AQUILA GROUP

White paper

LIFETIME AVOIDED EMISSIONS (LAE)

Measuring the Scope 4 emissions of clean energy assets

By now we are all too familiar with the fact that we need to make a step change in the measures we are taking to tackle one of the great challenges of our time – the climate crisis. Our study *European Power Sovereignty through Renewables by 2030* shows that it is still possible for Europe to achieve power sovereignty using current technologies and generate fossil fuel free electricity by 2030.[1] But the next decade is critical. Indeed, according to the IEA´s recent review of its World Energy Outlook, we need to definitively close the gap between rhetoric and action today to decrease the greenhouse gas emissions we release into the atmosphere tomorrow and reach Net Zero by 2050. Only by doing so will we still have a chance to keep the door to 1.5°C open.[2] Inciting real action is the goal of the 28th Conference of the Parties (COP28) of the United Nations Framework Convention on Climate Change in Dubai this November making *Lifetime Avoidance Emissions at Aquila Group* timely.

The energy sector holds the key to averting the worst effects of climate change. Currently it is the source of approximately three-quarters of global greenhouse gas emissions.[3] To change this requires a complete transformation of how we produce, transport, and consume energy. At Aquila Group it is our mission to become one of the world’s leading sustainable investment and development companies for essential assets[a] by 2030.

Our focus on clean energy in the form of wind energy, solar PV, hydro power and battery storage as well as in specialised decarbonisation strategies supports the world’s transition to Net Zero. We develop, construct and manage essential assets along their entire value chain and through their full lifecycle around the world.

To turn this into action we set an ambitious goal. We plan to avoid 1.5 bn tonnes of CO2e across all our portfolios and over their full lifetime by 2035, which is equivalent to 4% of worldwide greenhouse gas emissions in 2021.[4] We set this moonshot goal because we believe in our ability to innovate and grow, and because we need big goals to achieve big things. Moreover, we realise that all of us – our clients, investors, employees, and communities – need to have more information to better understand what technologies and solutions can contribute the most to this global problem. By setting a lifetime avoided emission (LAE) goal, Aquila Group will gather valuable information that will help us to consider emission avoidance alongside other factors as we build out our clean energy and decarbonisation portfolios. By measuring our contribution to lifetime avoided emissions, we are educating ourselves and our investors on an important factor within the energy transition that hasn´t yet become mainstream.

Scope 4 emissions, also known as avoided emissions, are emissions not released into the atmosphere as a result of a specific product or intervention. Due to the complexity and bespoke nature of measuring avoided emissions for renewable energy assets, a standardised and peer reviewed methodology is not currently available.[5] Meanwhile more broadly there is ongoing debate around the design and use of Scope 4 emissions calculations and reporting.[6]

In this publication we share our knowledge about lifetime avoided emissions, the methodology we have created to measure it in our clean energy portfolio – comprised of wind, solar PV, and hydro power assets – and outline its opportunities and limitations. By doing so we aim to level current informational inefficiencies about Scope 4 emissions and work with peers, clients, investors, and partners to support our universal goal in supporting the world to reach Net Zero. For us it is crucial that the method we use to measure LAE follows a robust, conservative, and science-based approach. While sharing our progress towards our emission avoidance goal, it is also important that we don´t hide from our Scope 1, 2 and 3 emissions. We look forward to engaging with all our stakeholders to continue to advance this work. With peers we hope to co-develop avoided emission best practice frameworks that help our investors accurately identify opportunities that underpin their Net Zero commitments. We believe that this information will be powerful to mobilize more capital towards the energy transition and to turn worldwide rhetoric into concrete action.

Roman Rosslenbroich
CEO and Co-Founder of Aquila Group

[a] Please refer to the glossary for a description of essential assets

CONTENT

1. Introduction – the 'what' and 'why'

In simple terms avoided emissions or Scope 4 emissions are emissions that *are not* released into the atmosphere because of an action or policy.[7] Lifetime avoided emissions (LAE) are built on the same premise yet expanded to consider the entire operational lifetime of an asset. LAE include actual emissions avoided to date, as well as an estimation of future avoided emission potential. In both cases the emissions generated during the construction, transportation, installation, operation and decommissioning are factored into the calculation.[8] Our LAE approach considers all greenhouse gas (GHG) emissions (shortened to 'emissions' going forward) expressed in CO2 equivalents (CO2e).

