THE TRULY GREEN RECORDING STUDIOS A REALITY OR STILL JUST A DREAM?

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1 INTRODUCTION

“Green”. This is the new fashion, the new axis of development of most industries, the new advertising method for many products and services, and an important branch of reflection for most occidental governments. It is however barely used, claimed, or studied in the music industry. There is only one professional recording studio in Europe to have an energy balance of zero each year thanks to a solar panel installation. It is Studio A at The Premises studio, in Hackney, London. “Some people are coming to our studio because they know they can produce an entirely Green album” said Viv Broughton, CEO of The Premises studio. Moreover, they are saving £1000 each year from their electricity costs. There are also some studios built using eco-friendly methods, such as Realworld Production’s Box Studio, in Box, England.[2]

There is not a single professional studio in the world combining green building and renewable energy. Furthermore, coming back to the example of The Premises studio, their balance of energy is zero or positive (they earn money), but they are selling the extra energy they produce to the UK National Grid when not needed, and buying any additional energy from the grid when they need it.[1]

Does this absence of fully ecological studios mean that the methods of construction, isolation and energy generation are not advanced enough to fit the needs of a high-end recording studio? By the use of a fictional case study, based on realistic facts, and thorough extensive research and precise analysis of the needs and potential of both the studio and the methods, materials and equipments available, we will verify if the construction of a completely green recording studio is possible or not.

First of all, what is a ‘completely green recording studio’? The concept of green recording studio used here is a high-end recording and mixing studio meant mainly to produce music, built using an energy efficient and environmentally friendly architecture, ecological materials and methods, equipped with carefully chosen high-end equipment with a low energy profile, a high-end sound quality, and a completely renewable energy production system allowing the studio to be completely cut off from any energy grid. The choice of such an extreme concept has been made to evaluate if the technologies exist to create it. A more affordable and useable approach will also be studied in this paper, based on the example of The Premises studio’s energy generation system, which is to produce more energy than that which is used on average by the studio, feed the surplus energy to the grid, and buy some energy from the grid when the production is not sufficient. This concept is less extreme in its ecological factor, but easier to realise and more cost efficient.

First of all, the studio that will be studied here will be presented with a detailed explanation of the choices that have been made of methods, materials and equipment. It will be followed by an analysis of the energy requirements of the studio and the available technologies and equipment that can be used to produce and store this energy. Finally, an evaluation of the cost of the energy production installation, and its payback time, will be made.

2 PRESENTATION OF THE STUDIO

2.1 Location

The best location for a green studio would be in open countryside, slightly uphill, far from any noise source or other buildings, and free from trees near its south façade. The idea is to have a minimum of obstacles to the wind, the sunlight, and the lowest sonic background possible to reduce the need for sound insulation. The studio needs to be oriented with the most possible free space on its south side, to maximise the use of sunlight for heating and lighting. Having a railway station a few minutes away would be a high bonus for the accessibility of the studio. This type of location could allow a change in the concept of the studio. Having some free land around would also allow the creation of an ecological residential building to house the clients working in the studio.

For this case study, the location chosen is close to Glasgow, in Scotland, in the countryside, a few miles from Maiden. The choice of this place was made for multiple reasons. First of all, the main source of energy for the studio is a wind turbine, and this location has a high average wind speed over the year (see Section 4, p.7 for more details on the energy generation choices). Scotland is known for its wind, and has projects which have 100% of their power consumption generated by renewable sources, which.[3,4]

Moreover, a railway station provides a regular connection from Ayr to Glasgow, guaranteeing a good national and international connection for the studio through the multiple national railway lines and Glasgow Airport. What is more, it is only a few miles away from Glasgow International Airport. Being so close to an airport could cause acoustical isolations issues, but the architecture of Earthship, having a high isolating property, and complemented with a good acoustical treatment, wool prevent any nuisance arising from this proximity.[5,6,52]

