PROSPECTIF

STUDY SUMMARY

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n° 9 | December 2023

canton de vaud

STATISTIQUE VAUD

Département des finances et de l'agriculture (DFA)

ENERGY TRANSITION IN THE CANTON OF VAUD BY 2050

The on-going energy transition will require in-depth changes to the current energy system in order to move from a system based on fossil and nuclear resources to a system based on locally produced renewable resources. The study[1] summarized here highlights the issues relating to this energy transition as well as the scale of the changes needed to achieve carbon neutrality by 2050. It shows that there is still a long way to go to reach this objective, although the transition has already begun. Indeed, if the deployment of renewable energy and energy savings (efficiency and sobriety) is not stepped up rapidly, this objective will be achieved with a "delay" measured in decades; such findings are in line with the scientific studies that have been carried out worldwide.

INTRODUCTION

Energy is an essential element of our modern societies. Human activities are intrinsically linked to available energy resources for heating, transport or for running our economy. This central role, which was strongly reminded to us by the risk of energy shortages following Russia's invasion of Ukraine, is not new.

The evolution of humankind and its lifestyles have always been influenced by changes in the energy system. In Switzerland, as in most developed countries, the evolution of final energy consumption was significantly modelled by the major social changes and the advent of our consumer society in the decade following the Second World War. Final energy consumption, mainly from fossil fuels, thus increased six-fold in the period of strong economic growth and improved living conditions between 1945 and 1973 (**F2**, below).

Yet, the current energy system has three major limitations:

1. Its impact on the environment and health, particularly due to its repercussions on the climate.
2. The supply risks linked to the limited geographical availability of fossil and nuclear resources.
3. The finitude of fossil and nuclear resources.

In recent decades, the impact of climate change on nature and human beings has escalated, while the attention paid to the warnings of the scientific community about the future consequences of global warming has grown.

The people of Switzerland and the Canton of Vaud confirmed their intention to join the global effort by enshrining in the Climate and Innovation Act as well as in the Constitution of Vaud, on 18 June 2023, their objective of becoming carbon neutral by 2050.

Achieving this goal means significantly reducing the greenhouse gas (GHG) emissions and actively removing from the atmosphere emissions that are (very) difficult to avoid. For instance by using natural or technological solutions to capture and store carbon, the potential of which is uncertain to this day.

To that extent, the Canton of Vaud has decided to accelerate its energy transition in order to **eliminate fossil fuels that are responsible for 67% greenhouse gas emissions in its territory.**

These emissions result mainly from the combustion of fuel oil, natural gas or the non-renewable waste used for heating buildings and from fuel used to travel by car or truck, according to our estimates[2] **[F1]**.

Contents

Purpose and method of the study

The purpose of the "Energy Transition to 2050" prospective study is to highlight the challenges, levers for action and obstacles relating to this transition, and to assess the changes which need to be made in order to become carbon neutral by 2050. To this end, we have outlined different pathways that the energy transition could take from now until 2050 in the Canton of Vaud. By energy transition pathways we mean the combined evolution of both sides of the energy system in Vaud: on the one hand energy demand, and on the other hand the deployment of production techniques to meet this demand.

This study uses different tools to comprehend each facet of this system; firstly the projection tools for energy demand, and secondly the Energyscope tool to model the energy production system of the Canton of Vaud. The resulting system thus combines several hundreds of variables (building renovation rate, kilometres travelled by car, etc.)

To measure the evolutions of the energy system from now until 2050, we have created three prospective scenarios representing contrasting realities. In each scenario, the key parameters pertaining to the energy production-consumption chain vary according to different assumptions. The latter have been developed on the basis of scientific literature and consultation with specialists.