1.1 What's the idea?

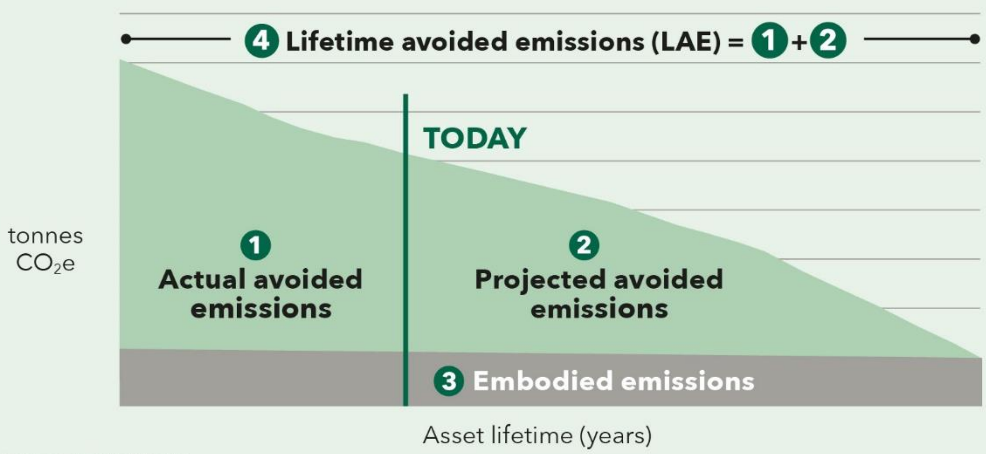
For clean energy assets, the logic is that the electricity produced displaces electricity from the grid, which contains more emission intensive energy sources such as coal, oil and gas. For integrity this calculation must remove the emissions created in the production, operation, and decommissioning of the asset ('embodied emissions'). There are four interrelated but distinct terms for the calculation of LAE of a clean energy asset or portfolio of assets. These definitions are highlighted in *Figure 1 – Illustrative chart to explain components of LAE terminology*.

1. **Actual avoided emissions**: Avoided emissions are ex-post observations within a specified reporting period that include the clean energy produced and the grid emission intensity of the specific region in question.
2. **Projected avoided emissions**: An estimation of future avoided emissions based on forecasts of clean energy production and grid emissions intensity. The projection of regional grid compositions is based on scenarios that define a range of possible outcomes given the uncertainty of predicting the energy system. Over the course of an asset's lifetime, projected avoided emissions are successively replaced by actual avoided emissions.
3. **Embodied emissions**: Emissions incurred to produce, use, and decommission an asset during its entire life cycle. Since embodied emissions are released into the atmosphere during an asset's life cycle, they must be considered to provide a holistic picture. When embodied emissions have not been removed from avoided emissions they are referred to as 'gross' avoided emissions and when they have been deducted, they are referred to as 'net' avoided emissions.
4. **Lifetime avoided emissions (LAE)**: Represents the sum of all avoided emissions over the lifetime of an asset or portfolio of assets. This calculation requires the summation of actual (ex-post) and projected (ex-ante) avoided emissions net of embodied emissions.

To calculate lifetime avoided emissions is a relatively involved process that requires projections for the energy output of an asset, the energy mix of the future grid and embodied emissions. This is outlined in more detail in the chapters that follow.

Figure 1

ILLUSTRATIVE CHART TO EXPLAIN LAE TERMINOLOGY



Source: Aquila Group

1.2 Why avoided emissions matter

There are a variety of reasons that measuring LAE is helpful. But first let´s put this discussion into context: We know that urgent action is needed. Annual worldwide carbon emission data shows that we haven´t peaked yet – with 2022 registering 41.3 bn tonnes CO2e emissions, a one percent increase over 2021 emissions.[9] Meanwhile the IEA´s latest outlook shows that Net Zero, while still possible, is becoming harder to reach.

Today, Net Zero emission reduction regimes are based on the premise that atmospheric emissions need to be reduced to zero by 2050 according to a defined pathway, as this is what the scientist community agrees needs to happen for us to have a good chance of achieving Paris. This requires the measurement of country, industry or company level carbon footprints along Scope 1, 2 and 3[b] to understand where emissions are concentrated, the development of short- and medium-term goals, and execution of targeted emission reduction plans to bring emissions down to zero.

It is not surprising that global decarbonisation efforts are focused on reducing our collective emission *liabilities*. However, we argue that this lens stops short of the *solutions* side of the equation, because it ignores the measurement of industries and companies focused on the creation of emission avoiding technologies such as in the energy transition and/or in decarbonisation of other areas of the economy.

At Aquila Group we want our emission avoiding activities to be as effective as possible and believe that lifetime avoided emissions act as an important *complement* to the measurement, reporting and reduction of Scope 1, 2 and 3 emissions because LAE helps us to evaluate the assets, technologies, and products that support our path to Net Zero. By measuring lifetime avoided emissions we gather information about which climate change mitigation solutions work best and get valuable insights to help us optimise these technologies for better emissions avoidance performance going forward. For example, in *section 3* of this paper, we outline the early learnings about LAE for clean energy assets. For these reasons LAE can help to incentivise the mobilisation of larger amounts of capital for the development of clean energy, which according to the IEA will have to triple by 2030.[10]

However, this is not the same as using lifetime avoided emissions to *compensate* or adjust Scope 1, 2 and 3 carbon footprints. We acknowledge the concerns of the World Resources Institute (WRI), Science Based Targets initiative (SBTi) and others who state that offsetting unabated corporate carbon footprints through Scope 4 emissions is not compatible with the world's effort to reach Net Zero by 2050.[11] This is why we do not compare our progress towards lifetime avoided emissions alongside our Scope 1, 2 and 3 emission management in our transparency activities. Nor do we use the former to negate the latter.

