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Power to the People
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Energy and Sun

Towards a Communal Solar Landscape

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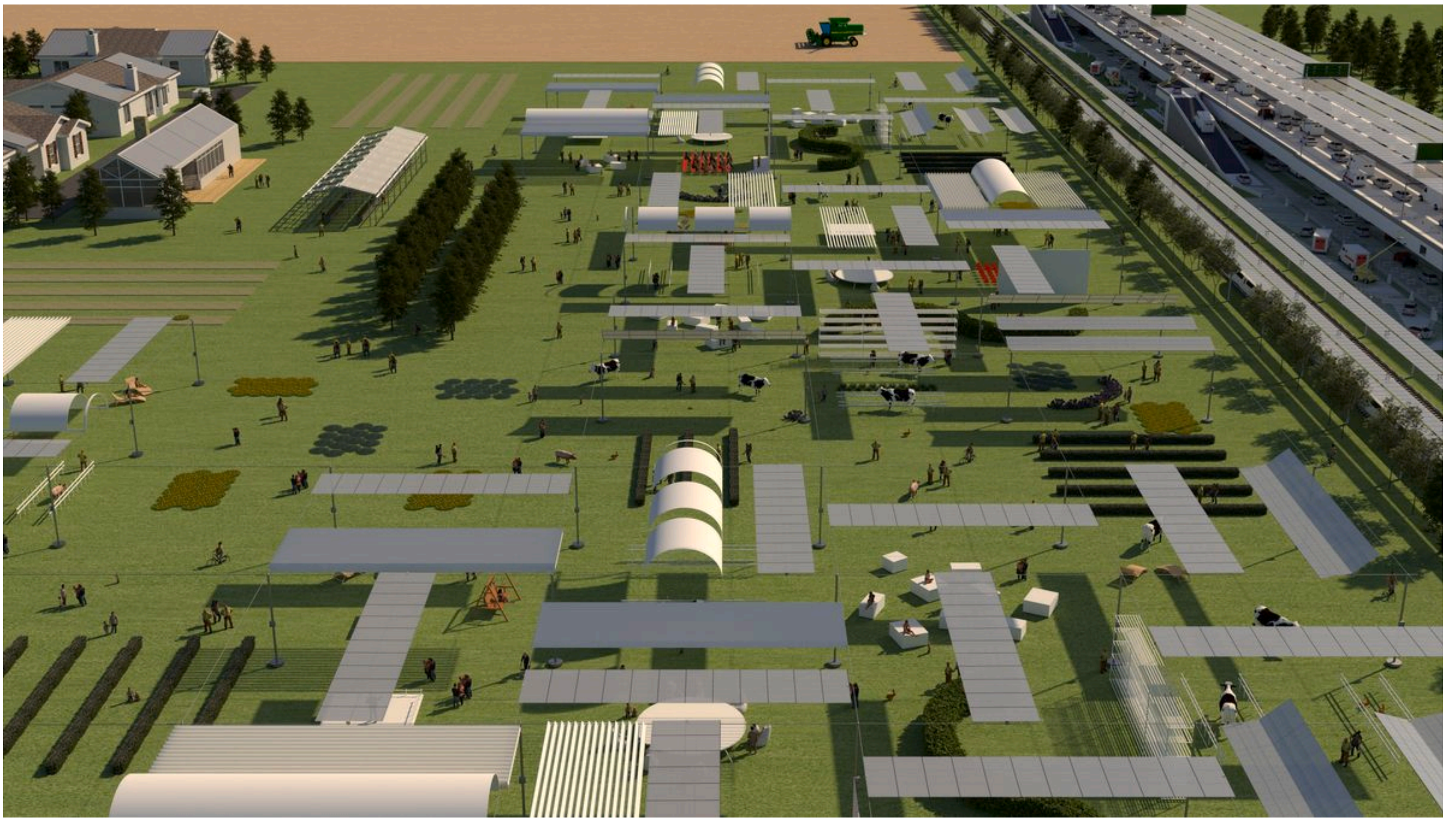
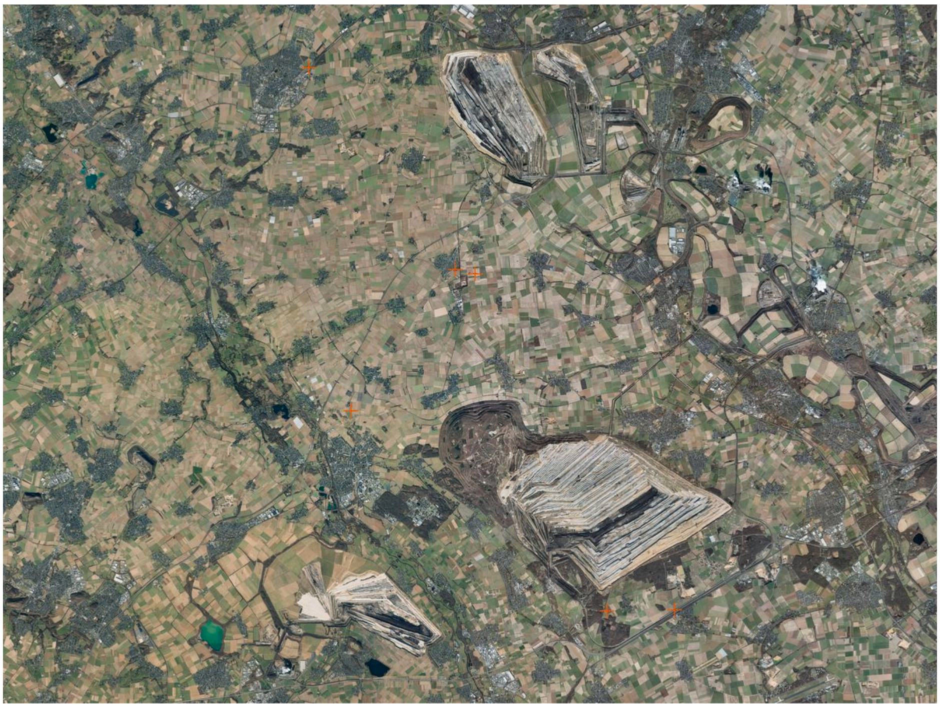