In concrete terms, this energy transition implies the following actions:

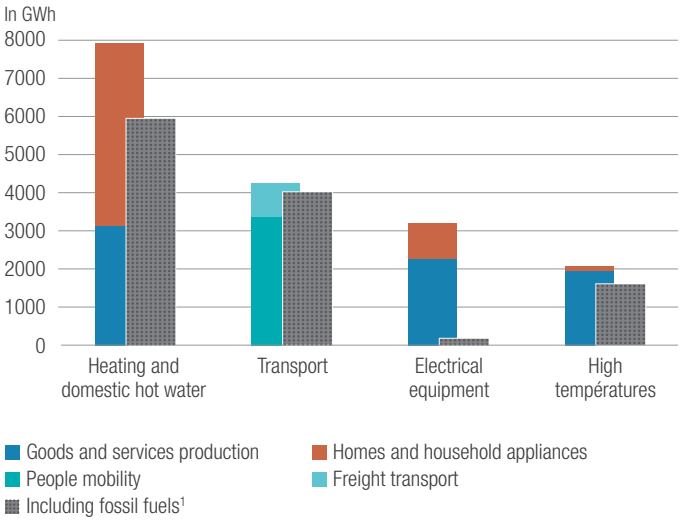
1. Reducing the Canton's energy needs by replacing the current equipment with more efficient equivalents or with equipment that runs on renewable energy, and adopting a more frugal behaviour through sufficiency.
2. Extensively deploying renewable energy production and distribution facilities throughout the Canton to meet its energy needs.

Furthermore, this transition will enable the Canton of Vaud to increase its energy independence and secure its energy supply. **Indeed, 84% of the energy consumed in Vaud comes from outside the region, mainly from abroad**. Naturally, this makes the Canton more vulnerable to price fluctuations, while exposing it to energy rationing risks.

The energy transition has already begun in the Canton of Vaud, in particular with the marked development of solar energy and heat pumps as of the mid 2000s. Yet, there is still a long way to go [F2]: in Switzerland, the share of renewable energy in the final energy consumption amounted to 28% in 2021 (compared to 17% in 2005).

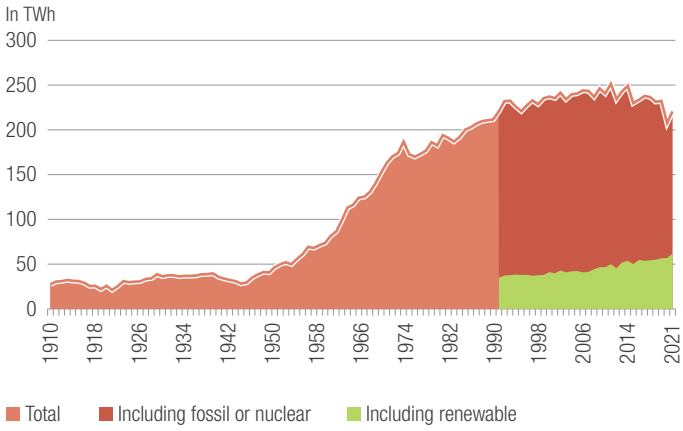
> "The Canton's energy supply depends highly on foreign resources, which makes it vulnerable to price fluctuations and exposes it to energy rationing risks."

[F1] FINAL ENERGY CONSUMPTION BY ENERGY SERVICE IN VAUD IN 2017



[1] The value of fossil fuels takes into account the portion of non-renewable waste as well as the portion of non-renewable electricity produced in Vaud. The portion of electricity produced by non-renewable means (nuclear, fossil, etc.) in Switzerland is not taken into account in this category.

[F2] FINAL ENERGY CONSUMPTION BY TYPE OF ENERGY SOURCE IN SWITZERLAND, 1910-2021[1]

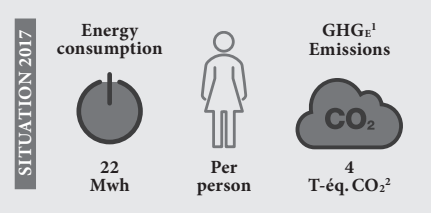


[1] The portion of renewable energy was not available prior to 1990 in the energy statistics. Most of it was hydroelectric power from the 1950s to the mid 2000s.