2. Methodology

Lifetime avoided emissions (LAE) consider the lifetime of an asset which in the case of clean energy can extend well beyond 25 years (i.e. hydro power average is 100 years).[12] LAE requires:

(1) Actual energy production and grid emissions intensity

(2) Forward projections of clean energy production

(3) Forward projections of grid emissions intensity

(4) Embodied emissions of each clean energy asset

Lifetime avoided emissions are equal to a clean energy asset´s produced electricity multiplied by the emission factor of *the grid*, minus the electricity produced by the asset multiplied by the emission factor of *the asset*. The first part of this equation is the gross emissions avoided, which is subtracted by embodied emissions – the negative effects of developing, constructing, and operating clean energy assets, to result in a total which

$$\mathbf{LAE = \sum [(P_{c,a} * GRID_c) - (P_{c,a} * LCA_c)]}$$

LAE = Lifetime avoided emissions

P = electricity production of the clean energy asset, kWh

GRID = grid emission intensity, gCO2e/kWh

LCA = Embodied emissions factor of the clean energy asset, gCO2e/kWh

c = country or region; a = year

[b] Please refer to the glossary for a definition of Scope 1, 2 and 3

equals net avoided emissions. The calculation is repeated for each year of an asset's lifetime, representing lifetime avoided emissions. At Aquila Group, we report LAE at the asset, fund, investor and group level.

2.1 Actual energy production and actual emissions intensity of the grid

To enhance the rigor of LAE measurement Aquila Group tracks and reports actual avoided emissions on an annual basis.[13] This is in line with GHG Protocol's Policy and Action Standard which recommends ex-ante modelled parameters be replaced with actual data once ex-post data becomes available.[14] We selected Ember[c] to represent the grid mix data, as it is a trusted data source for many recognised institutions, including the European Commission.[15] We will use Ember to report the actual avoided emissions of our portfolio, assets and funds going forward.

2.2 Forward projections for clean energy production

Aquila Group has a proven track record in the development, construction, and operation of clean energy assets. With 14.6 gigawatts of capacity installed and under development as of June 2023, we have significant experience in the projection of future expected energy production and associated revenues for solar PV, wind and hydro power. To ensure the quality of our financial models, a lot of effort goes into the validation of our assumptions that are built into our estimations, especially during the technical due diligence phase.

Depending on the technology there are a large variety of factors to consider. For example, in the case of solar PV, on-site irradiation levels, the panels' capacity and transposition of the sun's rays, are important determinants of the 'gross' energy yield. These production forecasts are adjusted further to the impacts of shading and reflection, the equipment's degradation pathway, energy distribution losses brought on through cables and inverters, curtailed electricity, and other factors. To minimise the variability of our estimations from actuals we consider all these factors. This provides a relatively informed estimation of an asset's production capability for the expected lifetime of the asset.

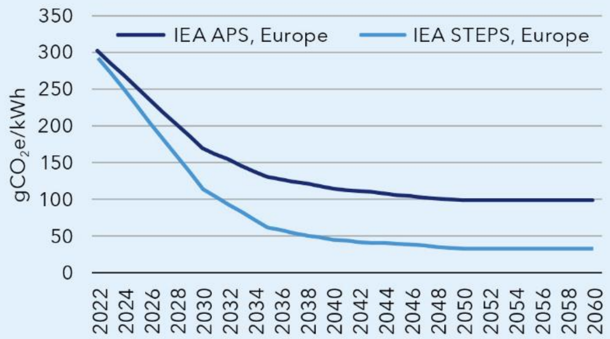
2.3 Forward projections of the emissions intensity of the grid

The projection of the future grid composition on the other hand depends on many extraneous factors which are impossible to predict with confidence. While the scientific consensus on the cause and effects of man-made anthropogenic GHG emissions and climate change is clear, the degree to which government policies and societies behaviour will curb emissions and limit global warming is highly uncertain. Consequently, researchers have developed climate models that can be used to help demonstrate numerous use cases and assumptions that result in a variety of scenarios and pathways. We draw on this work to create a picture of the future emission intensity of the grid and make inferences as to how regional energy mixes will unfold to 2060.

Figure 2

PROJECTED GRID EMISSION INTENSITY

(based on IEA scenarios, Europe)



Source: Aquila Group, IEA, ecoinvent

After a detailed evaluation, which we outline in the *epilogue* of this paper, we decided to use the scenarios of the International Energy Agency's (IEA) World Energy Outlook to inform our predictions of the energy grid mix. IEA is an established organisation for global energy-related research and its scenarios are widely adopted in the financial industry and beyond. For example, a review of climate model adoption shows that multiple banks leverage these models in their Net Zero commitments and reporting.[16]

[c] Please refer to https://ember-climate.org/about/ for details

Further the IEA scenarios focus purely on energy systems as a modelling framework. This is also the focus area of the assets for which we measure lifetime avoided emissions. Equally the IEA data is updated relatively frequently which is helpful as many other models are only updated every 5-7 years.