2.2 Construction method

There is a wide choice of architecture following ecological principles that can suit a studio. Each has its own strengths and weaknesses. The one that has been chosen for the studio analysed here is the concept of Earthship.[7,8,9,52] The concept is to use recycled tyres, filled with earth, for the walls, and covered by any kind of ecological surface material on which it is possible to apply the acoustic treatment desired. The north face and the ceiling are covered with earth for thermal insulation. All the south façade is made with glass, to gather as much sunlight and heat as possible throughout the day. This type of architecture is normally used for single floor constructions, but the height of the ceiling can easily reach 6m, which would be sufficient for a large scale performing room.[8]

One of the advantages of this type of architecture is that its design makes it completely insulated sonically, thanks to the thickness and the absorbent properties of the earth contained in the walls and ceiling.[10,11] Furthermore, this type of architecture is hugely cost effective, as the tyres can usually be obtained virtually free of charge, and most of the earth can be dug from the land on which the studio is built as the foundations are created. Also, if the studio is slightly buried into the top of a hill, earth can be obtained from the flattening of the building area[7].

Finally, an Earthship does not require any concrete, and can be created mainly with local materials, which makes it a particularly good choice for environmentally friendly constructions. The concrete manufacturing industry is the industry creating the third most pollution (responsible for 10% of the worldwide emission of CO_2), and local products do not need to be transported, reducing, again, the emission of CO_2.[7,52]

2.3 Plan of the studio

A studio usually needs four main distinct rooms: The reception, the control room, the performing room (which can have some side booth for drums, vocals or a piano) and the machine room (which contains all the computers, power supplies, and all the outboard equipment that is not accessed

everyday, such as the analogue to digital converters). For a studio powered by renewable energy, particularly if it is made to be stand alone, a room to store all the energy production equipment and the energy storage system is required (see Section 4, p.7 for more detail about the energy production system).

As the studio is based in Scotland, a cold and not particularly sunny location, the layout of the studio needs to be studied to benefit as much as it can from the solar energy. The architecture of Earthship is studied in this manner, planning a south façade entirely made of glass.[7,12,52]

To optimise as much as possible the passive solar heating, each inhabited room that require some heating should have a wall as part of this south façade, which means that the reception area and the performing room should each have a wall on the south part of the Earthship. For the control room, the main need will be cooling, as the equipment present in the room are constantly generating heat. An air conditioning system will be set up for that purpose, but it is possible to limit its activity and energy requirement by using the walls' energy absorption property. Walls made of stacked earth can absorb a lot of heat when the air is warmer or the sun hits their surface, store it throughout the day, and heat the air when it's cooler, during the night. Therefore, it is possible to create the control room in the back of the earthship, surrounded by earth, for it to absorb the heat dissipated by the equipment, therefore limiting the need for the air conditioning system to cool the room. Sunlight inputs can be arranged by having a large window between the control room and the performing room and light-wells placed in the roof.[8,9,20,32,51,52]

The glass walls need to be made in a particular way for the performing room and the control room in order not to disturb the acoustics of the rooms. First of all, they need to have multiple layers of glass (minimum two, preferably three) that are not parallel, with an empty space separating each layer in order to have the best sound insulation possible and to avoid any internal standing waves.[6,10] Moreover, having a glass wall assembled with multiple pieces of glass at different angles in order to avoid having a flat inner wall would reduce the disturbing reflection of sound and would create a more diffuse acoustic for the rooms.[10] The presence of a curtain that could be closed over a part of, or over the whole of, the wall of the performing room would allow both to modify its acoustics and to limit the heat loss when there is no sun, such as at night.[10]

Finally, it is useful to have the reception room directly connected to both the control room and the performance room in order to avoid the need for people to go through one room to access the other.