Solar power for electrical energy has been promoted by the state since the 1980 Energiewende in Germany. Over the past decades, Germany has seen great potential in solar energy to manage the phase-out of nuclear energy by the end of 2022. Apart from the reduced dependence on international oil and gas imports, photovoltaics has been a tool that is economically as well as politically lucrative. However, this has led to an increase in large-scale ground mounted solar farms owned by big players. This has challenged the initial plans for decentralised modes of energy production, through small-scaled roof photovoltaic ownership. In the context of a highly industrialised agricultural landscape like Titz, should there be a direct-proportional relationship between energy transition and adoption of hybrid-photovoltaic systems such as Agrivoltaic? The imminence of the situation also asks for a new model of equitable solar development.

Prologue: A Journey Through the Regional Solar Landscape

A huge diversity of scales and types of PV systems are visible in the German landscape.

A huge diversity of scales and types of photovoltaic systems are visible in the german landscape. Ranging from the small-scaled roof photovoltaic, where these systems are directly attached unto the roofs of existing homes, to large-scaled roof photovoltaic systems on farms and state-owned infrastructures such as schools. Large-scaled ground mounted solar farms also occupy the landscape while leaving the spaces underneath uninhabitable. Due to land constraints, new forms of multi-layered (hybrid) photovoltaic systems are introduced to maximise land-use while minimising the impact on the existing livelihood under these systems. These include Agrivoltaic and photovoltaic systems along highways.



SATELLITE MAP WITH THE SOLAR INFRASTRUCTURES.