MAIN RESULTS OF THE STUDY FOR 2017 AND 2050

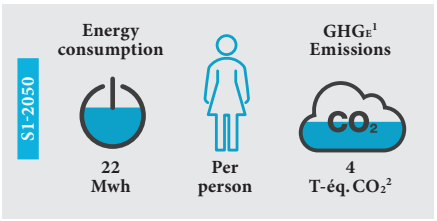
Energy transition can take many different paths. In order to illustrate the variety of the possible developments of the energy system by 2050, we have created three prospective scenarios representing the contrasting realities in terms of the energy and climate issues faced by society in Vaud. The main differences between these scenarios are the intensity of investments in equipment and technology as well as the extent of changes in practices and behaviours. As a consequence, there are several possible paths for the energy transition between now and 2050.

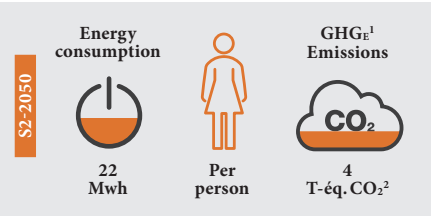
Scenarios and main results per person



In 2017, the reference year for this study, the inhabitants in Vaud consumed an average of 22 MWh of energy per person. The greenhouse gas emissions related to this energy consumption– the GHG$_E$[3] – were equivalent to 4 T-eq. CO_2 per person[4], or two thirds of the Canton's total territorial emissions. The remaining third came mostly from ruminant farming, cement manufacture or waste disposal.

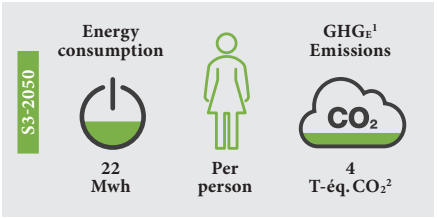
In scenario No.1 ***continuity*** (S1), the current trends continue and are even consolidated, which leads to a slight acceleration in the energy transition, while society remains energy-intensive.
Hence, the final energy consumption per inhabitant will drop by 32% compared with 2017, while GHG emissions relating to the energy system per person will be halved.





In scenario No. 2 ***change of pace*** (S2), all the actions and investments stimulating the energy transition are considerably reinforced. Building renovation and renewable energy development are given a boost, while habits and lifestyles adapt but remain consumerist.
The final energy consumption per inhabitant will drop by 45% and the GHG emissions relating to the energy system per inhabitant will amount to 70%

In scenario No. 3 shift to a ***new paradigm*** (S3), the actions and investments are made much faster than in scenario No. 2. Furthermore, the consumption habits of Vaud's inhabitants become more frugal. The actions to carry out the energy transition are thus scaled up, which marks a break both with the intensity of the existing initiatives and with the widening of the range of changes implemented. The final energy consumption per inhabitant will drop by 54% and the GHG emissions relating to the energy system per inhabitant will amount to 80%.

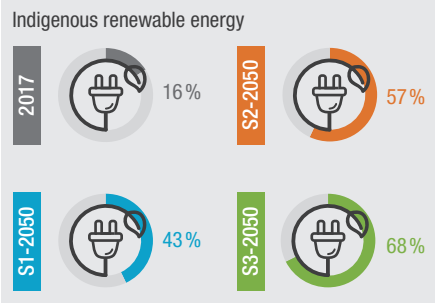


FINAL ENERGY CONSUMPTION

The reductions of final energy consumption are smaller at the cantonal level (compared with the individual level) [F3]. Indeed, these reductions occur within a context of demographic and economic growth (respectively +0.8% and +1.9% per year between 2017 and 2050), two factors which increase the number of people and businesses consuming energy, leading de facto to higher energy needs.

At the cantonal level, the drop in consumption would be limited to 11%, without any new impetus (scenario No. 1), whereas it would be more significant in the other two scenarios, with a reduction that could reach between 28% and 39% depending on the scenario, if the actions in favour of climate were further strengthened or even multiplied.

The breakdown of the final consumption shows that the housing and household appliances sector, as well as the transport sector and services sector should see their consumption drop in all our scenarios, but to a greater or lesser extent depending on the intensity of the changes in practices, the deployment of energy-efficient techniques and the indigenous production of renewable energy [F4].



