: PJ = petajoule. Numbers for 2018-36 are based on business-as-usual projections by USAID based on TIMES model..

Sources: IEA (2020d), *World Energy Balances* (database), www.iea.org/statistics/; USAID (2019).

The relatively high level of household energy consumption – primarily in the form of natural gas – translates into significant end-user costs. In fact, some low-income households spend up to 50% of their income on energy (HFH, 2020), primarily for home heating and cooking. However, it is cooling and water heating costs that are expected to increase more than any other end uses (Figure 2). While currently accounting for a relatively small share of overall demand, cooling-related energy use in Armenia is projected to quadruple from 0.36 PJ in 2020 to 1.61 PJ in 2036, overtaking energy demand for lighting.

Figure 2 Armenian energy demand by end use, 2018-36 (projected)



Notes: Based on projections. Total demand for each end use in 2020: cooking – 9.68 PJ; heating – 19.52 PJ; cooling – 0.36 PJ (more than quadrupling to 1.61 PJ in 2036); lighting – 1.22 PJ; water heating – 3.38 PJ (nearly doubling to 5.85 PJ in 2036); appliances and other – 2.12 PJ.

Source: IEA (2020d), *World Energy Balances* (database), www.iea.org/statistics/; USAID, 2019

The relatively high level of residential energy demand for essential services such as heating and cooking means that energy tariffs are an important economic, political and social issue in Armenia, intertwined with geopolitical concerns related to gas imports and electricity exchanges with third parties. Higher gas and electricity tariffs (at peak winter heating times, for example) may be necessary to fund energy infrastructure investments and could also serve as an incentive for households (particularly middle- and higher-income ones) to invest in energy efficiency. Without mitigating policies for vulnerable population segments, however, tariff increases could provoke greater poverty and discomfort for low-income households that cannot afford home efficiency upgrades.

For Armenia's larger energy consumers, including public buildings, natural gas tariffs currently decrease at higher consumption levels once a certain threshold has been reached. This not only incentivises greater gas consumption but discourages energy efficiency investments. While this roadmap does not include an in-depth exploration of tariffs, they are an important consideration because they affect building-efficiency policy formation, investment incentives and market development.

Influencing factors

This section examines some of the factors that influence efforts to make Armenia's buildings more efficient. In addition to cross-sectoral issues such as data and governance, it investigates policies and financing that specifically target building efficiency improvements. It also discusses measures to raise public awareness while creating production capacity and markets for higher-efficiency building products and services.

Data collection and quality

Having access to good data is indispensable for building-efficiency policymaking. The systematic compilation and dissemination of building energy data gives policy makers, operators and other stakeholders insights into how energy is being used in buildings, which can help them create the accurate consumption baselines needed to set energy-efficiency targets and track policy and programme impacts.

To facilitate analysis of whole-building performance, for example, it is important that governments establish uniform calculation methodologies (and that qualified building auditors and technicians adopt them) to help policy makers and market participants (notably lenders) compare and track building efficiency performance across sectors, geographies, etc. For individual technologies, strong data collection and supporting measures, such as import controls and testing facilities, are also often essential to determine minimum energy performance standards (MEPS) and labelling policies, as discussed in more detail in the following pages. Policy makers also need access to reliable datasets covering a range of equipment types, such as:

- boilers and heating systems
- stoves and appliances (e.g. refrigerators, dishwashers)
- insulation, windows, and roofing materials
- air conditioners (ACs) and fans

Data is also linked closely with capacity, as discussed later in this section and elsewhere in this roadmap. Building energy audits, for example, which are an essential starting point for energy efficiency retrofits, can be carried out only by trained and qualified professionals. Furthermore, access to good data is crucial for lenders and financiers to quantify and articulate energy efficiency investment opportunities.

Although it is costly to collect high-quality energy statistics (e.g. based on surveys of final energy consumption), not having proper data could result in disadvantageous policy decisions and actions, and, consequently, even higher costs. Armenia's data collection efforts could be critical to its ability to develop effective building efficiency policies, especially for the residential subsector for which a detailed household survey remains pending. In the public and commercial buildings subsector, information gaps exist concerning buildings' energy performance and/or efficiency potential. More data are also needed from the construction sector to understand how new buildings are performing with respect to Armenia's building codes and/or compared with international performance benchmarks (i.e. kilowatt hours per square metre [kWh/m^2]), for example.

Institutions and governance

The Ministry of Territorial Administration and Infrastructure (MTAI) has overall responsibility for energy policy, including Armenia's transposition of the 2010 EU Energy Performance of Buildings Directive (EPBD) as part of the EU-Armenia CEPA implementation. MTAI is supported in its EPBD transposition and other building policy issues by the Urban Development Committee, which is also involved in determining building codes for new constructions and housing policy. Other ministries, including Environment, Economy and Finance, also provide implementation or policy support related to building efficiency as required.

In addition, the Renewable Resources and Energy Efficiency Fund (R2E2) was established with support from the Global Environment Facility (GEF) in 2006. Although the R2E2 in effect acts as an energy agency in Armenia and plays a leading role in developing impactful efficiency projects as well as energy efficiency markets and capacity, it lacks the official power to be the overarching authority for energy efficiency policymaking. Instead, responsibility for energy efficiency policy pertaining to buildings is shared by several ministries and institutions.

Institutional arrangements and energy efficiency policy governance is a key issue in most countries. International experience, notably within EU member states, suggests that establishing a dedicated agency can be instrumental to create capacity for energy efficiency (as well as renewable energy) products and services in local markets. A dedicated agency and/or a more centralised approach to energy efficiency policymaking can also help ensure that energy market regulation creates incentives for energy efficiency in buildings and across the economy.

Policy framework

The Armenian government has identified energy efficiency in buildings as an important part of its overall energy strategy, as evidenced by action plans, strategies and laws developed since the early 2000s. These include the Law on Energy Efficiency and Renewable Energy (2004), the National Program on Energy Efficiency and Renewable Energy (2007) and two National Energy Efficiency Action Plans (NEEAPs), whereby the NEEAP-1 was adopted in 2010 and NEEAP-2 was developed but not formally adopted in 2015.

The government has also adopted specific measures for energy efficiency and energy-saving regulations in the construction sector (2013) and minimum energy performance requirements for new and renovated buildings (2016). Furthermore, secondary legislation, norms, standards and calculation methods based on international best practice have been adopted for the buildings sector in the past decade to address energy auditing, thermal insulation, building energy performance and a range of other topics (Energy Charter, 2018).

Nevertheless, Armenia's building efficiency policy framework contains gaps, and local experts frequently cite issues around implementation and enforcement of codes for new construction or retrofits, for example.[1] Other important gaps exist around codes for new construction, the non-uniformity of methods used to calculate building energy performance and inconsistencies among the various norms and standards that Armenia

[1]Specifically, fulfilling the technical requirements of decision 426-N of the Armenian government on "The energy saving and energy efficiency in newly built residential multi-apartment buildings, as well as in the facilities built (reconstructed, repaired) at the state expense," as adopted in 2018.

has adopted (i.e. a mixture of International Organization for Standardization [ISO], Russian and EU standards).

In addition, key housing sector laws, notably the Law on Apartment Building Management and the Law on Condominiums, which mandate that every MAB must form a legal entity (e.g. a housing association that can manage or procure whole-building efficiency improvements), have not been fully implemented and enforced.[2] Shortfalls in implementing and enforcing these and other key policies directly affects prospects for improving the efficiency of MABs, since "without the homeowners, no energy efficient interventions can happen" (HFH, 2017).

Policy makers in Armenia are already addressing this implementation and enforcement gap as part of the EU-Armenia CEPA. A number of important elements are addressed in the framework of this agreement, including a comparative methodology for calculating the optimal costs levels for the minimum energy efficiency requirements (as per the EPBD), the development of a range of technical and normative documents and improved building energy performance certification. According to the European Commission, "the development and enforcement of the laws and regulations, combined with enhanced donor co-ordination, and support to effective institutional set-up will create the necessary enabling environment" for building efficiency (EC, 2019a).

Standards and labelling

MEPS and labels – or energy efficiency standards and labelling (EESL) programmes – are a cornerstone of effective building efficiency policy frameworks. Usually established through dialogue with a range of stakeholders including experts and leading companies, MEPS and labels can cover most energy-consuming devices available to consumers. When deployed effectively, MEPS keep the worst-performing technologies (from an energy efficiency standpoint) out of markets, thereby mitigating the impact of less-efficient technologies on energy demand, electrical grids and greenhouse gas (GHG) emissions. Labels, meanwhile, can provide simple information on product efficiency and can steer consumers towards more efficient devices.

Developing and introducing effective EESL programmes does, however, have cost implications and entails regulatory complexity. As a result, designing effective MEPS and labels generally requires governments to commit both budgetary and administrative resources. However, EESL programmes have also proven to be highly cost-effective policy instruments that do not necessarily increase prices for consumers. Based on studies covering 50 different equipment types in all sectors across 80 countries, the benefits of standards and labelling programmes outweigh the costs by 3 to 1, with little long-term impact on appliance prices and a highly positive effect on technology innovation (IEA 4E TCP, 2016).

Although Armenia has made some progress in developing its EESL framework for buildings sector technologies, some gaps remain. As part of efforts to complete this framework, a detailed report and recommendations to accelerate the adoption of MEPS and labels for five priority product groups was submitted in 2018 under the EU4Energy programme. Starting in

[2] These laws are designed to address issues related to the transparency with which government bodies manage the residential building stock; poor apartment-owner perception or awareness of their rights and liabilities concerning shared building ownership; and poor management and/or cash flow among housing management associations (UNECE, 2015).