PHOTOVOLTAICS ON ROOFS IN TITZ.
Source: Bastien Terrettaz, 2022.

PHOTOVOLTAICS ON A FARM IN TITZ.
Source: Bastien Terrettaz, 2022.

SOLARPARK MERSCHER HÖHE.
Source: Kreis Düren, 2022.

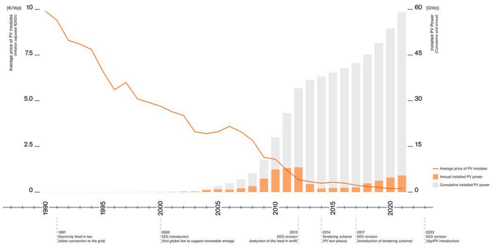
SOLARPARK ERKELENZ.
Source: Ruth Klapproth, 2018.

SOLARPARK BUIR A4.
Source: Daniel Chatard, No Man's Land, 2017

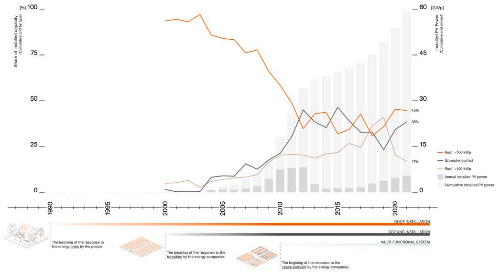
AGRIVOLTAICS FORSCHUNGSZENTRUM JÜLICH.
Source: Bastien Terrettaz, 2022.

Evolution of Solar Infrastructure Since the 1990s

Tracing from the 1990s, the rise of Big Players in the solar landscape has been the “hidden” protagonist influencing the evolution of types and scales of solar infrastructure developing in the Germany.



EVOLUTION DIAGRAM OF THE MWP
INSTALLED AND THE AVERAGE
PRICE OF PV MODULES, 1990-2021
Source: Bundesministerium für Wirtschaft und Klimaschutz, 2022 [https://www.bmwk.de/Redaktion/DE/Artikel/Energie/energiedaten-gesamtausgabe.html] / Fraunhofer ISE, 2022 [https://www.ise.fraunhofer.de/en/publications/studies/photovoltaics-report.html]



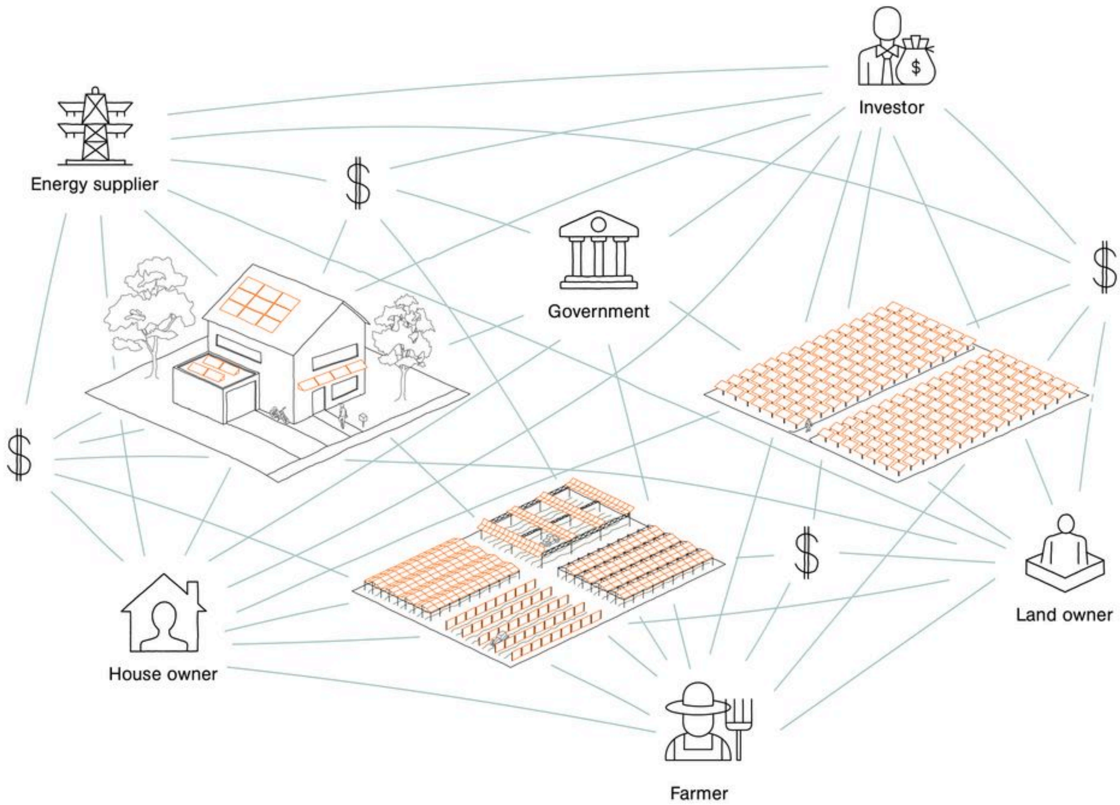
EVOLUTION DIAGRAM OF THE
DIFFERENT TYPES OF SOLAR ENERGY
INFRASTRUCTURES, 1990-2021.
Source: Fraunhofer ISE, 2022 [https://www.ise.fraunhofer.de/en/publications/studies/photovoltaics-report.html] / MaStR, 2022 [https://www.marktstammdatenregister.de/MaStR/Einheit/Einheiten/OeffentlicheEinheitenuebersicht]