A possible plan of the studio can be found in the appendix section, p.12

2.4 Sonic Treatment

Regarding the sonic insulation, the thickness of the tyre walls and the multiple layers of the glass wall make the studio well insulated, sonically, for any sound carried by the air. For the sound carried through the ground, such as that which might be generated by the wind turbine or other sources around the studio, the best solution for insulation is to use rubber blocks supporting each wall, to absorb any ground waves. The issue with this method is that rubber is not ecological at all. The other solution would be to create a mass and spring setup for the different layers of wall, with integrated panels of absorbent wool such as cellulose, cotton-waste felts or sheep's wool to create the necessary isolation, both from airborne sound waves and from ground waves.[6,10,11,13,14]

Regarding the acoustic treatment of the room, the concept of a green studio does not change the methods of treatment. More and more, the manufacturers of acoustic treatment solutions are slowly creating some ecological ranges of products that are equivalent to, and sometimes better than, their non-ecological equivalents, and for the same price.[11,15,16] A good list of examples of ecological acoustic treatments can be found in a 'Sound on Sound' magazine article on green studios published in October 2010.[17]

Most of the bass traps, Helmholtz resonators and diffusers can be made of wood, which is one of the most eco-friendly material available, as long as it is harvested locally and treated with environmentally friendly products.[7] Asking the manufacturers for the origin of their materials and the

treatments they use on their wood is the best way to find if their products can be considered as green or not. It is also easy to find guidelines for building those products online, which is a way to reduce the cost and make sure that the origin of the materials and the methods of manufacture are green. For example, a BBC research department report provides the formula and DIY guide to build the wood diffusers they use in some of their studios[5,18]

For the absorbers, it is possible to make them using recycled absorbent materials or sheep's wool. Also, some examples of DIY guidelines for creating absorbers from recycled furniture are available online, such as the one provided by studio design consultants from Recording Architecture, explaining how to create a free standing, mobile, absorber panel using Ikea's "Billy" bookcase.[17]

Acoustic treatment can be considered as an art open to new ideas, such as Magnetofon's performing room, in Maastricht, which is renowned for its particular acoustic conditions which please the ears of all of its customers, created using recycled dispatching pallets, screwed together in a spectacular ceiling.[19]

2.5 Lighting

The lighting of the studio is not as easy as it appears. The concept of green building would include the idea of reducing as much as possible the energy requirements of the studio, and so using low energy lighting, such as halogen, fluorescent, or LED lights. The issue with some of those lights is that they produce sonic or electric interference. For example, some ecological light bulbs generate a buzz and crackling noises on the output of an electric guitar. It is also important to consider that some light switches may generate sounds, such as buzz from dimmers and clicks on some multi-way switches. Moreover, lights such as halogen or LED require a lot more energy to be produced than normal light bulbs, which reflects in their price and initial carbon footprint. However, compared to the amount of energy they save and their lifespan, they end up being highly energy efficient and cost-effective. What is more, they don't use mercury, which removes the risks of inhaling the deadly vapours that are contained in fluorescent light bulbs, and which may spread into the air when they are broken.[20,21]

The best solution to reduce the energy required for lighting is to maximise as much as possible the sunlight input with windows and light-wells through the roof [20], to place the lighting sources in strategic points to maximise their efficiency, and to choose light colours for the walls covering. The use of well-placed reflectors can also improve the efficiency of the lights.

For the choice of lights, some long-life bulbs are particularly interesting, as they limit the waste and the energy required to make them, as long as they are not creating any nuisances. There are also certain types of LED bulbs that are made to use 240V current, thus not causing any nuisances, and that use between 10 and 50 times less power than usual light bulbs.[21,22] Lights intended for film sets can be a good alternative, as they are designed to be highly energy efficient and to suppress any possible nuisances that lights can create.[23]

It can also be wise to install multiple electrical circuits to isolate the lighting from the equipment, in order to reduce the risks of interference.