In 2017 energy consumption by heating systems dominated the housing and household appliances and services sectors. Replacing fossil fuels with renewable energies and improving the energy efficiency of buildings mainly through refurbishing would allow to substantially reduce the amount of energy needed to heat residential and commercial premises by 2050. The same applies to the transport sector, which could experience a considerable fall. Most of this reduction would result from the electrification of vehicles - which would be more energy-efficient – thus avoiding a large amount of GHG emissions in the Canton of Vaud.

The situation is different for the production of goods sector, where the energy consumption rises over the period in all our scenarios.

In 2017, consumption in this sector was dominated by processes requiring the production of heat at high or very high temperatures (cement works,

pharmaceuticals, etc.). On an industrial scale, it is difficult to use renewable energy to reach such high temperatures, which implies that fossil fuels will continue to dominate over time.

PRODUCTION OF INDIGENOUS RENEWABLE ENERGY

In scenario No. 1 the use of fossil fuels would fall by -42%. This fall would be more noticeable in scenario No. 2 with -68% use and up to -83% use in scenario No. 3. These reductions, coupled with the development of renewable energies would boost the Canton's energy independence, as shown by the rise of the portion of indigenous renewable energy in the Canton's final energy consumption.

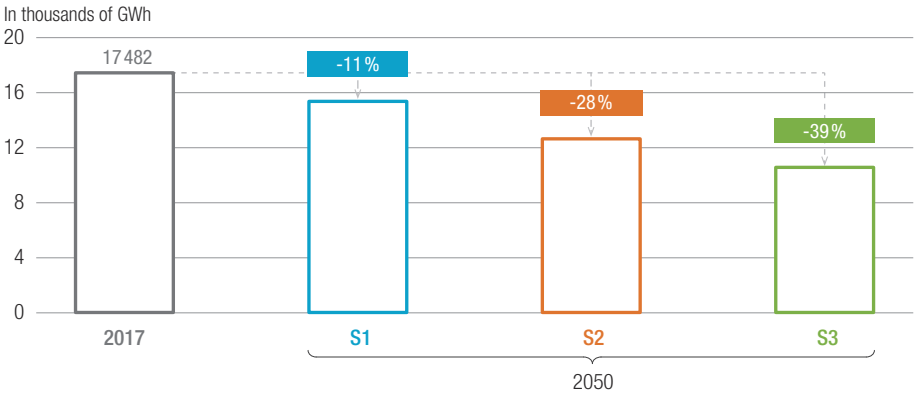
Substituting renewable energy for fossil fuels would cause a sharp rise in electricity consumption (e.g. following the electrification of vehicles). Far from being insignificant, this rise would imply a sharp increase in the Canton's electricity production capacity at a time when obtaining supplies from neighbouring countries is no longer guaranteed.

In concrete terms, the production of so-called "conventional" renewable energy (hydropower, wood and the renewable part of waste), which is already well established in the Canton of Vaud, would increase from 11% to 26% by 2050 according to the scenarios. The so-called "new" renewable energy such as solar, biomass, wind, environmental heat and geothermal, would increase much more strongly.

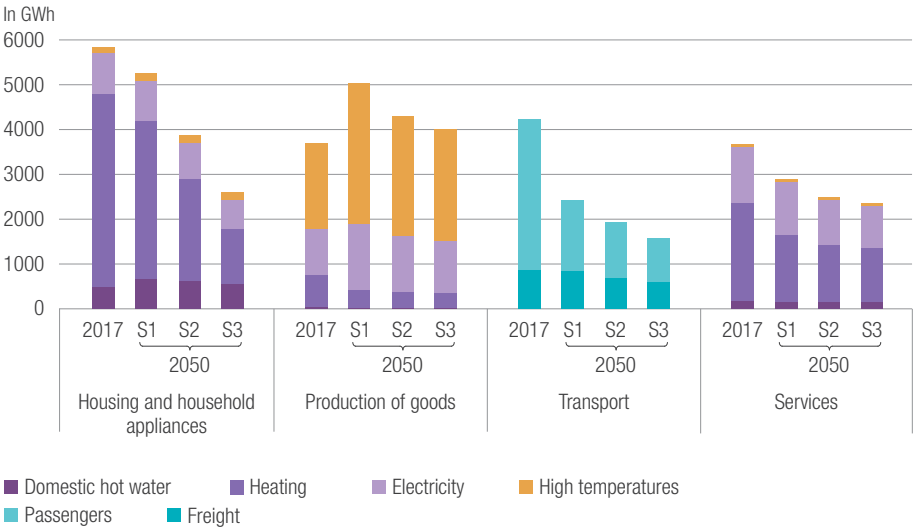
Its production would be 9 to 11 times greater in 2050 than in 2017, with solar panels spearheading this relocation of energy production. At present, approximately 1.5 km² of roofs are covered with solar panels (PV) and the equivalent of 0.15 km² are installed per year. A strong impetus would be required to cover the 18.5 km² which would allow to