To understand how the present-day solar landscape is shaped, we need to look at the recent history of solar and solar politics in Germany.

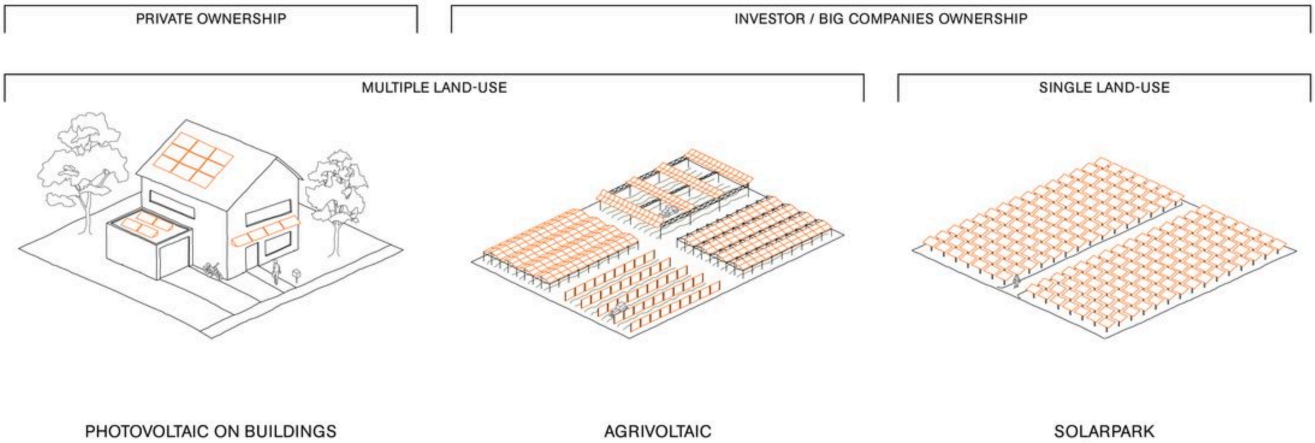
Beginning from 2000, the introduction of the Feed-in Tariffs (FIT) scheme by the new German Renewable Energy Sources Act, EEG sparked the rapid uptake of renewable energies like photovoltaic. The fall in average price of photovoltaic modules also see an increase of small-scaled roof photovoltaic systems installations overtime. Though the constant revision of the EEG, individual homeowners could begin affording such systems and feed energy back into the grid as well as personal consumption. However, at this point, it does not mean that the goal of democratising electrical energy is achieved, as solar energy is still used as a way for big corporations of sustainable energy producers to exacerbate the existing economic and social inequalities. This is seen from the larger rate of increase in ground-mounted photovoltaic systems which tend to be expensive to install and require large capital to buy up land for these systems. The growth of small-scaled photovoltaic systems has also begun to reach a plateau in recent years. Overall, there has been a shift in the trend for the type of photovoltaic systems: from roof to ground and in more recent years, hybrid systems.