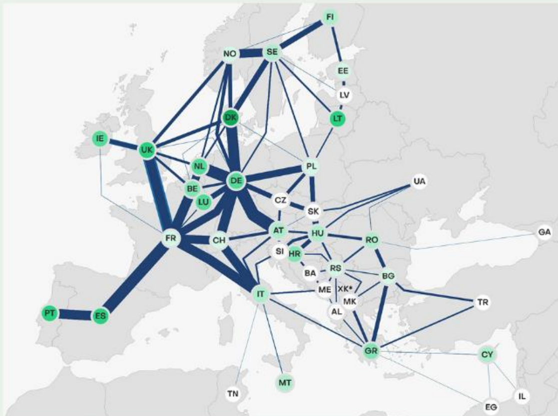
The three scenarios of IEA's World Energy Outlook and their main assumptions:

- **Announced Pledges Scenario** (APS) models the extent to which announced ambitions and targets, including the most recent ones, are on the path to deliver emissions reductions required to reach Net Zero by 2050. It assumes countries fully implement national targets.[17]
- **Stated Policies Scenario** (STEPS) provides a more conservative benchmark because it does not assume that governments will reach all announced goals. Instead, it takes a more granular, bottom-up, sector-by-sector look at what has been implemented to reach these and other energy-related objectives. STEPS shows where the energy system might go without a major additional steer from policy makers.[18]
- **Net Zero Emissions by 2050 Scenario** (NZE) is a normative scenario that shows what is needed from the global energy sector to achieve Net Zero emissions by 2050 and give the world a reasonable chance to limit the global temperature rise to 1.5°C.[19] In a recently published review of its World Outlook the IEA states that while still possible NZE requires a 3-fold increase in global renewables capacity to reach 11,000 gigawatts and a 30-fold increase in battery storage capacity by 2030.[20]

At Aquila Group we use the first two scenarios – IEA APS and IEA STEPS – as our predictions for the future energy mix. As outlined in our methodology it is important that the scenarios can be broken down to a regional level, something that is not possible with IEA NZE. However, we do envision a future in which this outcome is still possible. In fact we recently commissioned a study in cooperation with the Potsdam Institute for Climate Impact Research that outlines a path to 100% renewables generation by 2030, which entails a very high ambition level for Europe.[21] Figure 2 shows the grid emission intensities based on IEA APS and IEA STEPS for Europe.[22]

There are a variety of ways in which we enhance the IEA APS and IEA STEPS scenarios. For example we adjust them to reflect all greenhouse gases in CO2e terms. Additionally, we accommodate for transmission and distribution (T&D) losses to avoid overstating the electricity displaced. Moreover, we believe that regional granularity is appropriate in the measurement of LAE to the extent that the electricity which is displaced by clean energy is available and consumed regionally. While today Europe´s electricity is predominantly consumed nationally, we predict that the current interconnection capacity of 120 gigawatts will grow substantially through 2030 and beyond as this is

Figure 3
TRANSMISSION CAPACITY
(Europe in 2025e)



Source: Ember climate

crucial for Europe's power sovereignty.[23] This is illustrated in *Figure 3 – Transmission capacity, Europe*.

Meanwhile we are aware that the levels of grid connectivity may vary considerably across regions, countries, and even within communities. Our choice of geographical granularity of grid intensity can have a material impact on the LAE. For this reason, we will continuously evaluate our ability to get access to more rigorous, science-based and timely grid intensity data at more granular levels going forward.

2.4 Embodied emissions of clean energy assets

Factoring embodied emissions into our LAE methodology is critical to provide an accurate view of emission avoidance. This is consistent with the GHG Protocol's view that 'negative effects' should be considered.[24] The measurement of embodied emissions ensures that the emissions incurred during an asset´s life cycle[d], including material sourcing, manufacturing, transport, installation, use phase and decommissioning, are captured.

At Aquila Group we use life cycle assessments (LCA) to provide insight into the embodied emissions of different clean energy technologies in different regions. Bespoke emissions data at the asset level is however not yet widely available. The emission footprint data provided by an LCA covers the entire value chain of a given product or service. The LCAs we are using follow established methods and standards, using a variety of sources such as the IEA, ecoinvent[e], as well as specific empirical studies.[25] Similar to the emission factors used for the grid emissions intensity, the LCA data for clean energy assets is adjusted for T&D losses and in case of wind and solar PV, it is further adjusted for regional differences in full load hours by asset class.

It is important to use LCAs that are reasonably up-to-date, since manufacturing processes and other stages of the value chain are changing over time. For example, the embodied emissions of solar PV assets have decreased by -30% over the past decade, proving that decarbonisation in the renewable energy sector is also important.[26] At Aquila Group we apply a conservative approach to the selection of emission factors, which is supported by a sample of LCAs for specific onshore wind turbines conducted by our suppliers that suggesting lower emission factors than currently applied. To ensure that our LCAs accurately measure the embodied emissions of our clean energy assets throughout their full lifecycle, we will continue to engage in this area with the aim to improve our measurement of embodied emissions going forward.

3. Learnings to date

The measurement of lifetime avoided emissions gives us information on the avoidance potential of our clean energy assets. The three main drivers influencing the size of LAE in relation to this methodology are time, location, and technology. By further investigating the sensitivity of these and by adding granularity in our measurement methods we hope to enhance the information we have about the emissions created from each asset class as well as the optimal phase and region of an asset's acquisition, development and construction. Our current learnings are preliminary, and we aim to develop them further as we continue to enhance our understanding of LAE.