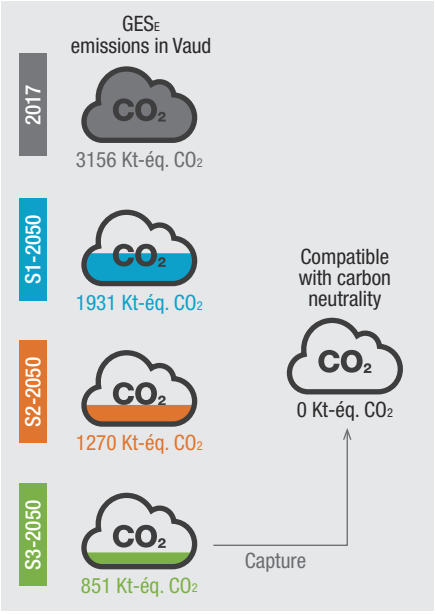
> "Substituting fossil fuels with renewable energies will imply a significant electrification of the energy system."

[F3] FINAL ENERGY CONSUMPTION IN VAUD IN 2017 AND PROJECTIONS FOR 2050



[F4] FINAL ENERGY CONSUMPTION BY SECTOR IN VAUD IN 2017 AND PROJECTIONS FOR 2050





Greenhouse gas emissions, several possible indicators

The GHG emissions can be approached from several angles. In this study, we have chosen the territory approach. Firstly, because climate targets are generally set and monitored at this level. Governments can, indeed, take more direct actions on their own territory. Secondly, it is also easier to count them. Moreover, if each country achieves carbon neutrality within its borders, it will also be carbon neutral at the world level. That being said, negotiations are underway on how efforts should be shared out among the different countries[1]. Whatever the case, one should bear in mind that the lifestyles in Vaud, as in Switzerland, are responsible for nearly twice as many greenhouse gas emissions abroad than on its territory. These emissions concern mainly imports of manufactured goods, food and drink. There are many ways to reduce emissions, ranging from buying local - or at least continental - to moderating consumption.

[1] The main alternatives discussed are distribution according to global perspective and historical responsibility for the GHG accumulated in the atmosphere, as well as financial capacity.

practically eliminate fossil fuels by 2050 according to scenario No 3. In this scenario, which is the most frugal, electricity imports could drop by more than half by 2050, thereby increasing the canton's energy independence.

GREENHOUSE GAS EMISSIONS AND CARBON NEUTRALITY

Improved energy efficiency and less energy-consuming behaviours, coupled with substitutions of fossil fuels with renewable energy, would reduce GHG emissions at the cantonal level but would not be sufficient to achieve carbon neutrality by 2050 in our scenarios.

In scenario No. 1 the Canton of Vaud would produce 39% less GHG emissions in 2050 than in 2017. Emissions would drop by 60% in scenario No. 2 and by 73% in scenario No. 3[5]. Even in the most low-impact scenario, this still represents 850 kt-eq. CO_2 emitted on Vaud territory in 2050. Consequently, performing the energy transition will likely be possible only if we change our practices and become more frugal: technical solutions alone will not suffice.