To question this general evolution of photovoltaic typologies, we need to question the character of the different types of solar infrastructure? On what basis can we compare them with, and more importantly answer the question of ownership and land-use.

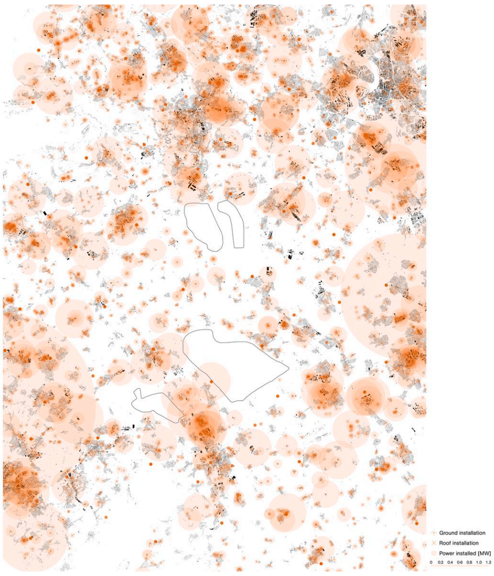
Solar Infrastructure Ownership and Land-Use



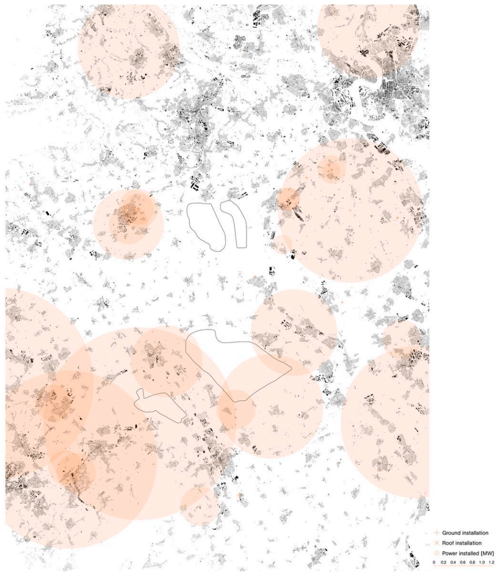
The multivalence of solar infrastructures calls to address the relevance and effectiveness of the various systems. Through business models, the welfare of the individual stakeholders is surfaced.



ORGANIGRAM OF THE DIFFERENT TYPE OF SOLAR INFRASTRUCTURES AND ITS OWNERSHIP AND LAND-USE.

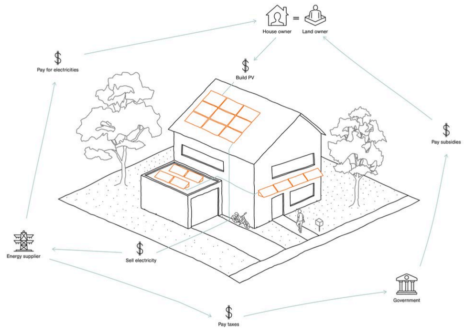


MAP OF THE ROOF PV INSTALLATION IN THE REGION AND ITS POWER.
Source: WMS Erneuerbare Energien NRW, 2022 [http://www.wms.nrw.de/umwelt/erneuerbare_energien_nrw]