As the lighting industry is rapidly changing, and each electrical installation is reacting differently to each type of light and equipment, the only way to be sure that the chosen lighting solution works for any given studio is trial and error. One of the first priorities to reduce the energy requirements for the lighting installation is to remember to switch them off whenever a room is not in use. It could be possible to use automatic detectors for that purpose, but it might not be effective, and end up being particularly not practical, as most of the time, the people working in the control room would not move.

2.6 Heating and cooling system

The heating and cooling installation has a high energy requirement, and is particularly important in the studio to guarantee not only the comfort of the people working there, but also the safety and the longevity of the equipment, and to maintain it in its optimum working condition. With regard to the equipment, most manufacturers recommend an average temperature of the room of between 20 and 30º C, and also publish charts showing the number of hours some parts (mainly the capacitors) are meant to survive at different temperatures. The higher the temperature is, the lower the lifetime of the equipment. In fact, it is possible for some parts to end up melting inside the machines when the temperature of the room gets too high (sometimes simply above 22º C) damaging the equipment and risking the possibility of starting fires.[24,25,26]

One issue with air-conditioning in a studio is the noise it creates. Some manufacturers make silent air-conditioning system made especially for studios. The best example is Silentaire, but their system is sadly not compatible with ecological heating and cooling systems such as geothermal installations.[27,28]

The air-conditioning of the studio needs to be able to handle different conditions, for example the presence of both many or few people in a room (when a band is recording in the performing room, the heat generated by the musician will not be the same as when only one person plays), hard weather conditions, with lots of wind, and very cold temperatures. The system also needs to be able to keep an environment highly controlled, without many fluctuations of either humidity or temperature, not only for the people and the equipment, but also for instruments such as pianos. The constant presence of equipment and acoustic instruments means that the condition of the air needs to be constantly the same, at any time of the day. Furthermore, for the control room, the main need will be cooling because all audio equipment will always run at a higher temperature than the air surrounding it. As the studio is built in Scotland, a solar energy based system will not be the most efficient. A geothermal heating and cooling system with a de-humidifier would be the most appropriate. The best setup of air-conditioning for the studios would be to use a heat pump (buried in the ground, to use it as cooler or heater) and under-floor heating. The under-floor heating is the least noisy system which is compatible with geothermal heating and heat pumps, and is also completely compatible with the architecture of a studio because the under-floor space which it requires is also required for ground wave insulation for the studio.[29,30,31,32]

3 EQUIPMENT

As this studio is planned to be a high quality professional studio, the equipment also needs to fit this quality requirement. The issue here is that there are no manufacturers of audio equipment which create ecological equipment. Therefore, the choices made need to consider the energy efficiency, the build quality, the heat dissipation and, if possible, the place from which the products are manufactured, in order to reduce the energy requirements for the powering, the cooling, the replacement or repair and the transportation of the equipment.

After comparing different types of mixing desks (analogue, digital, hybrid analogue and digital, and DAW controller) from different manufacturers (Neve, SSL, Icon)[33], the only desk that combined all the requirements (low energy requirement, low heat dissipation, high quality of sound, high quality conception, and even manufacture in the UK[34]) was the SSL AWS 900 SE.[24]

For the DAW, the choice did influence the energy requirements a few years ago, as most of them required special hardware, but they are now all shifting to a native setup that can accommodate any third-party hardware. Therefore, the criteria end up being only the usual ones for a studio, without any influence coming from ecological considerations. The two DAWs selected for the studio are Pro Tools HD Native and Nuendo 5. As Pro Tools HD will be used, the I/O interfaces will have to be Avid's HD I/Os, as Pro Tools HD is not compatible with any other brand of interfaces. In order to meet the 24 tracks present on the AWS 900 SE, two interfaces will be needed, one with 16 analogue inputs, another with 8 analogue inputs, and the other with 8 digital inputs.[35,36,37]