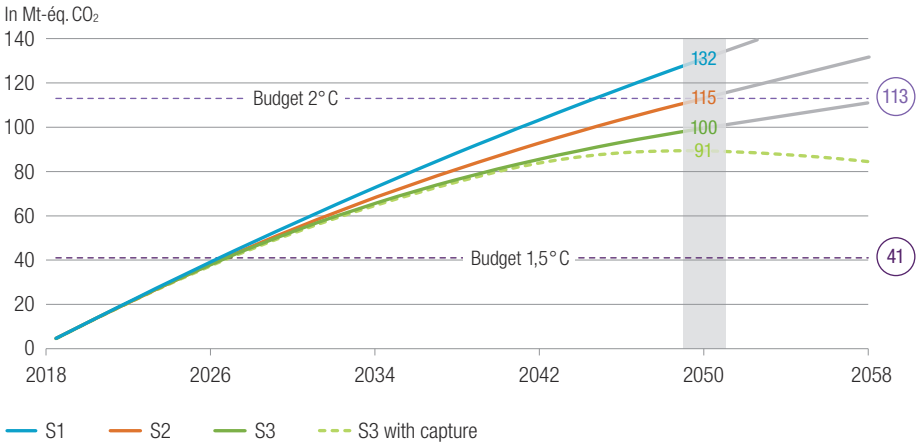
By 2050, the energy system of Vaud will thus be called upon to meet the energy requirements needed to capture the CO_2, that would still be emitted in the Canton, in order to achieve carbon neutrality. This supply challenge, together with costs, technical and political uncertainties, are real limitations to large-scale deployment of capture techniques in Switzerland and in the Canton of Vaud. Hence, reducing GHG emissions by curbing consumption and substituting renewable energy should remain the priority, while capture can only be considered as a complement.

CUMULATIVE GREENHOUSE GAS EMISSIONS

Achieving carbon neutrality by 2050 within the Canton of Vaud is imperative so as to maintain global warming below 1.5° C, in compliance with Switzerland's commitments under the Paris Agreement. However, the GHG emitted accumulate in the atmosphere over time and it has been shown that there is a quasi-linear relationship between this accumulation and global warming. It is, therefore, not enough to stop emitting GHG

> “The energy transition will probably only be possible if we change our practices and become more sober: technical solutions alone will not suffice.”

[F5] CUMULATIVE TERRITORIAL GHG EMISSIONS IN VAUD FROM 2018 TO 2058



> The timetable for implementing measures to mitigate global warming is a key issue. The faster they are implemented, the less excess of GHG emissions will need to be eliminated.

in 2050: emissions need to be reduced in time to ensure that the cumulative quantities emitted stay below the threshold of the remaining carbon budget on the planetary scale.

The cumulative GHG emitted in the Canton of Vaud for each of our scenarios over the 2018-2050 period considerably exceed the threshold compatible with a warming of 1.5°C [F5], Only scenario No. 3 would enable us to follow the carbon budget compatible with a warming of 2°C. This excess is mainly due to the time needed to modify the energy system (deployment of renewable energy and energy-efficient measures) and to change our habits. In other words, the Canton of Vaud can only reach a path compatible with a warming of 1.5°C if its net GHG emissions are negative in the long term, i.e. well after 2050. To achieve this it will have any energy-efficient and sobriety measures that have not been fully exploited until then as well as potential capture solutions that have yet to be developed.

More generally, these results confirm that the timetable for implementing global warming mitigation measures (use of renewable energy, energy efficiency, sobriety and capture) is a key issue, as the faster these are implemented, the less excess of GHG emissions will need to be eliminated. As a matter of fact, in accordance with the reports of the Intergovernmental Panel on Climate Change (IPCC), our projections indicate that only an immediate and significant change in our lifestyles would allow to reduce greenhouse gases fast enough to ensure that their cumulative effect does not exceed the budget corresponding to the 1.5°C by 2050.

LESSONS LEARNT AND LEVERS FOR ACTION LINKED TO THE ENERGY SYSTEM

Tackling such a vast subject over such a long period of time invariably means making simplifications and renouncing exhaustiveness. Nevertheless, the results of the study, which is summarised here, highlight several lessons and levers linked to the energy transition.