3.1 Time

The point in time an asset goes ´live´ or in industry terms reaches COD – commercial operation date – is a very important determinant of LAE. This is because as the grid becomes successively cleaner, the LAE contribution starts to diminish as the electricity which the asset displaces becomes less emission intensive. This is underpinned by the well-established law of diminishing returns, which applies to the scaling of all products and services – including clean energy´s contribution to avoided emissions.[27]

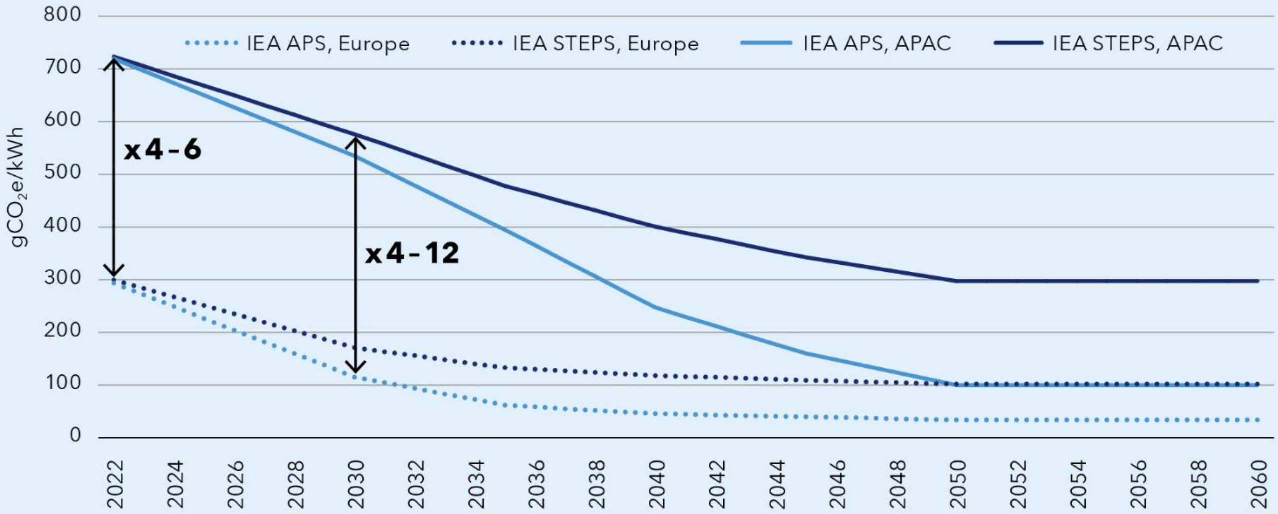
The underlying driver is that regional grid emissions intensities are projected to decrease until 2050 according to the IEA's scenarios. However, as we have seen recently from the Russian/Ukraine war, in reality they may increase for a period of time in individual regions or countries, as a result of natural gas supply shortages prompting increase generation of coal-fired electricity generation. Our LAE methodology minimises these effects through the observation of actual grid data in the calculation of actual emission avoidance to smooth out estimation errors over time. Nonetheless the use of energy system scenarios to evaluate future grid emissions means that unless the already sanctioned climate policies around the world are reversed, time is an essential factor for investors seeking a positive contribution to lifetime emissions avoidance. This speaks to the urgency of the energy transition and the need to scale clean energy investments sooner rather than later – a call echoed by climate scientists generally which is magnified in this LAE methodology more specifically.

[d] Please note that lifetime and life cycle are distinct terms. Lifetime refers to the operational phase of an asset, whereas life cycle is meant to include any stages prior, during, and after the operational lifetime such as sourcing, manufacturing, and decommissioning.

[e] ecoinvent is the world's most consistent and transparent life cycle inventory database according to ecoinvent.org

Figure 4

PROJECTED GRID EMISSION INTENSITY APAC VS. EUROPE



Source: Aquila Group, IEA, ecoinvent

3.2 Location

The degree to which politicians will create policies that support emission curbing behaviour by governments, industries, corporations and individuals to limit global warming is uncertain. Moreover, for socio economic reasons, the timing and speed at which different regions will decarbonise their electricity grids is expected to vary as is their divergent starting points. Currently the average emission intensity of electricity generation in emerging and developing countries is approximately 70% higher than in advanced economies, with coal generation being the main contributor.[28] These regional differences are highly relevant from an emission avoidance perspective, because – all else being equal – developing an asset in a region with relatively higher grid emission intensity translates into higher emissions avoidance, and vice versa. *Figure 4* above illustrates this regional difference between Asia Pacific and Europe, where the LAE 'yield' from the same asset is four to six times higher in Asia Pacific in 2022 and predicted to be four to twelve times higher in 2030. While the difference between grid intensities in developing regions versus developed countries is obvious today, it will be interesting to see how this landscape evolves over time. China for example, which currently exhibits a higher grid emissions intensity, is predicted to move more quickly than many other countries as a result of its ability to effectively implement climate commitments through its 14th Five-Year Plan, which would deliver almost half of new global renewable power capacity over 2022-2027.[29]

3.3 Technology

Achieving Net Zero emissions by 2050 will require innovation throughout the entire economy. Research estimates show that with low-cost clean energy as the building block, decarbonisation in other sectors such as industrials, buildings and transportation, an additional investment of around EUR 28 trillion is required.[30] As our methodology shows, achieving incremental emissions avoidance through clean energy becomes more challenging and costly from here. That said we expect to see further innovation and cost deflation in clean hydrogen, battery storage, carbon capture[f], and other clean tech solutions, to push these options further along the abatement curve and allow them to become viable investment opportunities.[31] We believe that LAE can maximise the potential of these technologies in the future and is a suitable metric to inform capital allocation decisions in this context.