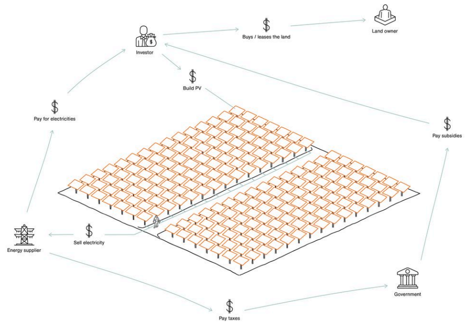


MAP OF THE GROUND PV INSTALLATION IN THE REGION AND ITS POWER.
Source: WMS Erneuerbare Energien NRW, 2022 [http://www.wms.nrw.de/umwelt/erneuerbare_energien_nrw]

To begin with, the regional solar scene shows us that ground installations tend to be large solar plants. But, they are geographically less dense than that roof installed photovoltaic panels. This is the result of the centralisation of the energy production by investors in order to make profits.



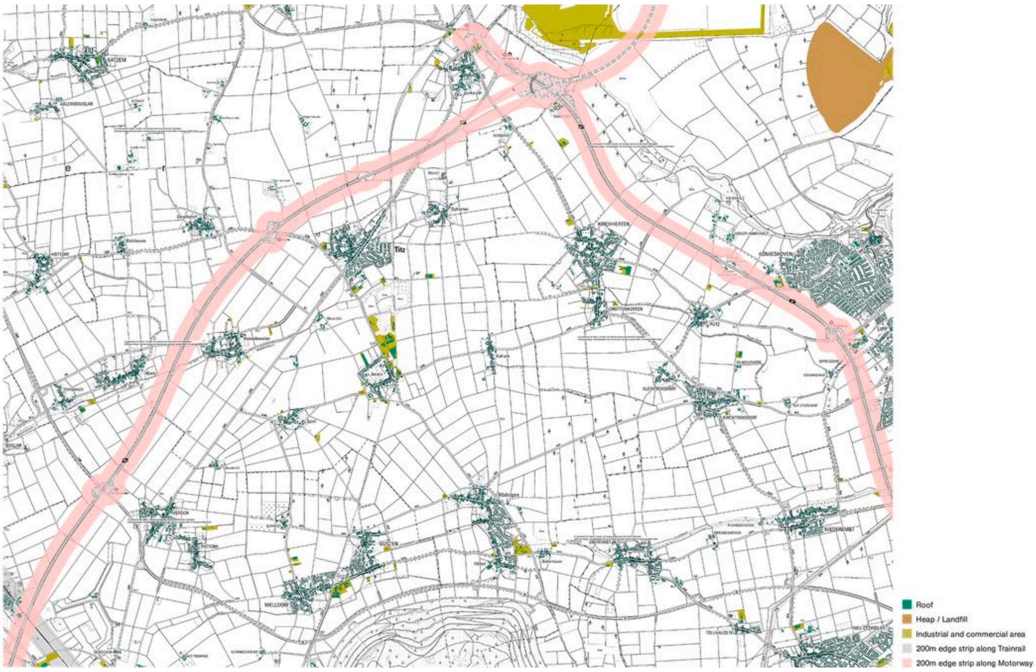
SKETCH OF THE PHOTOVOLTAICS ON BUILDING SYSTEM AND ITS OWNERSHIP MODEL.



SKETCH OF THE SOLARPARK SYSTEM AND ITS OWNERSHIP MODEL.

The multitude of roof infrastructures is due to the decentralised form of the ownership models of these small installations. The focus of prosumer-centric systems reduces the need for large scale energy supply infrastructure. This form of local generation reduces transmission losses and lowers carbon emissions. Each owner can consume energy produced by his own PV panels and excess can then be fed back into the grid. As building permission is not required, it is very simple to build a small solar installation.