The choice of computer ends up relatively easy to make, as both Pro Tools and Nuendo 5 are developed for Mac, and adapted for Windows afterwards. They are therefore much more efficient and stable on Apple computers. As ProTools HD needs a card added to the computer, the only Mac compatible is the Mac Pro. All Apple computers are built with ecology in mind, which make them also quite suitable for the studio.[38] In order to reduce the need for energy of the computer accessories, the Mac Pro will be fitted with as much storage as it can have, to limit the need for external storage. Each external storage device requires its own power source, and converts the energy with small transformers which are not as efficient as the Mac Pro's power supply, therefore consuming more energy.[36,37,38,39]

For the screen, the Apple cinema display is highly expansive and consumes four times more energy than a Samsung 27" LED display (Apple Thunderbolt display requires 108W only for the screen, and up to 250W if it is connected to USB equipments and a MacBook, whereas a Samsung display requires 29W) . It is better to have one large screen than two small ones, as they would consume more energy. What is more, LED screens are highly energy efficient, *and* high quality, which make them the best choice for the studio.[40,41]

Concerning the outboard equipment, the best way to reduce the amount of energy they require is to have only as few as necessary, or even not to have any at all, and to replace them by plug ins, as in most cases they are as efficient and as good a quality as the hardware versions.

For the speakers and amplifiers, having two sets with different characteristics is the minimum required, in order to be able to compare the sound in different contexts. The energy requirements for the speakers and amplifiers is mainly dictated by the amplifiers, but also by the efficiency and the sensitivity of the loudspeaker's drivers. For example, using woofers of 90 dB or 96 dB sensitivity for 1 watt at one meter would make the difference between needing a 500 watt amplifier or a 2,000 watt amplifier, for example.[6,51] In addition, having three-way speakers and amplifiers allows each frequency band to be powered as efficiently as possible by its own amplifiers, and may deliver a higher quality of sound. As different types of amplifiers behave differently with different types of speakers, and at different level required by the room (depending of the size and the acoustic treatment of the room), the best way to choose is to test different combinations of speaker/amplifier at the required level, and to compare the power they consume for the level required in the control room. It is also important to consider that studio loudspeakers are often silent, and therefore the power consumed by the amplifier when no sound is produced is also important to take into account.[42,43,44,51, 52]

The choice of backline equipment and instruments does not matter much, as most bands will bring their own. If some instruments and backline equipment are chosen, having some energy efficient ones are the best, but it will be necessary to plan the energy needs in order to be able to supply any equipment bands bring, as they are almost always chosen for their sound characteristics, not for their energy efficiency.[51]

For the reception, a computer and a screen are needed, along with a printer. For the computer, the system that would use the least energy is the combination of a MacBook Air and a 20" LED screen. A combination of Mac Mini and a 20" LED screen of the same brand as the one chosen for the control room would also be suitable, but uses nearly twice a much energy. Having a laptop reduces greatly the energy consumption compared to a desktop, but the MacBook Air is very expensive. The choice depends on price allocation, other possible uses, and preferences. The choice here would be a MacBook Pro 13" with a 20" LED screen, in order to be able to work comfortably on a large screen and to have a laptop that could make it possible to carry around the work of the studio. For the printer, a simple, all-in-one printer, without wireless connection, requires only 10W of power. [40,41,45,46]

4 ENERGY

The energy needs for the whole studio are calculated in kilowatt hours needed per month in the table below.

Equipment	Power req. (W)	Daily usage (h)	Monthly usage (day)	kWh/month
AWS 900 SE[24]	480	10	30	144.00
Mac Pro[38]	600	10	30	180.00
Screen[41]	62	10	30	18.60
HD I/O (x2)[35]	480	10	30	144.00
MB2S-A (x2)[44]	400	10	30	120.00
AML2 (x2)[44]	1400	10	30	420.00
Musician equip.[33]	2000	12	6	144.00
Lights[33,22]	179	5	30	26.85
Reception equip.[38,41,45]	75	10	30	22.50
Comfort appliances[33]	*	*	*	164.00
Air conditioning[29,30,31]	*	*	*	167.00
			Total	**1,550.95**
			Margin (20%)	**310.19**
			Total + margin	**1,861.14**

Fig 1, calculation of the energy needs in kWh/month

The musicians' equipment power requirement is based on an average of 24 sessions of four hours per month with a full band requiring guitar amplification, keyboards... As it is not possible to plan in advance what will be the exact energy need, as each band is different, and each musician uses different equipment, it is better to take a high average, in order to be able to have the energy required by as many cases as possible.