[f] Lifetime avoided emissions strictly speaking do not apply to carbon capture technologies since these are direct carbon *removal* technologies. The approach would be adapted to lifetime emission *removal* of carbon capture, net of embodied emissions.

Solar PV – 47gCO2e/kWh for Europe (Source: German Environment Agency, IEA)

For solar PV, the production of polysilicon at a solar-grade quality is energy-intensive and has the most significant impact on embodied emissions, ranging between 70-90% depending on the production location and its applicable grid mix.

Onshore wind – 11gCO2e/kWh for Europe (Source: German Environment Agency, IEA)

For wind parks, the production process is also the most emission intensive stage of the life cycle with around 65% of total emissions as relatively high amounts of bulk material are required, specifically steel and concrete.

Hydro power run-of-river and reservoir – 5-32gCO2e/kWh for Europe (Source: ecoinvent, IEA)

Hydro power plants have the advantage of significantly higher lifetimes, averaging around 100 years. This contributes favourably to the embodied emissions performance of this asset class relative to its production capacity, as the total amount of embodied emissions is spread over a much longer period of electricity production.

We are also open-minded for these developments in the clean tech industry and have developed a sizable utility-scale battery energy storage systems (BESS) business as an early mover. BESS are critical enablers of the energy transition because of their ability to provide flexibility and security to our power systems.[32] But in addition to these enabling qualities, our LAE measures of BESS indicate a contribution to lifetime avoided emissions.[33] Despite high embodied emission factors, BESS can deliver positive lifetime avoided emissions after a certain ´pay back´[9] period because of the correlation between power prices, the emission intensity of the grid and price-optimised load cycles.

There are notable differences in LAE among existing clean energy technologies. The ability to maximise clean energy production at a given location is a function of multiple factors – nature being the most obvious, i.e. local wind patterns, irradiation levels and precipitation. But there is also a variation in terms of the embodied emissions of different technologies (see box above). Solar PV for example exhibits roughly four times higher embodied emissions per unit of capacity than onshore wind. This is due to a combination of factors, most notably the production process and material sourcing, but also its estimated lifetime and the recyclability of its component parts.

We believe that the embodied emissions of clean energy technologies become a more relevant conversation once the grid mix has approached very high levels of decarbonisation. And we expect that the decarbonisation of the grid and our supply chains will bring about a less energy-intensive production of clean energy assets. We can see this with solar PV for example where embodied emissions have decreased by around 30% over the past decade, largely due to less emissions intensive manufacturing processes.[34]

4. Limitations

Measuring lifetime avoided emissions involves a certain degree of assumptions. In this section we outline the main limitations associated with lifetime avoided emissions of clean energy assets. The main challenges have to do with how the future electricity grid is modelled, the general and backward-looking nature of LCA´s and the lack of country level detail about electricity grids.

The first limitation is that the displaced grid electricity used in this methodology assumes that the grid's emission intensity is a weighted average of the individual generation sources and their total electricity generation over a given period. While in

[9] Pay back period is a term used to measure the amount of time required for the BESS to recover its embodied emissions through emission avoidance.

practice, electricity generation is subject to a certain merit order, meaning there is a prioritisation or ranking at which power plants are dispatched.[35]

The second challenge is that life cycle assessments (LCAs) are primarily based on ex-post analyses of existing value chains. This means that they are less suitable for ex-ante predictions as the changes to materials sourcing, manufacturing and production processes, that lead to different emission factors in the future, are unknown today. Generally, we expect that innovation will result in lower emission factors in the coming years, yet there is uncertainty as to how exactly this translates into embodied emissions as there are multiple forces at play, including for example the onshoring trend of the manufacturing industry. To the extent that emission factors decrease through technological advancements to processes, the current approach leads to an overestimation of embodied emissions and under-estimation of LAE.

Further we are aware that embodied emissions vary on an asset-level due to multiple factors – i.e. use of different suppliers, transport routes, site conditions, maintenance frequencies, etc. Admittedly, accounting for these factors is not practically feasible at this time.

As highlighted in *section 2* where we outline our methodology, there are limits as to the level of granularity we can reliability access for our grid mix estimations. Given the lack of country level data we use regional predictions from the IEA to calculate lifetime avoided emissions. We understand that use a regional representation of the grid can lead to an underestimation (overestimation) of avoided emissions in cases where our assets are situated in countries with higher (lower) national grid emission factors. That said we believe that this effect will be mitigated by the increasing practices of countries within a region to enter into trade and energy distribution agreement across country borders such as those planned in Europe.

5. Conclusion and outlook

According to the Carbon Disclosure Project (CDP), more than one third of surveyed companies have made claims on avoided emissions of their products.[36] Yet only a fraction of these report on Scope 4 or avoided emissions. This means there is not enough actual data available to paint a clear and picture of what solutions are best situated to help mitigate climate change. While many companies are occupied with their Scope 1, 2, and particularly Scope 3 emissions, we expect that corporate and financial market participants will increasingly adopt Scope 4 measurement and reporting to close that information gap – building on a promising yet nascent trend.[37]

Measuring Scope 4 or avoided emissions is not a new idea. The World Research Institute (WRI), which established the GHG Protocol and published an initial framework for avoided emissions in its Policy and Action standard, followed by a more specific framework for products.[38] The LAE approach that we have outlined in this paper aligns to many of the key principles of WRI's frameworks. With our robust, conservative and science-based approach for LAE we hope to contribute to the broader application of Scope 4 as a metric to incentivise and facilitate investment in climate solutions.