REBUILDING THE ENERGY SYSTEM

The energy transition of the Canton requires a significant transformation of the current energy system. Indeed, it will involve building new segments for this system, in particular to produce and distribute renewable energy, but also to capture the CO_2 that is still emitted. Furthermore, to carry out this transition the current energy system will need to be more adapted: a large portion of the equipment in use will have to be replaced by more efficient equivalents and/or by equipment running on renewable energy. All this work will call for the mobilisation of substantial investments amounting to billions of francs by 2050, but these will be compensated, in particular, by significant reductions in energy costs due to lower imports of fossil fuels.
Several factors will influence the speed and scale of these transformations. For example, the life span of the installations, framework conditions, support of the different players in the society, financial arrangements, habits and availability of manpower.

MORE FRUGAL LIFESTYLES

Structural changes to the energy system alone will not suffice to achieve carbon neutrality by 2050. It is only in conjunction with more frugal ways of living and working that energy consumption will drop sufficiently so that the renewable energy produced will

RENOVATE

Reducing energy demand strongly depends on the renovation of buildings to improve the energy efficiency of homes and commercial premises. This is spearheaded by insulation work and the replacement of fossil-fuel heating systems with renewable solutions.

ELECTRIFY

The Canton's electricity needs will increase rapidly. This rise will result mainly from the electrification of vehicles and the growing use of heat pumps. The installation of photovoltaic solar panels will be an adequate response to this need.

be enough to meet demand in 2050. Changes in individual and collective behaviour are thus powerful levers for action.

Supporting changes in behaviour. However, the weight of habits is heavy when it comes to changing routines and automatisms. For people to change their energy consumption behaviour, they must first understand the effects on their consumption. They must subsequently have the will to change and finally find the opportunity and capacity to do so. Social norms and practices are the main elements that determine individual actions, since they define the framework of what is seen as desirable.
Current practices could tend towards more sobriety if on-going trends are favoured and supported. Individual changes can be reinforced by incentives, obligations, bans (regulations) but also by information, changes in the society's perception or by educating the younger generation.

Sharing. With a view to reducing the use of energy sources while keeping the same standard of living, pooling is an interesting approach. It can be described as the transition from ownership to use, from private to shared. Sharing and sufficiency in general urge us to think about our real needs, especially in terms of how we heat our homes, how much living space we need or how we travel and how far. Our uses should then be adapted so that we can do without what is not essential, while keeping the comfort of our chosen life. One of the advantages of pooling is that it shortens the payback period for equipment and installations.

SUSTAINABLE PRODUCTION TO DISTANCE OURSELVES FROM IMPORTS

Producing indigenous renewable energy is imperative if we intend to move away from fossil fuels and nuclear power, while cutting our energy dependence.
By 2050, it is indeed highly likely that the Canton will not be able to do without energy imports altogether. The Canton's activities would not be completely free of fossil fuels even in scenario No. 3, which forecasts significant investments and changes in behaviour. Furtherrnore, electricity imports would be necessary to compensate for seasonal variations in local production, which would not yet have reached their full potential by 2050. However, uncertainties linked to the quantities of energy available abroad for import mean that there is a risk of shortages during the winters, when production of renewable energy is low and energy needs are high, particularly for heating.

Moving away from fossil fuels. Aside from considerations linked to GHG emissions, moving away from fossil fuels offers a number of other advantages in terms of energy supply. Security of supply issues have indeed been in the spotlight since the beginning of the war in Ukraine. The threat of shortages, coupled with higher energy prices, make the risks linked to a system relying heavily on energy resources more tangible. On the face of it, production of renewable energy in the Canton should be profitable compared with continuous imports, since electricity prices are expected to rise.
That being said, even if such were not the case, the probable additional cost would allow to protect against price spikes and the risks of energy blackouts with potentially higher human and economic consequences.