2021, Armenia must also implement standards for a range of energy-using technologies as part of its Eurasian Economic Union (EAEU) membership (UNDP, 2020a).

As mentioned above, beyond ensuring that individual technologies available to consumers comply with MEPS and are properly labelled, Armenia can also set and enforce energy performance requirements for existing buildings, making them visible and tangible through building energy efficiency performance certificates or "passports". In addition, public awareness campaigns – accompanied by financial incentives such as grants, rebates or tax breaks – are often essential complements to standards and labelling programmes, since they help consumers understand the benefits of energy efficiency and provide information on how to procure more efficient technologies.

Financing

Financing is a key issue, as it affects virtually all aspects of energy efficiency in buildings. Although significant upfront investments are required in many cases to capture the full benefits of efficiency improvements, long-term returns are robust and certain high-efficiency technology investments can be recuperated in under two years. Individual building retrofits alone can save tens of thousands of dollars in reduced energy bills over a multi-year period, assuming appropriate financing instruments such as energy performance contracts (EPCs) or energy services agreements (ESAs) are in place.

In addition, refurbishing a large number of buildings or procuring technologies in bulk, as discussed in more detail in the technology section of this roadmap, can have a transformative impact on markets and change the economics of efficiency. Major public-private investments and interventions in efficient buildings give local supply chains an incentive to mobilise the means to meet higher demand for products such as double- or triple-glazed windows, insulation materials, and efficient heating and cooling equipment, in addition to other technologies. This in turn enables parties all along the supply chain to procure materials in large volumes, creating the economies of scale needed to reduce technology costs, and thereby the overall cost of retrofitting.

So far, most investments in energy efficiency improvements in Armenia have been based on grants and loans from IFIs, with international organisations such as United Nations (UN) agencies or non-governmental organisations (NGOs) such as Habitat for Humanity (HFH) playing a central role in project delivery. During 2010-15, for example, IFIs committed an estimated USD 86 million to energy efficiency-related projects in Armenia, with the European Bank for Reconstruction and Development (EBRD) and the International Finance Corporation (IFC) providing the majority (nearly 90%) of funding, which leveraged over USD 23 million in additional financing from the private sector. These investments have had a notable impact on the country's banking sector, as local financial institutions (LFIs) have not only administered funds but also invested significant additional funds through a variety of loans.

However, only a small portion of these significant sums – about 0.3% – was invested in improving building energy efficiency, mainly in public buildings rather than residential dwellings. Industry received the largest share at over 35%, the power sector garnered approximately 22%, small and medium-sized enterprises (SMEs) 18%, and municipal infrastructure projects 14% (Econoler, 2015). While these investments have created a market for energy efficiency financial services targeting industries and SMEs, for example, many LFIs in Armenia still do not offer financial products aimed at residential housing efficiency. In addition, central and local government budgets to implement and enforce building efficiency policy measures have been limited.

Without a market for efficiency financing and a major increase in government budget allocations, Armenia will need to rely (at least initially) on further IFI support to capture the full potential of building efficiency improvements. Fortunately, energy efficiency projects tend to deliver solid long-term returns for investors and the financial viability of building-efficiency investments has been proven repeatedly, both in Armenia and globally. In principle, IFI funding can therefore help to create and solidify a domestic market for investments in building efficiency, causing residential financing instruments to become widely available without IFI support.

Some credit lines for energy efficiency improvements have already been deployed in Armenia, and policy makers are now working to further unlock residential building efficiency financing as part of a Neighbourhood Investment Platform (NIP) being developed with the European Union under the CEPA initiative. The NIP "will aim at supporting low-income households [and MABs] with piloting innovative financing schemes which could be scaled up in the future" (EC, 2019a).

International experiences may also be useful: in addition to grants that help homeowners purchase insulation and windows, some countries have developed revolving funds that help households access the financing they need to make their homes more efficient. Estonia, for example, created the KredEx Revolving Fund for energy efficiency in MABs in 2009 with support from IFIs, including Germany's KfW. The fund was based initially on the disbursement of grants for efficiency upgrades in eligible homes, and cost savings resulting from energy efficiency gains are reinvested into the fund so that it can become self-sustaining and be scaled up over time (Cityinvest, 2017).

Revolving funds can also be deployed in a public sector setting or at the municipal level. Under the Municipal Services Improvement Project in Macedonia (MSIP), for example, municipalities are able to repay loans (co-financed by the World Bank and the Ministry of Finance) through cost savings generated by efficiency projects for public buildings and street lighting (World Bank, 2014).

Awareness and communication

Low awareness of the benefits of energy efficiency improvements, combined with insufficient capacity to secure financing for efficiency upgrades, is limiting the availability of financing for the residential housing efficiency improvements in Armenia (UNECE, 2015). Raising awareness is critical to create demand for energy-efficient products and services, which would in turn stimulate policy maker, consumer and market activity. Greater awareness is also important to raise financing for energy efficiency projects.

Making the decision to invest in a more efficient (but potentially more expensive) technology – such as a condensing boiler, a highly efficient air-conditioning (AC) unit or a double-glazed window – is not always straightforward even for wealthy and middle-income families, not to mention low-income households. Consumers and other market participants need accurate and accessible information about the benefits of energy efficiency, technologies and financing options – and about the cost of inaction.

As part of its Residential Energy Efficiency for Low Income Households (REELIH) project, which led to efficiency upgrades in 13 residential buildings in Yerevan, HFH proved the effectiveness of using a training programme to raise awareness among households (UNECE, 2019). A survey conducted post-training found that 71% of participants had begun to implement energy efficiency measures (conversation with HFH, June 2020).

In addition to raising householder awareness, the REELIH project facilitated dialogue among homeowners, the municipality and financial institutions to develop financial products that support energy-efficient retrofits. In other words, the project used outreach and awareness-raising to create capacity among key stakeholders involved in the project. Awareness is a central issue for building-efficiency initiatives generally, but it is especially linked with markets and capacity, as discussed further below.

Markets and capacity

Once information about the benefits of energy-efficient buildings has become readily available and some level of market awareness has been established, capacity is needed along the value chain, notably among households and/or homeowner's associations (HOAs), housing management companies (HMCs), LFIs, energy auditors, suppliers, etc. to actually implement efficiency measures. According to the European Commission, "strengthening the capacity of key energy sector stakeholders, including those at central and local government levels, as well as capacitating a one-stop shop for technical support, will further contribute to the success of planning and managing energy interventions" (EC, 2019a).

Armenia has already shown leadership in this area by using public buildings as models. As part of projects implemented by R2E2, energy efficiency improvements were carried out on 124 public and social buildings between 2012 and 2016. Projects were extended for a second phase to 2020 after they exceeded initial projected energy and GHG reductions targets by nearly three times and delivered average energy savings of more than 50% across all projects (EC, 2019a). R2E2's efforts translated into energy savings of 540 million kWh and 145 tonnes of CO_2 (t CO_2) emissions (IEG and World Bank, 2019).

Beyond reducing energy consumption and CO_2 emissions, the project also developed essential building blocks for an energy services market featuring energy service companies (ESCOs). For example, a new financing model for energy efficiency retrofits based on repayment through guaranteed energy savings (performance contracting) was developed, featuring an ESA that enables energy efficiency investments in public buildings without budgetary support. R2E2 also engaged extensively with construction companies and developed a turnkey services concept that includes auditing and design, financing, measurement and verification of savings and other services (IEG and World Bank, 2019).

While the successes of this project have so far not been replicated or scaled up in Armenia, it established a precedent and provides evidence that a market for energy services and ESCOs can, indeed, be developed. Public buildings, which have an average energy efficiency potential of 58%, could continue to play a leading role in the early establishment of this market, helping to generate demand for efficiency services, creating incentives for the supply chain to upskill and increase capacity to respond to the new demand, and spurring LFIs to develop more financial instruments for energy services (Econoler, 2105).

Deploying efficient technologies

Energy-efficient technologies and materials can be widely deployed given, among other conditions, the right governance and policy environments, functioning markets and access to financing. This section explores approaches to expand the deployment of energy-efficient technologies in Armenia's buildings, beginning with envelopes and whole-building retrofits. It provides insights and recommendations, including for cooling, which is one of the fastest-growing sources of energy consumption both in Armenia and globally.

Whole-building retrofits including envelopes

Armenia faces significant obstacles to comprehensively retrofitting entire buildings including their envelopes (i.e. external walls, insulation, windows, doors, etc.), particularly for the many MABs in cities such as Yerevan. Due to the poor condition of many buildings, basic structural repairs may be needed before an energy efficiency intervention is logical or feasible (Econoler, 2015).

Armenia is not alone in the challenge of scaling up and replicating building efficiency retrofits. While many individual projects have proven the cost-effectiveness of "deep" building renovations, most countries are not at the stage at which these kinds of retrofits are commonplace.

In addition to technical and structural challenges – and market and financial barriers – successful energy efficiency interventions in whole buildings can involve a long list of stakeholders, including the owners of the buildings and/or individual apartments, installers and lenders. Ensuring that all these stakeholders work together on one or more whole-building efficiency projects is not always easy.

In Armenia, stakeholders involved in achieving whole-building retrofits include households (e.g. apartment owners and tenants); HOAs and HMCs; suppliers and installers (including energy auditors and other professionals); LFIs and IFIs; local governments; and energy providers (Figure 3).