We realise that lifetime avoided emission methodologies generally require a bespoke approach which has hampered broad standardisation. However, we believe that it is important to build such an approach for clean energy as this will enable us to mobilise more capital to the energy transition and enhance our ability to drive the Net Zero economy.

Epilogue - A brief insight into our learning curve

Aquila Group´s track record in climate change mitigation extends beyond 15 years. We started in 2007 with the launch of two climate funds and the decision to become climate neutral. In 2009, we started to focus on real asset development with the acquisition of a wind farm and we added solar PV and hydro power shortly thereafter. In 2020 we started to track avoided emissions and two years later we committed to avoid 1.5 billion tonnes CO2e by 2035 over our portfolio´s lifetime. We started to define our LAE approach at the same time as we started tracking avoided emissions to ensure that we create a robust, conservative, and science-based approach. Below we outline a few of the steps we took, including an overview of the models we evaluated to create our current LAE methodology.

In 2021, we started to collaborate with Forschungsstelle für Energiewirtschaft e.V. (FfE). FfE is a non-profit research institute based in Munich specialised in climate science, energy system analysis and life cycle assessments. Leveraging FfE´s expert opinion - we expanded our methodology to include all greenhouse gas emissions (expressed in CO2e), define a regional depiction of electricity grids for more granularity, net out the embodied emissions of our clean energy assets, include transmission and distribution losses, and introduce climate scenarios for projected grid intensities. Our approach was reviewed by an independent auditor – TÜV Rhineland – and certified to be "reasonable, transparent and appropriate".

This year, we identified two areas to advance further. First, we decided to (1) find ex-post data to reflect the grid intensities over reporting periods and (2) analyse the scenarios that we were using to ensure that they are appropriate predictions of future grid mix intensities and useful models to support decision making.

Aquila Group tracks and reports avoided emissions annually which can be measured using actual data from Ember as the source of grid intensity rather than scenario-based models.[39] Given that the GHG Protocol stipulates it is advisable to substitute ex-ante modelled parameters with actual data once ex-post data becomes available, we feel this change makes sense.[40]

Meanwhile it was more challenging to review the climate models available and identify the scenarios most appropriate to measure LAE at Aquila Group. There are many factors, which should be thoughtfully considered, depending on the underlying use case. Generally, there are two types of approaches: **1) Integrated Assessment Models** (IAMs) and **2) Energy System Models** (ESMs). IAMs are relatively comprehensive and interdisciplinary scientific models, linking the key features of society and the economy to the biosphere and atmosphere in one framework.[41] IAM models, while helpful in cases where it is important to measure the interdependencies of a variety of systems on global warming, can also be complex and non-transparent. This is less helpful when reviewing, understanding and explaining the impact of underlying assumptions on outcomes – i.e. predicted future grid mix intensities – to explain the drivers of LAE depending on different circumstances. This lack of transparency makes it impossible to explain our models and influence business decisions.

ESMs on the other hand have a more focused modelling scope, simulating various components and processes *within* an energy system. They are typically used to analyse, predict, and optimise the generation, distribution, and consumption of energy resources in a specific region, industry, or system.[42] Due to this more bespoke modelling approach, ESMs generally tend to be easier to understand and are less complex, therefore have relatively clearly defined and transparent assumptions that are important for LAE at Aquila Group, which is used to inform decision making. For these reasons, ESMs were selected as the preferred models for LAE which means that we need to substitute the IAM-based Image scenario with scenarios from the IEA's World Energy Outlook in our LAE approach.

Glossary

Actual avoided emissions: Avoided emissions are ex-post observations within a specified reporting period that include the clean energy produced and the grid emission intensity of the specific region in question.

Avoided emissions: See Scope 4 emissions.

Capacity: Refers to the maximum amount of electricity or energy that an energy generation facility can produce under optimal conditions.

Carbon footprint: Measure of the total amount of greenhouse gases that are emitted directly or indirectly by an individual, organisation, event, or product during a specific period. Typically expressed in CO2 equivalents covering Scope 1, 2 and 3 emissions.

Carbon intensity: Amount of CO2 or GHG emissions produced per unit of output or investment. This metric is often used to compare companies' carbon footprints and is commonly expressed in terms of CO2 or CO2 equivalents relative to revenue.

CO2 equivalent (CO2e) emissions: Are the expression of GHG emissions in carbon dioxide terms. CO2e emissions represent the unit of measurement of all GHG gases released into the atmosphere relative to the heat warming effect of carbon dioxide for a defined time horizon, most commonly 100 years which also applies in this paper.

Electricity mix approach: A way to measure the emissions intensity of electricity generation by taking the weighted average across all generation sources of electricity production.

Embodied emissions: Emissions incurred to produce, use, and decommission an asset during its entire life cycle. Embodied emissions are deducted from actual and projected avoided emissions to provide a holistic picture of an asset's emissions profile.