The comfort appliances include a fridge, a coffee machine, a kettle and an electric hob, with an average daily usage calculated for the whole month. More details can be found in a paper published by the same author at the SAE Institute[33].

The 20% margin included in the calculation of the energy required allows two hours of surplus power each day, on average, in case the studio needs to use more than average power at any time.

It is possible to follow two different methods for the energy generation. Both aim to generate at least all the energy that the studio requires for extensive use, and preferably a little more to have some margin. For both systems, the power generation is handled by a wind turbine, which is the best solution for the location of the studio as the wind is a lot more present than the sun in Scotland.[12] One is based on a system completely stand alone, that does not require any grid connection, nor any external input of power. This system requires high capacity batteries that can withstand a lot of incomplete charge and discharge cycles, and that will be charged when there is a surplus of power produced by the wind turbine. When not enough power is produced by the wind, the batteries deliver the amount lacking. The other system uses the grid instead of the batteries. It sells the surplus produced to the grid, and buys the energy it needs when the wind turbine does not produce sufficient. The aim of this system is to sell more energy than the studio needs to buy, in order to have a profitable energy balance. For more details, refer to the paper published by the same author at the SAE Institute.[33]

Both systems are achievable without any problems[33] but they have different approaches. The stand-alone system can be considered to be completely renewable, as it only uses energy produced on site. It also allows the studio to be able to be built in any suitable location, regardless of the possibility of any grid connection. However, it has two important issues. First of all, when the wind turbine does not produce enough energy for a long time, and the batteries run out of power, the studio cannot operate, as it does not have any backup power. This could be resolved by having an electricity generator, powered by gas, but it would go completely against the idea of ecology for the studio. The second issue is that it is not cost effective at all, because the cost of the batteries (that are efficient and reliable for only 5 to 10 years) requires a bigger investment than the money saved by having an ecological studio, thus *costing* money over the years instead of *saving*.[33] Also, the expiry of the batteries produces a high quantity of waste that is not environmentally friendly and is hard to treat and recycle. More details, including the calculations of the amount of batteries needed, the type chosen, and the cost of those batteries are available in the paper published by the SAE Institute.[33]

The other system is rather more interesting in regard to the money it saves. Moreover, feeding energy to the grid can become beneficial whenever a significant surplus is generated by the wind turbine. The system is also a lot easier to manage, as when the weather conditions are bad. or whenever more energy is required than had been expected, the studio can have an unlimited supply of energy coming from the grid. However, this system cannot be considered as completely ecological, as the energy coming from the grid, even when supplied as "green", cannot be certified as renewably produced. Moreover, the studio becomes dependent of grid tariffs which can completely change the balance of the energy bought and sold. The location of the studio also requires it to have the possibility of being connected to the grid.[4,33,47]

The system chosen for the studio is thus the one connected to the grid, as it is more interesting in the light of today's technologies and prices. It will be based on a Proven 35-2, eight meters in diameter and up to 25 meters in height. It is possible to estimate its average yearly production at around 51,000 kWh, with an average wind speed of 7.8m/s, which is the annual average wind speed at the location of the studio. According to the calculations above, the studio requires around 22,500 kWh of energy per year, which is less than half of the energy that the wind turbine can produce in that location. Moreover, it can produce energy efficiently up to a wind speed of 54 m/s and is designed to be silent at any given wind speed. As it can produce a current with the same characteristics as the grid current, it does not need to be converted, which reduces the need for extra equipment.[4,48]