Figure 3 Managing multiple stakeholders in whole-building retrofits

Note: This is an indicative diagram only. Specific cases may vary and can involve either more or fewer stakeholders.

Despite the complexities involved, envelope improvements and partial building retrofits are achievable through targeted engagement with key stakeholders, as illustrated by the REELIH project. In addition, nearly half of Armenia's housing stock was built during 1951-75 and 40% was constructed between 1976 and 1995. Only a small portion (around 7%) was constructed following the mid-1990s (EDRC, 2015). This suggests there may be potential to scale up and replicate structural repair programmes and/or envelope efficiency improvements systematically for many buildings of similar age and characteristics (i.e. construction profile).

One initiative that has employed precisely this kind of programmatic approach to building efficiency retrofits (including exterior wall improvements) is known as Energiesprong. Using prefabricated facades, carefully selected and efficient heating and cooling equipment, and insulated and solar photovoltaic (PV)-equipped roofing materials, Energiesprong has demonstrated the feasibility of retrofitting entire neighbourhoods at one time rather than targeting buildings individually (Energiesprong, 2020).

Given the differences in economic indicators, condition and type of buildings, etc., between Armenia and the Netherlands (or other EU countries and US states), policy makers may question whether the Energiesprong approach is feasible for Armenia. While specific technologies and methods would likely differ given Armenia's local requirements, some of the Energiesprong model's non-technological aspects may be relevant.

One of these is the business model itself, which is based on a repayment scheme wherein homeowners do not incur additional or upfront costs. Instead, the refurbishment cost is paid over a 30-year period through lower energy bills, factoring in budgets for planned maintenance and repairs. The model also works through HOAs, with homeowners paying Energiesprong via their HOA through a service charge that is equivalent to their regular payments for energy, maintenance and repairs (Energiesprong, 2020).

Including maintenance and repair in a residential building-efficiency business model may be particularly advantageous for Armenia. A repayment model based solely on energy savings – even over a long time period – would likely be insufficient to cover the potentially significant repair and refurbishment costs of the country's buildings. Integrating efficiency investments with the estimated USD 200 million Armenia spends annually on the upkeep of public buildings and social housing could be doubly beneficial.

Based on R2E2 estimates, the incremental cost of achieving a significant (up to 50%) efficiency improvement as part of comprehensive public building refurbishment is between USD 17 and USD 20 per m^2. This is approximately 10% of the average USD 200 per m^2 required for comprehensive rehabilitation of a public building in Armenia (Econoler, 2015).

Armenia has already shown leadership in stimulating local markets and supply chains as part of the R2E2 project targeting public buildings. This project provides a proof of concept for the creation of a local ESCO market in Armenia, driven by demand for energy efficiency improvements in a large number of buildings.

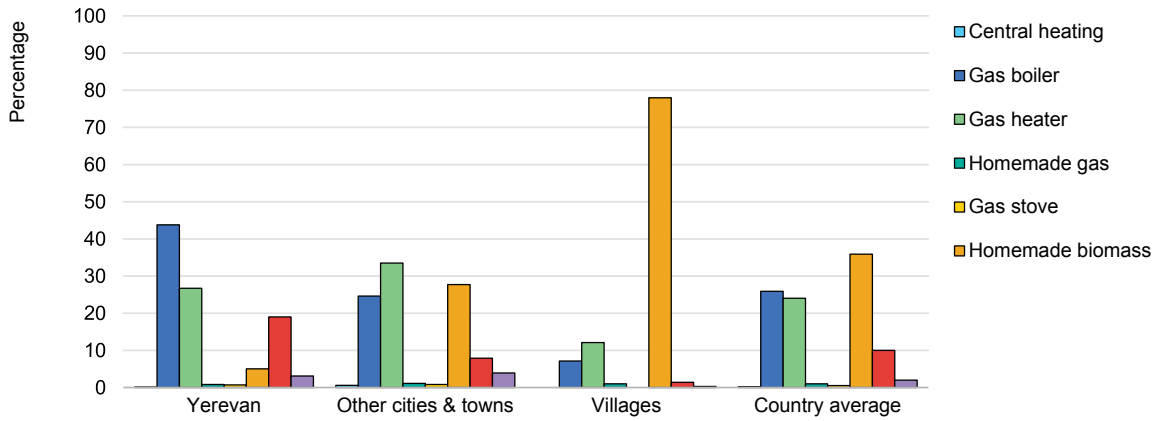
A renewed investment campaign initially targeting public buildings could eventually create demand for similar systematic retrofits of the many thousands of residential dwellings in Armenia. Indeed, this is precisely the focus of an ongoing United Nations Development Programme (UNDP) and Green Climate Fund (GCF) project that seeks to "reduce the overall investment risk profile of energy efficiency building retrofits to encourage private sector investment and reduce fuel poverty" (UNDP, 2016).

Heating

Heating is a central issue in Armenia's building efficiency discussions. Due to the length of the heating season and the severity of winter, particularly in certain rural parts of the country, heating (for space heating and hot water) accounts for the majority of energy consumption in Armenia's buildings (see Figure 2). Heating also has important fuel poverty, health and wellbeing implications. Of 2 500 households surveyed across Armenia in 2015, less than 40% claimed to be "comfortable" in winter, while nearly half are merely "close to comfortable" and more than 9% said they "hardly cope". The survey results indicate that discomfort due to insufficiently heated homes is more prevalent in villages, and in cities and towns other than Yerevan (EDRC, 2015).

Historical circumstances are partly to blame for this relatively high incidence of underheating. While 90% of MABs and public buildings relied on district heating networks or central heating during the Soviet era, after its collapse central systems were almost entirely replaced by individual installations such as gas-fired boilers and heaters, particularly in MABs (UNDP, 2020). Meanwhile, households in villages continue to heat their homes primarily with homemade stoves that burn wood or other forms of biomass (Figure 4). Strong reliance on individual heating systems that combust fossil fuels or biomass means Armenians are highly exposed to the risks associated with gas price fluctuations, and with biomass cost and availability.

Figure 4 Main heating technologies used in Armenian households



Note: Based on a 2015 survey of 2 500 households.
Source: EDRC (2015), *Residential Energy Consumption Survey: Analytic Report.*

Given the situation, a mixture of policies and efforts will be required to increase the efficiency, performance and affordability of heating technologies in Armenia. (Re)constructing district, co generation or central heating systems is clearly one option, particularly for MABs in which the underlying infrastructure for these systems is still viable. As part of a UNDP-funded project, 76 MABs in Yerevan (Avan district) have been connected to a modern co generation facility since 2010. The initiative has proven successful, as it provides better heating for residents while cutting average heating costs by 20% compared with individual gas heaters (UNDP, 2015a).

Beyond technical feasibility considerations, expanding district heating and co generation installations will also require that policy makers address a range of barriers, including weak regulatory frameworks, a lack of incentives to commercialise existing district heating operators and lack of capacity among market participants, notably MAB management associations (UNDP, 2012).

When district-level or central heating strategies are not feasible or economical (e.g. in village homes), policy makers may need to consider other ways to deploy efficient technologies. A bulk procurement approach (as outlined in the section on lighting) may be an option for technologies such as condensing boilers. Programmatic initiatives such as Energiesprong (discussed above) may also be worth exploring, as efficient heating technology installations are generally included in this type of retrofit package.

New Zealand's experiences may also be relevant. To address fuel poverty concerns in low-income households, since 2009 the government in Auckland has been working on a series of energy efficiency grant programmes that provide insulation retrofits as well as heating upgrades. Warmer Kiwi Homes, as the programme is now known, has provided both energy savings as well as measurable improvements in the health of building occupants (IEA, 2020b).

Furthermore, beyond "pure" efficiency technologies, Armenia has significant potential to integrate renewable energy with energy efficiency, notably through geothermal heat pumps and solar thermal water heaters. For instance, Armenia's 2011 Renewable Energy Roadmap estimates that geothermal heat pumps could provide more than 4 terawatt hours (TWh) of capacity annually, which is nearly four times Armenia's current heat generation based on natural gas and oil (Econoler, 2015; IEA, 2015). While geothermal heat pumps are currently at the testing and pilot stage only, solar thermal

has been identified as one of Armenia's most feasible sustainable energy technologies, and local market growth has exceeded expectations.

Although renewable heating and renewable energy and are not the focus of this roadmap, these important subjects intersect with building-efficiency policy development – especially in relation to NZEBs (Energy Charter, 2020). Heating is therefore likely to remain a central topic for Armenia's policy makers during NEEAP deliberations and for the implementation of standards and labels for key technologies such as boilers and heat pumps.