Electricity imports. In addition to enabling the replacement of fossil fuels, the rapid development of renewable energy has the advantage of reducing the Canton's dependence on electricity imports, which is likely to account for 17% of the energy consumption in Vaud in 2023, according to our estimates. Reducing this dependence may, however, be necessary as the quantities of energy that can be imported into the Canton are likely to be curbed.

Renewable gas and biofuel imports. Certain energy carriers, such as hydrogen, liquid biofuels and biogas could prove very useful to decarbonize freight transport or certain industrial processes. Still, as the production potential of these alternatives to fossil fuels is limited in Switzerland, their use will depend heavily on import capacity.

PRODUCT

Energy production intends to be renewable and local. The speed with which it is implemented and deployed will determine the level of dependence on imports and on GHG capture in order to achieve territorial carbon neutrality. Yet, the ability to import and implement capture techniques remains highly uncertain.

SUPPORT

The path of the energy transition is highly dependent on the regulations set up to shape it. Coordinating all the players at the international, federal, cantonal and communal levels, as well as the intrinsic dynamics of the system is a real challenge.

RAISE AWARENESS

Achieving carbon neutrality requires the support of all sectors of society. Information and training are key. It will be essential to take into consideration only not the different players involved in energy but also the population and its aspirations .

FINANCE

The financing and distribution of investments in the energy transition is a crucial issue. An adequate balance should be found to avoid burdening household budgets and to preserve the Canton's economic prosperity.

However, Switzerland is not alone in turning to these solutions in order to decarbonize its energy sector.

Local and sustainable production. Renewable energy is undeniably less polluting than fossil fuels. Nevertheless, its production process is not neutral and can damage the natural and human environments. It also requires natural resources and space. Yet, ecosystems provide "services" to humans that are the basis for our current ways of life (food, protection, etc.) and play a major role in mitigating the on-going climate change (carbon sinks, water cycle, etc.).
Taking ecosystems into account implies thinking systemically and considering energy in a circular way. Consequently, the trade-offs needed to move away from fossil fuels should also include a careful consideration of the level of energy needs that should be met. In other words, we need to prioritise our energy consumption and also try to do without what is not essential: an additional unit of avoided energy is, in principle, better than an additional unit to be produced, even if it is renewable energy (DGE, 2021)[6].

[1] Buri A. & Martin M.-J. (2023). *Transition énergétique dans le canton de Vaud à l'horizon 2050*. Lausanne: Statistique Vaud. This study was published in June 2023. Its projections have thus made before the new Climate Plan was implemented.

[2] The figures shown are based on estimates made for this study (source: own calculations), except for figure 2 which is based on data from the Swiss Federal Office of Energy (SFOE).

[3] In the remainder of this document, the GHG_E is used when dealing with greenhouse gases related to the energy system.

[4] The equivalents CO_2 (eq. CO_2) are a unit of measurement designed to standardise the climatic effect of the different greenhouse gases (GHG).

[5] The percentages of reduction are expressed here in relation to 2017, whereas the targets of the Council of State in its Climate Plan are based on 1990, as in the Paris Agreement.

[6] DGE – Direction générale de l'environnement (2021). *(Head of Environment for Vaud). Conception cantonale de l'énergie - CoCEn.(Cantonal Energy Concept) [Adopted the Council of State on 19 June 2019]. Vaud. Lausanne: Canton of Vaud*.

Date source: StatVD. OFS. OFEN.

CONNECT

The profile of the players involved in the energy system will change in the future, particularly with the decentralisation of energy production resulting from the development of renewable energy. This change in usage will imply a greater need for connection. Networks will have to become more flexible, in particular to adjust to the intermittent nature of certain types of production.

EMPLOY

Extensive changes to the energy system require know-how and a skilled work force. Owing to the current shortage, training, recruitment and promotion of jobs in this field are vital.

CONSERVE

The Canton's ability to adapt to climate change, and that of any other region, is intrinsically linked to the quality of its natural ecosystems, which represent important carbon sinks. The conservation of natural environments should continue to be given due weight in trade-offs associated with the energy transition.

To find out more...

The complete study and its various versions (infographics, vidéo clips) are available on our website: https://www.vd.ch/stat-prosp-energie

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