It could also be possible to use a hydro turbine to generate the energy the studio requires. It has a few advantages compared to the wind turbine. For example, if the flow of water is constant, the energy produced by the hydro turbine will be constant, making it easy to estimate, and to use. The main issue with a hydro turbine is that the location for the creation of the studio needs to have a stream of water powerful enough to power the turbine, and enough height to increase the power of the stream (the minimum required for a small turbine to work, producing 600kWh per month, is 10 meters). As the location has a rather constant and decent wind speed, a wind turbine is easier to use.[8]

5 PRICE

The price of the construction of the building, as most of the material does not need to be purchased and most parts of the building process can be done by any motivated volunteer (simply supervised by the architect) ends up being a lot cheaper than the usual building price for a studio. Moreover, it is often possible to find grants or incentives from the government for building ecologically. It is interesting to note that in some places, such as Scotland, the gathering of old tyres to reuse them is financed, as long as a licence is obtained. The builders of the SCI Earthship, near Edinburgh, were paid around £2 per tyres they used.[1,7,8,9,49,52]

For the energy generation, the installation costs a lot more than a usual electrical installation, as more equipment is needed. The total cost of the required equipment to produce the renewable

energy is £44,886 without including the setup costs. The maintenance costs on average are 1.5% of the original price of the turbine per year (thus around £700/year in this case). All the equipment has a lifespan of around 25 years.[50] According to the price of the electricity from British Gas, the studio would pay an energy bill of almost £3,000 per year.[47] Those figures therefore show that the payback time of the installation, without taking into account the benefit gained by the energy fed to the grid when surplus is produced, would be 13 years. As the estimated lifespan of the equipment is 25 years, it is highly profitable to choose this type of installation. This calculation does not take into account any incentives that can be claimed because of the ecological aspect of the building and its energy generation method. It is also not taking into account the probable increase in electricity prices in the coming years.

6 CONCLUSION

This case study shows that the technologies and methods to create a completely sustainable, self-sufficient and environmentally friendly, high standard studio, are available today. It also demonstrates that an ecological approach for this studio will not limit in any ways either the quality or the choice of equipment, or the ways to use the studio. What is more, it proves that, depending on the methods and the solution chosen, a completely eco-friendly recording studio can ally both the production of all the energy it requires, using renewable methods, *and* saving money, as long as the studio stays connected to the grid for additional energy inputs instead of being completely self sufficient. This solution, using the grid as the backup power source, also allows the selling to the grid of all the surplus energy produced when the conditions are optimum, or when energy is produced but the studio is not in use, and therefore can make some profit on the sale of energy.

The next step will be to put into practice this theoretical case study, and to see if the methods and means of producing energy can also be suitable for other types of applications, such as multi-channel mixing, film post production, etc., which require more equipment, and therefore more energy and more space.

The facts and data studied here are valid for today, but research work is advancing quickly towards new means of producing and storing energy, new methods of construction, and new materials, making this field of ecological creation one of constantly evolution. The concept in itself will stay the same, and, as the facts have showed during the years past, will become easier to achieve as the technologies become more affordable, more efficient, and the general energy cost increases.

The concept can be expanded to an idea of creating a place providing accommodation, catering, and general facilities for multiple activities related to the studio, all developing a community based on ecological thinking and artistic production, centred around the studio.

To conclude, an ecological approach for a building not only relates to the material used, the methods chosen to produce energy and the architecture selected. An ecological concept is, most importantly, a way of thinking of everything carefully, planning what is necessary and what is not, in order to limit the requirements of energy and materials, and to limit the waste. All of this goes along with a way of life which takes care of limiting the needs for energy by using only the equipment required, and only the resources required.