Cooling

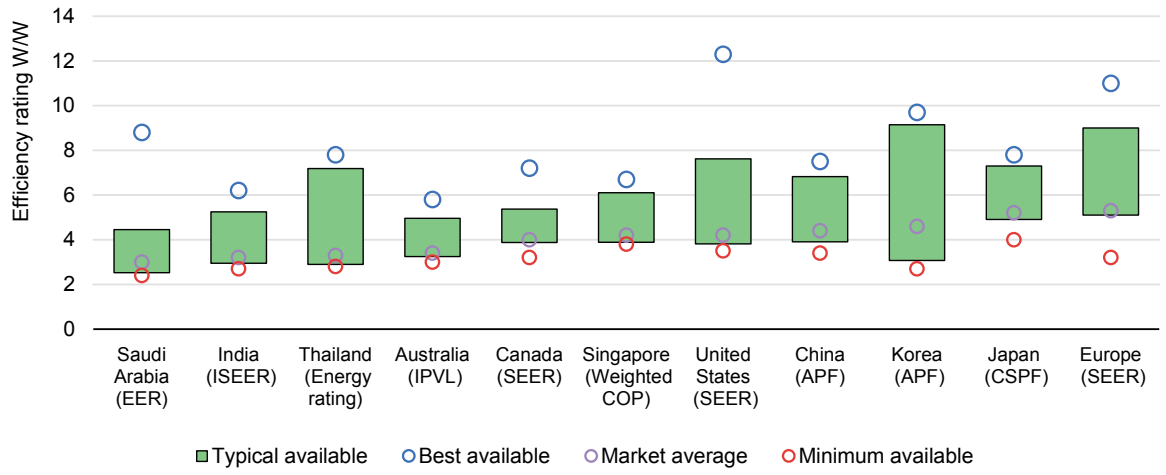
Unlike heating, cooling is still responsible for only a relatively small portion of overall energy demand in Armenia. Only 5% of Armenian households have an AC unit, although the figure is higher in Yerevan at just over 10% (EDRC, 2015). However, cooling is one of the fastest-growing sources of Armenian energy demand, mirroring a global trend resulting from climate change-induced average temperatures increases (IEA 2020b).

Average annual temperatures in Armenia are expected to rise by up to 2.2°C by 2050 (USAID, 2017). In addition, most Armenian cities are in the country's "moderate" and "warm" climate areas (EDRC, 2015). With greater population density in cities and urban heat-island effects, it is likely that demand for AC units and other cooling technologies such as fans will increase further, particularly among Armenia's city dwellers during summer heat waves.

Globally, "[s]pace cooling accounted for around 13% of the overall growth in electricity demand between 1990 and 2016 and 22% of the increase in electricity use in buildings alone" (IEA, 2018b). These trends are particularly visible in the United States and the People's Republic of China ("China" hereafter), as well as in emerging economies in the hottest parts of the world, where an expanding middle class and rising income levels have created unprecedented increases in energy demand for cooling. While China leads AC manufacturing and sales, yearly installations are rising by up to 15% in India and other hot emerging economies. This demand is driving up energy use and GHG emissions (both energy- and refrigerant-related) while creating significant pressure on already-strained electrical grids, especially during peak times (IEA, 2020a).

For policy makers working on cooling in Armenia and the world at large, a key consideration for regulation is the average efficiency of AC units available on the market. As discussed above, EESL programmes are likely to be critical tools, particularly since consumers in most markets are buying AC units that perform at well below their energy efficiency potential (Figure 5).

Figure 5 Efficiency ratings of available AC units by regional metric



Notes: W/W: watt of electricity input for watt of cooling output. The standards, test procedures, temperatures bins and metrics used to evaluate efficiency ratings differ among countries, so ranges should not be compared across countries. SEER = Seasonal Energy Efficiency Ratio. CSPF = Cooling Seasonal Performance Factor. APF = Annual Performance Factor. COP = Coefficient of Performance. ISEER = Indian Seasonal Energy Efficiency Ratio. IPVL = Integrated Part Load Value.

Source: IEA, Efficiency ratings of available AC units by regional metric, https://www.iea.org/data-and-statistics/charts/efficiency-ratings-of-available-ac-units-by-regional-metric.

One strategy that is being used to address this problem in at least 25 countries, including India and China, is the development of national cooling action plans that feature timetables for the adoption of MEPS and labelling programmes (among other measures), in parallel with efforts to phase out harmful refrigerants (K-CEP, 2019; K-CEP, 2019a). Development of Armenia's second NEEAP could be a unique and timely opportunity to include cooling-related measures in an overarching efficiency strategy.

A key first step to develop any cooling action plan – whether as a standalone plan or part of NEEAP-3 – is data collection. Having accurate and comprehensive information about energy-consuming technologies is critical to formulate effective policies and programmes, notably MEPS and labels. For cooling, policy makers need details about the efficiency performance of AC units and other equipment being sold to consumers in order to establish minimum standards or improvement targets for manufacturers; to develop labelling schemes; and to create incentives to help consumers access the most efficient models.

In Armenia's commercial and industrial sector, some data have already been collected and are being used to populate a technology selector developed in collaboration with the Green Economy Financing Facility (GEFF) and the EBRD. The technology selector features only products eligible for financial support by these IFIs because they meet established MEPS and "surpass current market practices" (GEFF and EBRD, 2018). The tool covers industrial and commercial technologies as well as residential cooling equipment such as efficient AC units. Mainstreaming and expanding the technology selector could make it a central component of Armenia's strategy for sustainable cooling, since it would facilitate access to financing instruments for households wishing to purchase more efficient AC units, for example. Indeed, the challenge faced by policy makers across the globe (especially in developing economies) is to balance affordability with high efficiency (Box 1).

Box 1 International efforts and innovations for sustainable cooling

A number of organisations, including Sustainable Energy for All (SEforALL) and the Kigali Cooling Efficiency Program (K-CEP) are working with countries across the globe to develop both policy approaches and financing instruments, including awards and prizes, to balance efficiency with affordability (SEforALL, 2020). These sustainable cooling efforts are also closely linked with two major ongoing global initiatives: the phaseout of harmful refrigerants (part of the Montreal Protocol on Substances that Deplete the Ozone Layer in support of the Kigali Amendment) and efforts to meet the climate-related goals of the Paris Agreement through the Nationally Determined Contributions (NDCs) being submitted by parties to the United Nations Framework Convention on Climate Change (UNFCCC).

Innovative leasing programmes could also promote efficient cooling in commercial and public buildings. For example, the government of Rwanda has launched a "Coolease" mechanism based on the principle of cooling as a service (CaaS), whereby technology providers offer cooling on a leasing or pay-as-you-go basis, essentially using an ESCO model (SEforALL, 2019). The success of the R2E2 project's use of ESCOs for public buildings suggests that this kind of approach could be effectively deployed in Armenia.

In the residential setting, a new initiative in Ghana and Senegal also offers potential inspiration for policy makers in Armenia. Through collaboration with local banks and vendors, and with funding from K-CEP as well as participating governments, the initiative aims to establish a financing mechanism to replace thousands of old, inefficient refrigerators and AC units. Building on a successful refrigerator scheme previously deployed in Ghana (see the section on appliances and energy-using devices below), the initiative features a recycling scheme with incentives for households to trade in their old devices (Ghana News Agency, 2020).

Armenia is already showing leadership in international engagement in this area. For example, a representative from the Ministry of Nature Protection presented a paper entitled "Financial Mechanisms to Support Adoption of Efficient and Clean Cooling Products" during a workshop on the climate and energy-efficient cooling in 2018 (UN Environment, 2018). In parallel, energy efficiency is a key priority in Armenia's first NDC (Government of the Republic of Armenia, 2015). However, based on key recommendations developed in a potential action plan on cooling, for example, more specific emphasis could be placed on energy-efficient cooling in Armenia's enhanced NDC while it continues to engage actively and in a co-ordinated manner with the Kigali agenda on ozone-friendly cooling. Recently published guidance is available to support policymaker efforts (K-CEP, 2019).

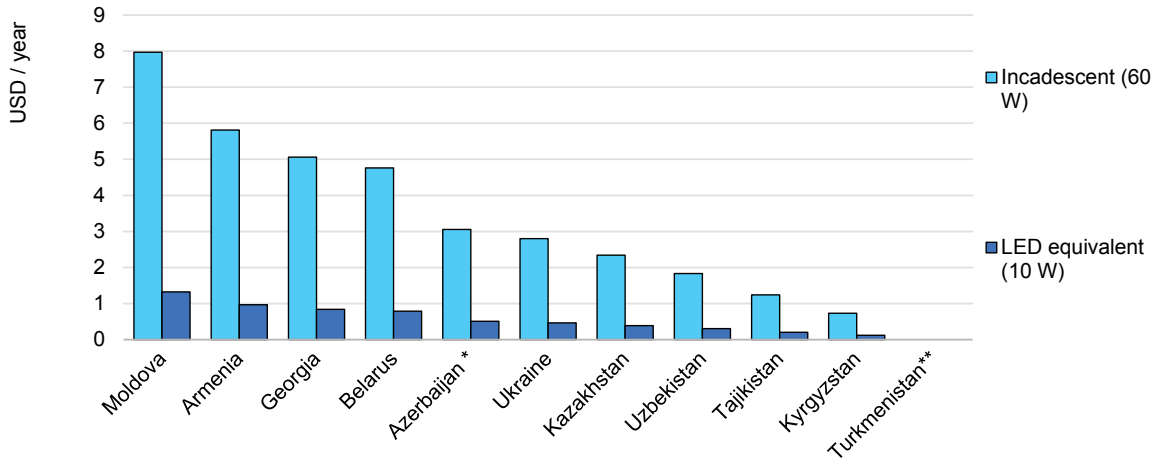
Lighting

Light-emitting diodes (LEDs) are perhaps the most iconic of all building efficiency technologies. LEDs are up to six times more efficient than conventional technologies such as incandescent and halogen lamps, so they can reduce energy consumption dramatically while delivering equivalent or better lighting. In addition, they last much longer than incandescent lamps, meaning fewer replacements are required.