Energy System Model (ESM): Simulating various components and processes within an energy system. They are used to analyse, predict, and optimise the generation, distribution, and consumption of energy resources in a specific region, industry, or system.

Essential assets: Essential assets include anything related to expanding or renovating the world's low-carbon infrastructure. This includes clean energy sources like wind, solar PV, hydropower and battery storage; sustainable infrastructure (green logistics and green data centres); and specialty asset classes such as carbon forestry, energy efficiency, and growth private equity in climate change mitigation.

Generation: Refers to the actual amount of electricity or energy generated by energy generation facility in a specified period of time.

GHG emissions: Greenhouse gas emissions are gases released into the atmosphere that have the potential to trap heat and contribute to the greenhouse effect (i.e., increasing the average temperature of the earth) including carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), and other gases. GHG emissions can be shortened to ´emissions´ for brevity and references to avoided emissions are synonymous with statements about GHG emission avoidance.

Gross avoided emissions: Avoided emissions based on positive effects only, without accounting for embodied emissions.

IEA scenarios: The IEA regularly publishes its World Energy Outlook (WEO), which is an annually updated database containing information on the projected future of energy system, including the composition of electricity generation sources at a regional level. The IEA's analysis employs three main scenarios as part of its WEO, which are abbreviated to 'IEA scenarios' in this paper. The WEO is arguably the most internationally recognised and established publication worldwide on global energy issues, and that is widely used by policymakers, businesses, NGOs, and other stakeholders.

IMAGE model: The Image model was developed by the PBL, Netherlands Environmental Assessment Agency. It is an application of an Integrated Assessment Model and its scenarios were used in the IPCC's Assessment Reports AR4 and AR5.

Integrated Assessment Model (IAM): Comprehensive and interdisciplinary scientific modelling approach linking main features of society and the economy with the biosphere and atmosphere into one framework. One of the more commonly known IAMs is employed by the IPCC to examine global transformation pathways through to 2050 or 2100.

International Energy Agency (IEA): The IEA is an autonomous international organisation that was established in 1974 to ensure the security of oil supplies. Its mandate has evolved from predominantly promoting energy security among its member countries to also foster international collaboration on other energy-related issues such as the energy transition.

Law of diminishing returns: Basic economic principle stating that the marginal output starts to diminish at some point for an additional unit of input.

Life cycle assessment (LCA): A comprehensive environmental impact analysis covering GHG emissions, human toxicity, eutrophication of water, and other factors for a specific product or asset. LCAs cover the entire life cycle, including raw materials sourcing, manufacturing, use phase, installation, operation, maintenance, and decommissioning. Not to be confused with 'lifetime' which specifies an asset's operational phase.

Lifetime avoided emissions: The sum of all avoided emissions over the course of the lifetime of a given asset or portfolio of assets, typically including both actual and projected avoided emissions. Embodied emissions that were incurred to produce, use, and operate an asset are subtracted.

Net avoided emissions: Net avoided emissions are calculated by subtracting embodied emissions from gross avoided emissions.

Net Zero emissions: Net zero emissions are achieved when anthropogenic emissions of greenhouse gases to the atmosphere are balanced by anthropogenic removals over a specific period. There are several associations who have committed to reduce emissions to net zero in their individual sectors. In the financial industry, the most important initiatives are the Glasgow Financial Alliance for Net Zero, Net-Zero Banking Alliance, Net Zero Asset Owner Alliance, and Net Zero Asset Managers Initiative. Members of these initiatives are subject to science-based emission reduction pathways, rules and methodologies. This typically includes a restriction of carbon offsets and avoided emissions, which do not count towards science-based targets.

Projected avoided emissions: An estimation of future avoided emissions based on forecasts of clean energy production and grid emissions intensity. The projection of regional grid compositions is based on scenario analysis and provides a range of possible results to avoid any pretence of being exact. Over the course of an asset's lifetime, projected avoided emissions are successively replaced by actual avoided emissions.

REMIND model: The Remind model was developed by the Potsdam Institute for Climate Impact Research. Similar to the IMAGE model, they are an application of an Integrated Assessment Model and its scenarios are used by the IPCC.

Scope 1 emissions: Direct emissions from owned or controlled sources

Scope 2 emissions: Direct emissions caused by the generation of purchased energy.

Scope 3 emissions: Indirect emissions that occur in the value chain of the reporting company, including both upstream and downstream emissions.

Scope 4 emissions: Emissions that are *not* released into the atmosphere because of an action or policy.

Transmission and distribution (T&D) losses: A certain amount of electricity is lost when transmitted and distributed from one location to another depending on the distance of those locations and other factors.

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Authors:

Angela Wiebeck
Chief Sustainability Officer
Sustainability Office

Benjamin Arndt
Manager ESG
Sustainability Office

In partnership with:

Forschungsstelle für Energiewirtschaft e.V.

For more information please contact:

Aquila Group

Valentinskamp 70, 20355 Hamburg, Germany

P +49 40 875050-100

info@aquila-capital.com

Hamburg · Athens · Frankfurt · Invercargill · Lisbon · London · Luxembourg · Madrid · Milan · Oslo · Prague · Schiphol · Seoul · Singapore · Taipei · Tokyo · Zurich · Sydney · Melbourne

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