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8 APPENDIX

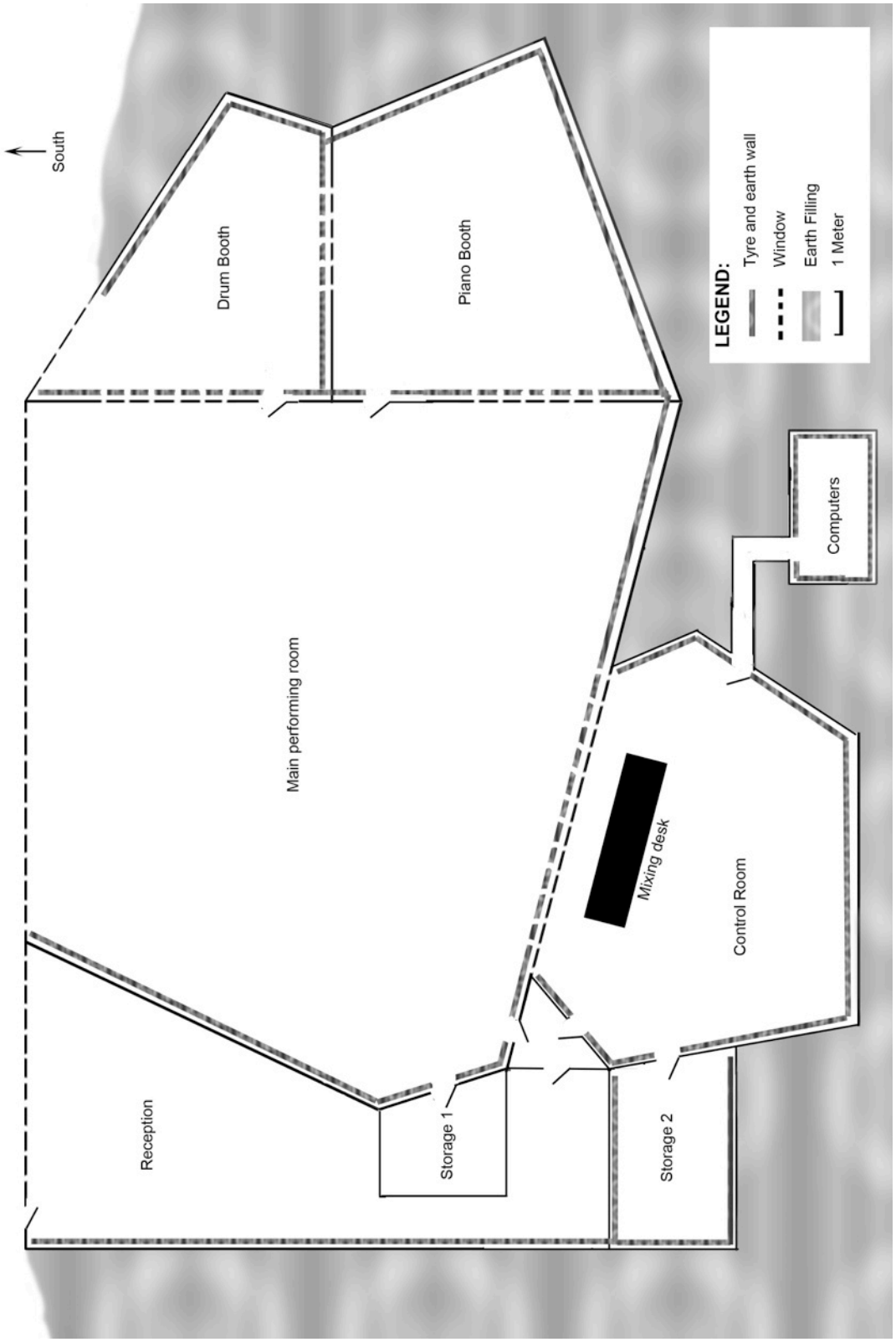

Fig 2. This plan is meant to give an idea of a possible placement of the rooms and the windows in the recording studio. The dimensions of each room have not been calculated to give a perfect acoustic.