Armenia has made considerable progress in converting to LED lighting, according to local experts. However, precise data for level of LED penetration – or, conversely, the number

of remaining inefficient incandescent lamps still in use – is currently not available. A survey of 2 500 households conducted by UNDP in 2015 found that incandescent lamps were still highly prevalent (up to 70%) in Armenian households (EDRC, 2015). For policy makers charting the future of efficiency in Armenia, a more accurate picture on the status of LED penetration would help to inform whether additional efforts are needed in this area. After all, those Armenian households that are still using incandescent or other inefficient technologies are spending more of their scarce resources on lighting compared with other Caucasus and Central Asian countries that have lower household electricity tariffs (see Figure 6).

Figure 6 Caucasus/Central Asia household spending on lighting, 2017



* Data are for 2017.
** Certain quota of electricity consumption is free.

It is worth noting that, despite their higher efficiency, longer lifespan, and significant long-term cost-savings potential, introducing LEDs widely is not always straightforward. Several barriers hamper their large-scale deployment particularly in low-income countries across the globe. The primary obstacle is the upfront cost of LEDs, which is often higher than for incandescent lamps, making them potentially inaccessible for low-income households that may not have sufficient funds to purchase them at their local shop. In addition to affordability concerns, consumers may not be fully aware of the benefits of efficient lighting. Alternatively, they may be misinformed about the health impacts – believing erroneously that LEDs contain mercury, for example – or may simply consider the quality of the light "too bright" (EDRC, 2015).

Some of the barriers to greater adoption of LEDs can be addressed with targeted communications and awareness campaigns that inform consumers about the benefits of switching away from energy-hungry incandescent lighting. However, policy makers need to consider at least two additional market issues.

The first is the quality of efficient lighting technologies available to consumers. Low-quality LEDs are likely to appear "too bright" (technically due to the colour temperature of the lamp being too low) and may fail after only several months of use. Like other consumer products, testing and labelling as well as quality controls on imports are critical to ensure that consumers have access to reliable technologies.

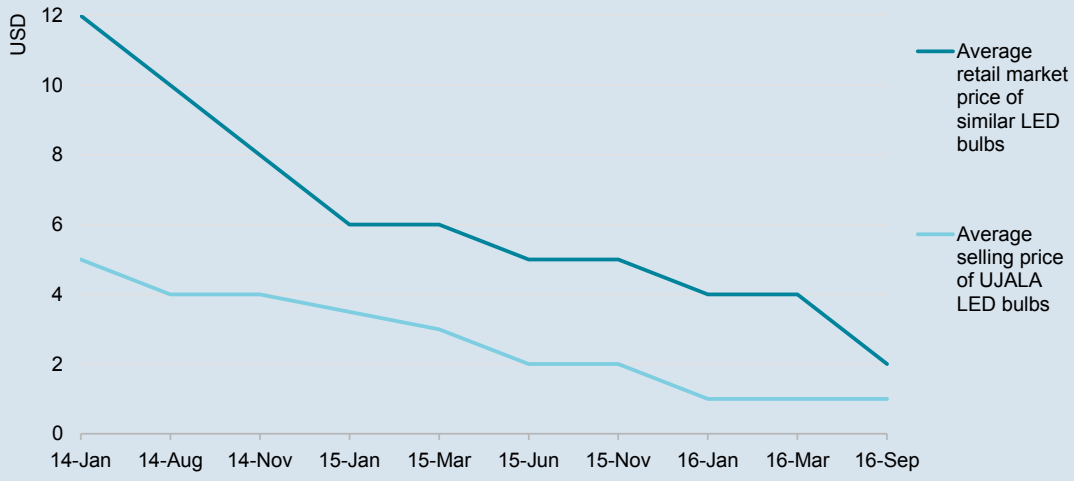
The second issue is financial support to overcome the higher upfront costs of more efficient lighting (an issue that affects nearly all high-efficiency technologies). In addition to preferential loans, grants or other direct support for households, governments could consider the more ambitious strategy of bulk procurement (see Box 2).

Box 2 Bulk procurement of efficient lighting in India and Mexico

India's "UJALA" [Light] programme is one of the world's most successful large-scale schemes to distribute LEDs to both rural and urban households in a developing economy. Thanks to the programme's high-level political endorsement and strong government support, households can obtain LED lamps at one-fifth their regular cost, and subsequently pay back the difference over time through instalments on their monthly electricity bills. In this way, IJALA does not rely on subsidies; instead, the programme reduces the need for subsidies by lowering household electricity consumption.

In addition to distributing over 320 million LEDs to date, the scheme boasts a range of achievements including 41 billion kWh of energy savings and the creation of 70 000 jobs. Perhaps most strikingly, the bulk procurement of millions of lamps also dramatically reduced the average selling price of LEDs over a two-year period (see figure below) and transformed India into the world's second-largest LED market (EESL, 2020).

LED price trends in India, January 2014 to September 2016, for 9 watt LED bulb



Source: U4E (2017), Accelerating the Global Adoption of Energy-Efficient Lighting.

Mexico's "Ahórrate Una Luz" [Save a Light] programme, concluded in 2017, employed a similar bulk procurement approach, replacing nearly 40 million incandescent lamps with CFLs for 8 million families. With a rural focus (communities of up to 100 000 inhabitants), the programme delivered 2.4 gigawatt hours (GWh) in annual energy savings and avoided emitting 1.2 million tonnes of carbon dioxide equivalent (Mt CO_2-eq). The programme also saved families an estimated USD 160 million in annual energy costs, while reducing the need for electricity subsidies by USD 320 million. Strong communication and outreach activities were key to the programme's success (Government of Mexico, 2017).

Other appliances and energy-using devices

Compared with heating and cooling technologies, devices such as electric stoves, televisions, computers and washing machines generally account for a smaller share of building energy consumption (primarily electricity). However, due in part to an increased proliferation of consumer electronics, connected devices and other small plug loads, energy-using devices now represent nearly 15% of global final electricity demand. In addition, most of this energy use is not covered by MEPS, particularly in developing economies where consumption is expected to grow rapidly in the next decade as incomes rise (IEA, 2019).

In Armenia, device ownership and usage levels are still relatively low. While most Armenian households have a stove, refrigerator, washing machine and television, ownership of devices such as microwaves, dishwashers and freezers is much lower. Computers, meanwhile, are present in approximately three-quarters of households (EDRC, 2015). Although these levels have already increased with economic growth and rising incomes, they will likely continue to rise. More disposable household income is naturally desirable and is indeed a core objective of economic development in any country.

Although standards and labelling programmes are commonly used by governments to manage the inevitable increase in device energy use as households become wealthier, policy makers could also consider direct market interventions that target specific types of technologies. As discussed in the previous section, bulk procurement of lighting technologies is an example of this kind of approach that has been successful in India and Mexico. Other countries have had similar success with refrigerators.

In Ghana, for instance, policy makers realised during the mid-2000s that average household refrigerators were consuming more than twice as much energy as devices in Europe and the United States. This was due largely to a proliferation of imported second-hand refrigerators, which, while inexpensive to purchase, were highly inefficient and sometimes accounted for 70% of household electricity demand. During this period Ghana was also struggling with significant power shortages (due to a prolonged drought that impaired hydroelectricity production) while energy demand was climbing significantly as a result of rising income levels and expanding energy access (Energy Commission, 2017).

The Government of Ghana adopted a two-pronged approach to address these issues. First, imports of used refrigerators were banned and MEPS were set for refrigerators (as well as for other energy-using devices). Second, with financial support from the GEF and UNDP, the government implemented a scheme whereby private citizens could trade their old refrigerators for vouchers to purchase new, efficient models. 10 000 refrigerators had been replaced under the programme by 2015, with new refrigerators now constituting 90% of the market. Meanwhile, participating households saved an average USD 140 annually on their electricity bills, while countrywide electricity savings totalled approximately 400 GWh (Energy Commission, 2017).

A similar approach is currently being deployed in Colombia as part of a “cash for clunkers” programme, under which a significant reduction in value-added tax (VAT) is being offered for new refrigerator purchases along with a recycling scheme for older models. The government aims to replace more than 1 million inefficient refrigerators, which is expected to create 12 000 jobs (Ministry of Mines and Energy of Colombia, 2018).

Getting future-ready

An effective roadmap must consider the longer-term issues at the heart of future energy systems that will inevitably impact Armenia's efforts to make its buildings more efficient. As Armenia's building energy efficiency transformation will not happen overnight, there is ample time and opportunity to explore emerging technologies and trends, to assess whether they are relevant for the country. Plus, taking advantage of emerging technologies and trends may allow Armenia to bypass previous methods and instead take advantage of the latest innovations to address the persistent barriers and challenges that have not been overcome through traditional approaches.

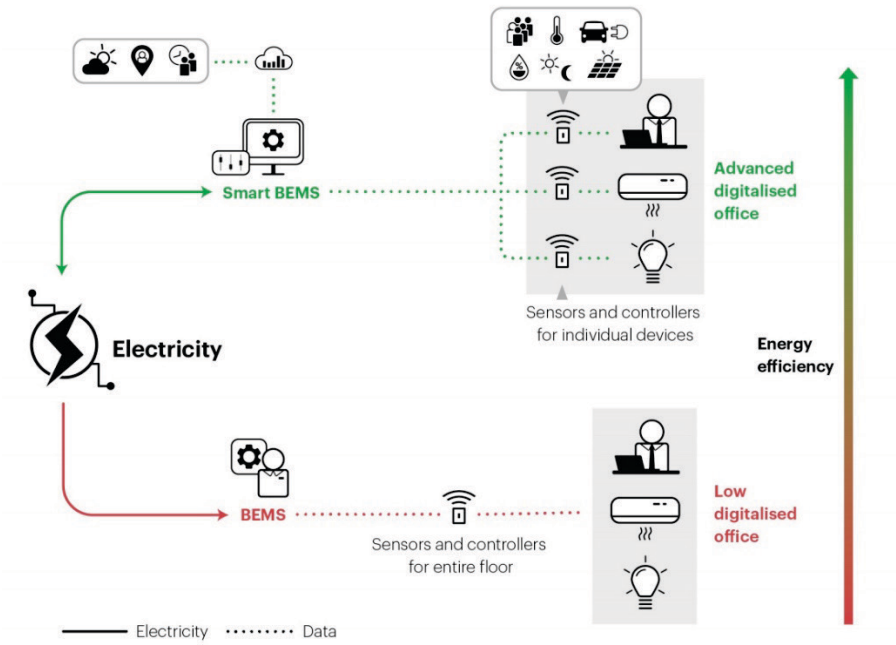
This section therefore offers a brief overview of the main areas of buildings-sector innovation, as well as the broader market and energy system innovations that affect buildings, beginning with digitalisation.

Digitalisation

A proliferation of digital technologies, notably smart phones, low-cost sensors and internet-connected devices has created a veritable revolution across countless industries. This revolution is based on a combination of data (i.e. digital information), analytics (the ability to compute vast amounts of data to produce actionable insights) and connectivity (the exchange of data between machines, or humans and machines, through digital communications networks). For analysing the energy efficiency of buildings, digitalisation offers very detailed insights into the performance not only of individual technologies but of the building as a whole (IEA, 2019).

Digital innovations in several areas can be applied to advance building efficiency in Armenia, both in the immediate future and the longer term. For instance, "smart" building energy management systems (BEMS) rely on sensors, software, analytics and even artificial intelligence to improve building efficiency and performance. BEMSs are particularly useful in public and commercial buildings, where they provide greater energy-efficiency potential, a range of additional insights such as building occupancy and usage patterns, and other functionalities such as the ability to control individual offices and even connectivity with renewable energy and battery-electric vehicle (BEV) charging infrastructure (Figure 7).

Figure 7 Smart vs. traditional BEMS in a commercial building



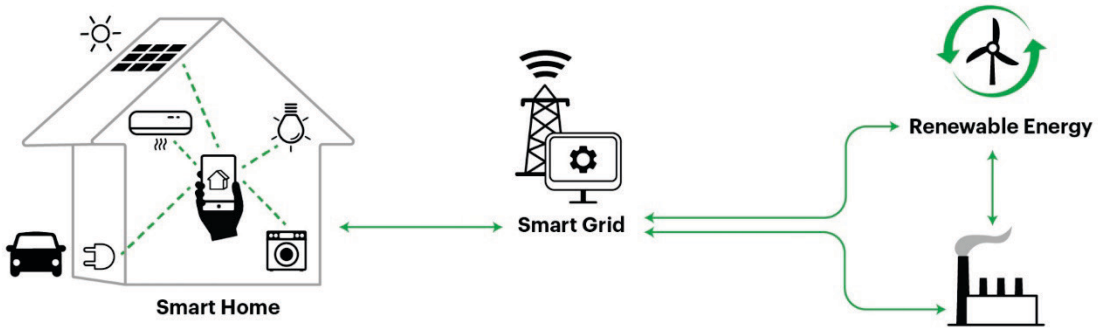
Note: For illustrative purposes only. Individual configurations may differ.
Source: IEA (2019a), *Energy Efficiency 2019*, https://www.iea.org/reports/energy-efficiency-2019

As part of an ongoing project in Armenia, the UNDP is placing a type of smart BEMS – referred to in the project as an Energy Management Information System (EMIS) – at the heart of its framework for measuring, reporting and verifying (MRV) energy savings in public buildings. Data obtained from the EMIS will be used to inform key stakeholders, especially financial institutions, to strengthen the business case for efficiency retrofits. According to the UNDP, a similar project in Croatia led to public budget savings of USD 18 million annually (EDRC, 2016).

In residential settings, digitalisation through the "smart home" phenomenon can be transformative (Figure 9). Rather than merely consuming energy (i.e. electricity or gas) provided by utilities at a fixed rate, smart homes "interact" with the energy system in a much more proactive way. Appliances and other energy-using devices can be programmed to operate at optimal times only, when electricity prices are at their lowest. Smart homes also produce renewable electricity, usually through rooftop solar PV, and they can help store excess grid electricity in EVs connected to onsite charging infrastructure. In this way, residential buildings and households are transformed from energy consumers into energy "prosumers", meaning they both consume and produce energy.

While these types of homes are not common in Armenia – indeed they are not common in most parts of the world, including advanced economies – many experts agree that this kind of connectivity and interactivity between homes and grids can play a key role in energy system decarbonisation. Furthermore, digital connectivity can be important in enabling the development of NZEBs, as discussed briefly in the next section and explored in more detail in a separate roadmap for Armenia (Energy Charter, 2020).

Figure 8 Smart homes and smart grids in flexible energy systems



Note: For illustrative purposes only. Individual configurations may differ.
Source: IEA (2019a), *Energy Efficiency 2019*, https://www.iea.org/reports/energy-efficiency-2019

Renewable energy and grid integration

Traditional buildings are standalone structures that consume electricity and gas based on occupant needs and/or the services provided within the building. In such buildings, demand-side modifications – e.g. energy efficiency improvements, or changes in occupant behaviour or equipment use – are the primary ways to impact energy consumption. In contrast, buildings that have some form of onsite renewable energy generation capacity such as rooftop PV and are connected to the grid have the potential to reduce their carbon emissions much more than they would through demand-side measures alone.

This is at the heart of the NZEB concept, which combines a high degree of energy efficiency (or performance) with the ability to generate onsite renewable power. For building occupants, owners and/or operators, this offers greater independence than reliance on grid-based electricity alone. At the macro level, it also provides an opportunity to dramatically reduce the overall carbon footprint of the buildings sector. As mentioned in the introduction, Armenia is already exploring its NZEB future through the development of a dedicated roadmap (Energy Charter, 2020).

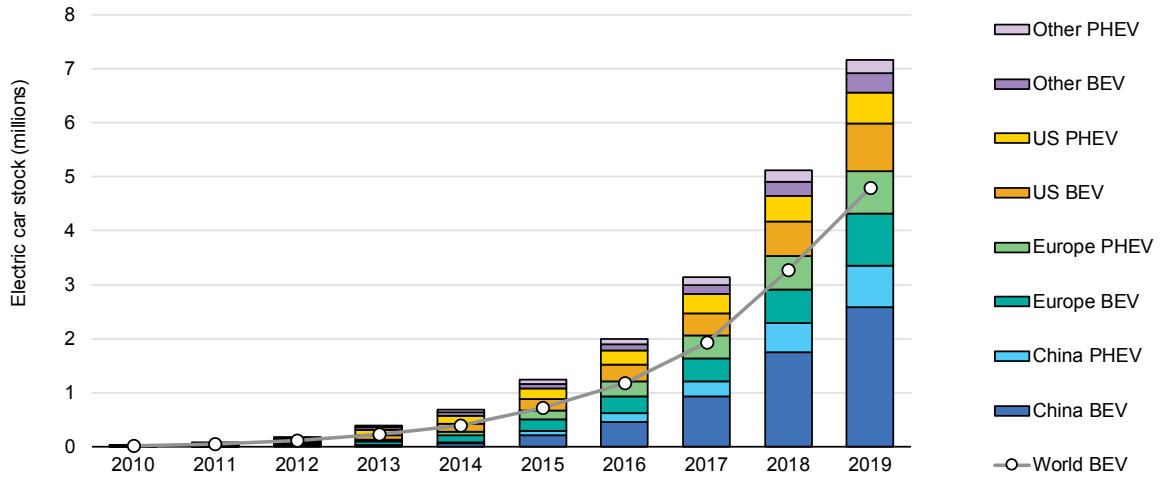
Beyond offering grid independence and reducing the carbon footprint of individual buildings, NZEBs or any grid-connected buildings with onsite renewable energy generation can be active participants in the energy system. As discussed above, digital technologies are enabling an important shift in the way buildings interact with the energy system, notably with electricity grids. For energy policy makers and energy system operators – especially distribution system operators (DSOs) – this creates both opportunities and challenges that need to be addressed as part of wider energy strategy development.

Electric vehicles, charging infrastructure and power storage

BEV numbers are on the rise globally, expanding by a factor of seven in less than a decade from negligible levels in 2010 to more than 7 million vehicles in 2019 (Figure 10). According to a June 2020 conversation with the UNDP, there are currently only 500 BEVs in Armenia. However, this figure represents a sharp increase and is likely to rise further as major global

vehicle manufacturers – notably in China and Europe – begin to shift their focus to electric alternatives, particularly in the wake of Covid-19 (Bloomberg Green, 2020).

Figure 9 Global BEV stock, 2010-19



Note: PHEV = plug-in hybrid electric vehicle.
Source: IEA (2020), Global EV Outlook 2020, https://www.iea.org/reports/global-ev-outlook-2020

While transport policy, BEV promotion and related topics are outside the scope of this roadmap, the growth of electric mobility is directly relevant to the buildings sector in at least two ways. First, buildings – and the land areas connected to them – are part of the core charging infrastructure for electric mobility. Facilities such as commercial and public buildings, airports, bus terminals and logistics distribution centres will be critical as the number of BEVs continues to increase.

Second, BEVs themselves can serve as power storage units for excess electricity generated onsite or supplied by the grid. For example, office parks designed for commuting employees could become BEV charging and/or power storage hubs, at least during daytime hours. While these kinds of systems are generally just at the pilot stage, the notion that passenger cars could be transformed from being “gas guzzlers” to an integrated part of energy storage at the building and grid level is compelling. Should this type of technology be developed at a global scale and become much more affordable for consumers (like BEVs in upcoming years), it is likely that BEV integration will become more pertinent for policy makers in Armenia.

Towards a roadmap for Armenia's buildings

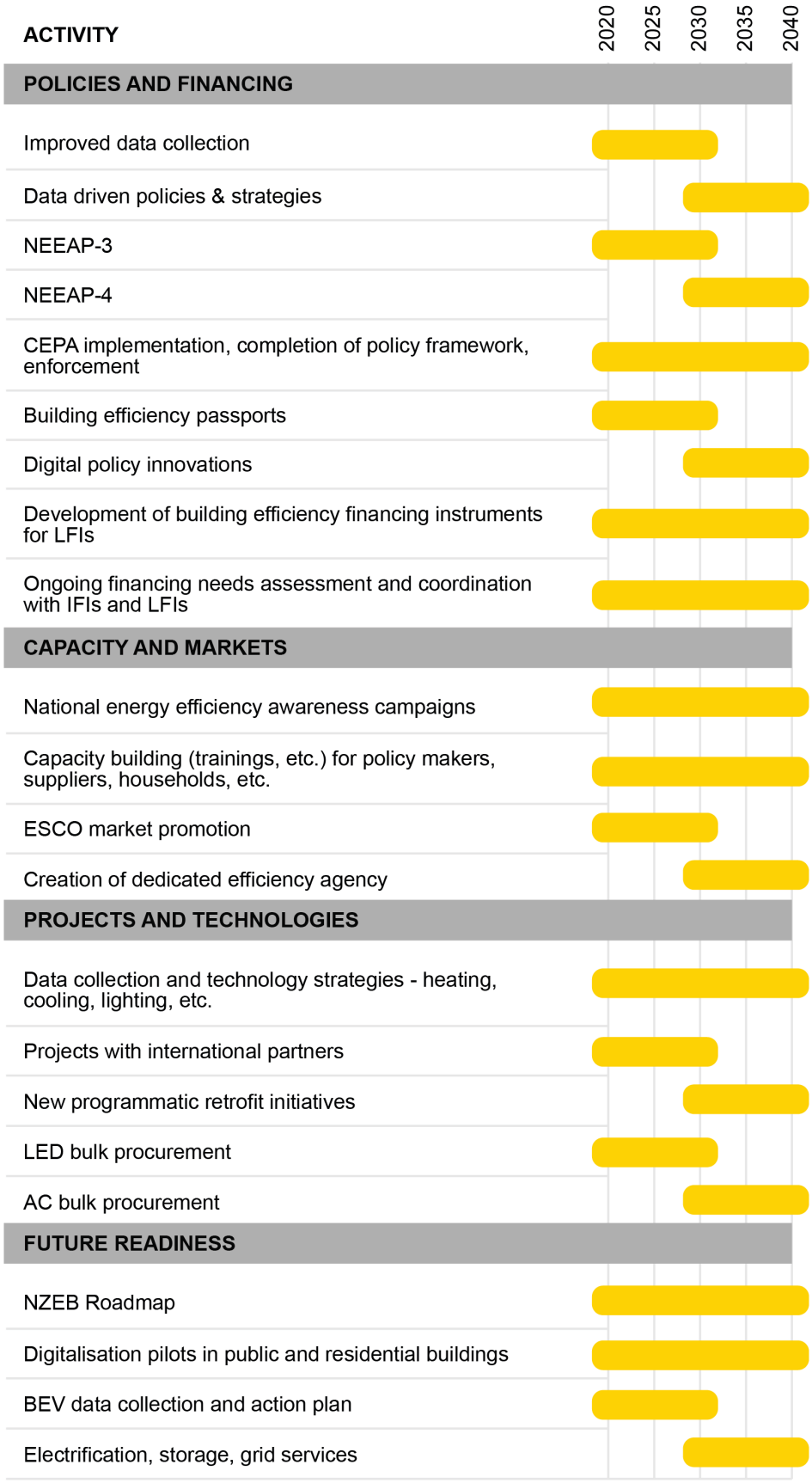
The preceding insights and analysis can inform Armenia's transition to a more efficient, resilient and affordable building stock over the next 20 years. Although policies and approaches will inevitably be adjusted during this time, it is possible to identify some activity and focus areas that are likely central to the long-term transition. Conceptually, a 20-year roadmap could be divided into five-year intervals across four categories of activity: policies and financing; markets and capacity; projects and technologies; and future readiness (Table 1).

Within each of these activity areas, Armenia could achieve numerous key building efficiency-related outcomes across a range of focus areas, including laws governing the way MABs are managed, data collection and quality, and ESCO market expansion.

Unfortunately, it is beyond the scope of this report to provide detailed action plans for each of the focus areas. Based on the Government of Armenia's preferences, these would be developed separately and as appropriate, relying on the expertise of policy makers, international organisations and lenders, NGOs and other stakeholders working to advance building efficiency in Armenia.

Nonetheless, the activities and focus areas outlined in Table 1 are intended to help structure discussions, support strategy development and prioritisation, provide initial inputs for funding proposals, etc. In this spirit, the following sections provide additional ideas and approaches.

Table 1 Roadmap at-a-glance: Activities and focus areas



Policies and financing

Given the number of concurrent building efficiency-related initiatives presently being enacted, 2020 is an opportune year for Armenia to develop a robust and supportive policy framework for building efficiency. The NEEAP-3 development process, along with the NZEB Roadmap, for example, provide excellent opportunities to address remaining gaps in key building efficiency areas, such as MEPS and labels (or passports) for individual technologies and entire buildings. In parallel, the IDR process can help identify any additional policy or process gaps (e.g. concerning data collection) and how to address them in the wider context of energy sector development and reform.

In the public sector, budgeting rule reforms could unlock ESCO market development, particularly since R2E2's activities have proven the concept of EPC-based projects. Meanwhile, the adoption of laws in 2020 governing HOAs and HMCs can provide greater legal certainty for residential building retrofits, which could in turn support the development of financing agreements with LFIs, for example.

The 2020-25 period is an ideal time to make progress while trialling new approaches and identifying additional focus areas. Work being carried out as part of the European Union's high-level initiative, combined with UNDP-led efforts related to de-risking and scaling up investments, gives Armenia the opportunity to kickstart and expand its residential efficiency financing market. The challenge for policy makers will be to ensure that these and other initiatives are well co-ordinated, and that experiential learning informs further initiatives that promote residential efficiency financing.

Capacity and markets

At the same time, properly implementing and enforcing existing policies must be an ongoing priority for Armenia. Rule enforcement is inextricably linked with deeper systemic capacity and market concerns, as local and national government departments, lenders and other market participants must have the capacity to properly implement standards and labelling strategies. International experience suggests the effectiveness of combining policy approaches and financing instruments with capacity-building measures (including awareness-raising), particularly in complex areas such as household efficiency improvements and major building retrofits.

Training sessions, technical support and public awareness/information campaigns can help Armenia enact a more robust and well-enforced policy framework that would in turn stimulate the building-efficiency market. Indeed, Armenia is already employing such a combined approach as part of EAEU standards and labelling work, based on a multi-pronged approach that includes the development of testing capacity and awareness-raising (EAEU, 2020). Meanwhile, public awareness-raising efforts accompany implementation of the NIP, being delivered in collaboration with EU partners (EC, 2019a).

In certain cases, capacity-building can also take the form of a new dedicated institution or entity to address key market barriers. For instance, particularly during its initial phases, the KredEx facility discussed previously relied heavily on the dedicated new KredEx foundation. The role of the foundation is to design loans, including all relevant terms and conditions, co ordinate funding delivery with both IFIs and LFIs and, together with ministry colleagues, engage HOAs and other key market stakeholders. R2E2 also played a role similar to that of the KredEx foundation during development of its public sector building efficiency initiative. There is scope to expand or renew R2E2's remit in this area, or to create a new entity to deliver building efficiency upgrades.

The dynamics of India's UJALA programme are comparable, as a dedicated super-ESCO (Energy Efficiency Services Limited) was created to procure LEDs in bulk and distribute them across India. Energy Efficiency Services Limited is a "joint venture of four major government-owned companies: Power Grid, NTPC, Rural Electrification Corporation Limited and the Power Finance Corporation Limited" (EESL, 2017). Owing to its success, Energy Efficiency Services Limited is now engaging internationally in clean-energy-related initiatives.

Many countries have developed a considerable number of building efficiency financing instruments to generate financing for energy efficiency in recent decades. Lessons from their efforts could offer helpful insights for policy makers in Armenia working on roadmap focus areas. While approaches may differ according to local context (notably prevailing market conditions and finance ministry and LFI capacities), instruments are generally accompanied by enabling measures – from collateral development and training programmes for auditors, installers and local lenders, to the creation of dedicated organisations to lead implementation (Table 2).

Table 2 Energy efficiency financing instruments and enabling measures

FINANCING INSTRUMENT	SECTOR FOCUS	ENABLING MEASURES (CAPACITY)
Grant, preferential loan or line of credit	Residential	Finance ministry resources; supply chain and LFI training sessions; awareness-raising campaigns targeting households
Revolving fund	Residential and public, including municipal	Creation of a special-purpose vehicle (SPV) to coordinate/oversee financial flows across the fund
EPC/ESA (ESCOs)	Primarily public/commercial	Standard contracts; pre-approved pools of suppliers; technical assistance; training for energy auditors
Bulk procurement	Public and residential	Super-ESCOs to deploy technologies, along with market promotion measures through collaboration with energy providers
On-bill financing (efficiency loan paid back through monthly utility bill)	Public and residential	System elaborated between energy regulators and utilities, whereby government institutions can be facilitators and beneficiaires for financing public building retrofits

In addition to being paired with enabling/capacity measures, policy efforts can be strengthened if they are delivered in tandem with effective outreach and communication, including public awareness-raising. This applies particularly to more comprehensive initiatives (e.g. adopting laws on HOAs and HMCs, combined with promoting whole-building retrofits). Efficiency interventions in buildings can be disruptive and appear costly for homeowners and building occupants unless policy makers, installers, energy providers, lenders and other stakeholders convey their benefits using effective communication tools:

- local assemblies and meetings (with Covid-19 precautions in place) or online alternatives to introduce initiatives and address questions/concerns
- newspaper and billboard advertisements
- dedicated websites
- social media campaigns
- television advertisements (including by energy providers/utilities partnering with the government to deploy grant schemes, for example)

Communication with the public is clearly essential for efficiency programmes to be successful. New Zealand, for example, has made clever communications and awareness campaigns a core part of its overall efficiency strategy, which includes the Kiwi Warmer Homes programme. The country's Gen Less campaign was praised in the Global Commission for Urgent Action on Energy Efficiency's recommendations because it "seeks to make a climate-positive lifestyle appealing and desirable through positive messages and articulates the role of energy use and energy efficiency in achieving that lifestyle" (IEA, 2020b).

Good communications and awareness-raising are also important for effective engagement with key market and supply chain actors (construction firms, auditors, installers, etc.). Using voluntary agreements and/or having networks of companies collaborate on energy efficiency-related issues can ensure private sector support for key changes to building codes and other efficiency regulations. One means to increase private sector interest and engagement in these networks is to emphasise the job creation potential of building-efficiency upgrades. Building retrofits are generally labour-intensive and "create mostly non-exportable jobs, with 15-19 jobs created for every EUR 1 million invested" (World Bank, 2014).

Given the importance of capacity and markets – and associated communications and awareness-raising campaigns – it may be appropriate for Armenian policymaker and expert discussions to focus on these topics during 2020 and beyond. It is certainly relevant for the Energy Efficiency Board (being established as part of the EU-Armenia high-level initiative) to consider these areas carefully. Alternatively, a dedicated committee, working group or other body could be established to ensure that targets set in the NEEAP and other policy documents are achievable from a capacity point of view and can be accompanied by awareness campaigns. This would also be an opportune moment to identify capacity gaps that could be addressed, for example with additional IFI support. The creation of a dedicated energy agency or super-ESCO, or an expanded remit for R2E2, would likely be one of the core propositions in these discussions.

Projects and technologies

Investing in building-efficiency projects in Armenia could be highly cost-effective, given the country's significant potential for project and market development, investment opportunities, reduced costs for consumers and improved living conditions. In other words, the underlying business case for raising building efficiency is as strong in Armenia as it is in many other countries across the globe.

Heating – upgrading existing home systems to increase both efficiency and thermal comfort, particularly for low-income households – clearly must be a key focus area for the government. International precedents for programmatic retrofits and technology deployment, especially through bulk procurement, could be further examined to determine their feasibility for Armenia.

In the area of lighting, Armenia could investigate the feasibility of a bulk procurement programme for LEDs that could be rolled out with support from international lenders and local supply partners, potentially during 2025-30 or earlier. Such a programme could, in turn, provide the basis for subsequent or parallel heating-related endeavours (e.g. the large-volume purchase of highly efficient boilers for apartments) that could be launched simultaneously with grants for rural households to replace biomass-based heating systems.

Bulk procurement – or at least a programmatic approach – could also be used to promote efficient cooling, to ensure that Armenians do not make impromptu purchases of inefficient AC units and fans if average temperatures and summer heat wave frequency and intensity continue to increase.

Concerning technologies used in public and commercial building projects, the EBRD technology selector provides a foundation for further work to target and promote specific technologies, for example through tax-based incentives. This is the basis of the UK Enhanced Capital Allowance (ECA) scheme, which lists approximately 14 000 technologies that are among the top 25% most energy-efficient in their category. Companies that invest in listed technologies can benefit from tax relief of up to GBP 1 million over a two-year period. Among the many technologies included in the ECA scheme are heat pumps; heating, ventilation and air conditioning (HVAC) equipment; motors and drives; and solar thermal systems (Department for Business, Energy and Industrial Strategy, 2020).

As emphasised in the discussion on markets and capacity, efficient and reliable technologies and services need to be readily available on the market for projects to be successful, and all parties along the supply chain – architects, contractors, installers, energy auditors and technicians, in addition to banking and real estate professionals – need to be knowledgeable about high-efficiency options.

Future readiness

Building-efficiency technologies are increasingly intertwined with renewable energy and digitalisation, both in homes and in public and commercial buildings. This combination presents both challenges (from technical issues such as interoperability and grid integration, to regulations relating to data and privacy) and opportunities in terms of unprecedented connectivity, optimisation and analytics. The pilot projects proving new concepts and innovations in this area around the world may now be particularly relevant given the shift in work locations and patterns incited by the Covid-19 pandemic.

In this context, the NZEB Roadmap is an excellent aid for policy makers charting the course of Armenia's buildings sector for the next 20 years and beyond. Combined with data collection and planning work related to BEVs and their potential integration with buildings and storage systems, Armenia's NZEB aspirations can help stimulate innovation and increase progress on building efficiency.

Conclusions

Armenia has considerable untapped potential to raise the energy efficiency of its buildings, but several barriers and challenges must be addressed if notable progress is to be achieved in the coming decades. The information contained in this roadmap is intended to support strategic discussions and decision-making. Rather than a fixed blueprint, it is meant to provide a framework that can be adjusted according to policy discussions and evolving priorities.

International collaboration is likely to remain key for ensuring both the short-term success and the long-term viability of Armenia's efforts. Collaboration and engagement with the EU in the context of CEPA, or UNDP's work around de-risking and scaling efficiency financing, for example, are opportunities for Armenia to make progress in key areas. The challenge for policy makers will be to ensure coordination across these and other initiatives, and to ensure that lessons are used to inform wider building efficiency progress.

At the same time, proper implementation and enforcement of existing policies remains an ongoing priority for Armenia. This is an issue that is inextricably linked with more systemic capacity and market issues. Indeed, capacity building, combined with communications and awareness raising, are fundamental to the success of building efficiency in Armenia. Key actors along the value chain – public officials, lenders, energy auditors, contractors, etc. – must have the information and capacity to deliver their role in building efficiency programmes, such as reforms to the communal management of apartments, the delivery of whole building retrofits, or the development of a market for energy services.

While sweeping political changes in 2018 and the Covid-19 pandemic in 2020 delayed or slowed progress, Armenia's building efficiency work is slowly regaining momentum. The period 2020 to 2040 presents a window of opportunity to address barriers, progress ongoing initiatives, trial new approaches and identify feasible opportunities related to digitalisation and electrification. Ultimately, strong political commitments and a focussed approach are needed so that building efficiency can progress in Armenia.

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Abbreviations and acronyms

AC	air conditioning
BEMS	building energy management system
BEV	battery electric vehicle
CaaS	cooling as a service
CAPEX	capital expenditure
CFL	compact fluorescent lamp
CO_2	carbon dioxide
DSO	distribution system operator
EBRD	European Bank for Reconstruction and Development
EC	European Commission
ECA	Enhanced Capital Allowance scheme (UK)
EESL	energy efficiency standards and labelling
EMIS	Energy Management Information System
EPBD	Energy Performance of Buildings Directive
EPC	energy performance contract
ESA	energy services agreement
ESCO	energy service company
EU	European Union
EV	electric vehicle
GEF	Global Environment Facility
GHG	greenhouse gas
HFH	Habitat for Humanity
HMC	housing management company
HOA	homeowner's association
HVAC	heating, ventilation and air conditioning
IDR	in-depth review
IEA	International Energy Agency
IFC	International Finance Corporation
IFI	international financial institution
ISO	International Organization for Standardization
LED	light-emitting diode
LFI	local financial institution
MAB	multi-apartment building
MEPS	minimum energy performance standards
MSIP	Municipal Services Improvement Project (Macedonia)
MTAI	Ministry of Territorial Administration and Infrastructure
NEEAP	National Energy Efficiency Action Plan
NIP	Neighbourhood Investment Platform
NGO	non-governmental organisation
NPV	net present value
NZEB	nearly zero-energy buildings
R2E2	Renewable Resources and Energy Efficiency Fund of Armenia
REELIH	Residential Energy Efficiency for Low Income Households project
SMEs	small and medium-sized enterprises
SPV	special-purpose vehicle
UNDP	United Nations Development Programme

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