On the other hand, ground mounted photovoltaic farms tend to be profit-oriented rather than energy oriented. This is seen from the presence of investors with large capital that could buy up or lease lands to build solar plants. Subsequently selling the electricity to the energy supplier to receive subsidies from the government fixed through a call for tender made each year. Despite a large potential of 1700 GW, the question of using the land solely for energy purposes poses a problem.



MAP OF THE SOLAR CADASTRE OF THE REGION.
Source: energieatlas.nrw.de [https://www.energieatlas.nrw.de/site/karte_solarkataster]

Furthermore, existing regulations in the context of North Rhine-Westphalia (NRW) shows the untapped potential of agriculture land. This is to safeguard the productivity of crops on the high fertile soil within the region. Expansion of photovoltaic along highways has been the main plans by the state after the EEG 2021. But once that is done, should the growth of solar energy move to the land in the form of Agrivoltaic?

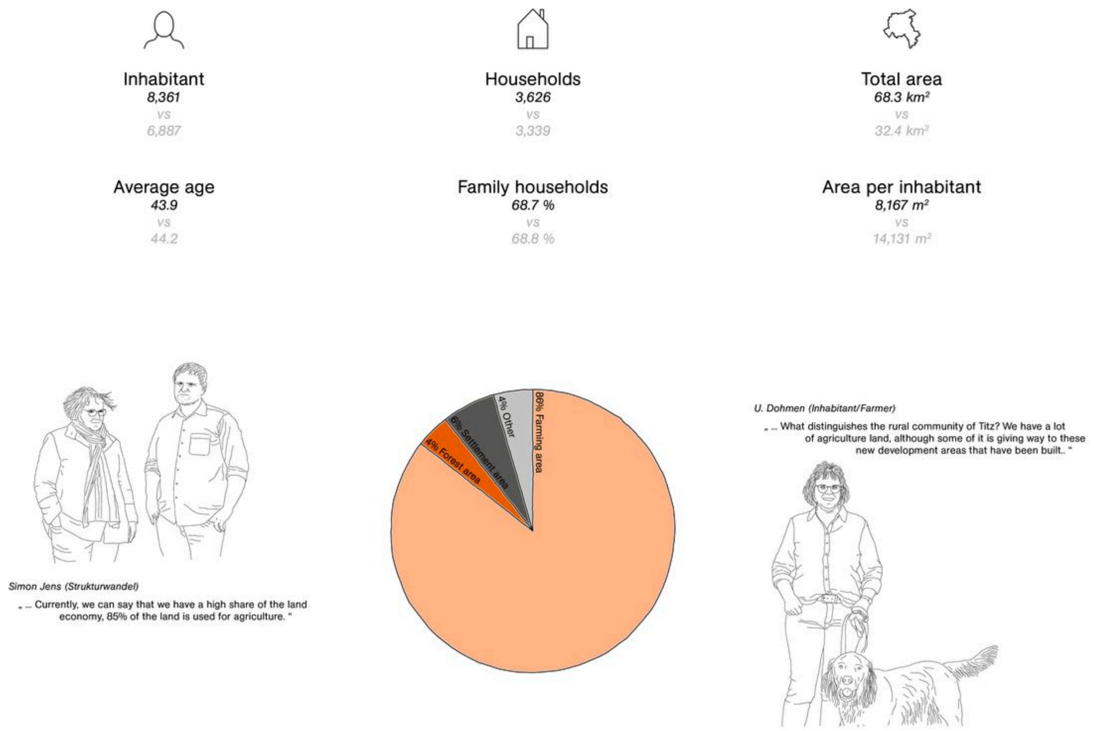
Agrivoltaic: Good or Evil?

Does energy transition mean that we must increase the number of Agrivoltaic installations? We acknowledge the presence of a Mental-Discerning Presumption. Through comparison, majority would encourage the proliferation of new hybrid photovoltaic systems as beneficial for our energy landscape. However, the question of such systems being ecologically and economically sustainable remain at large.

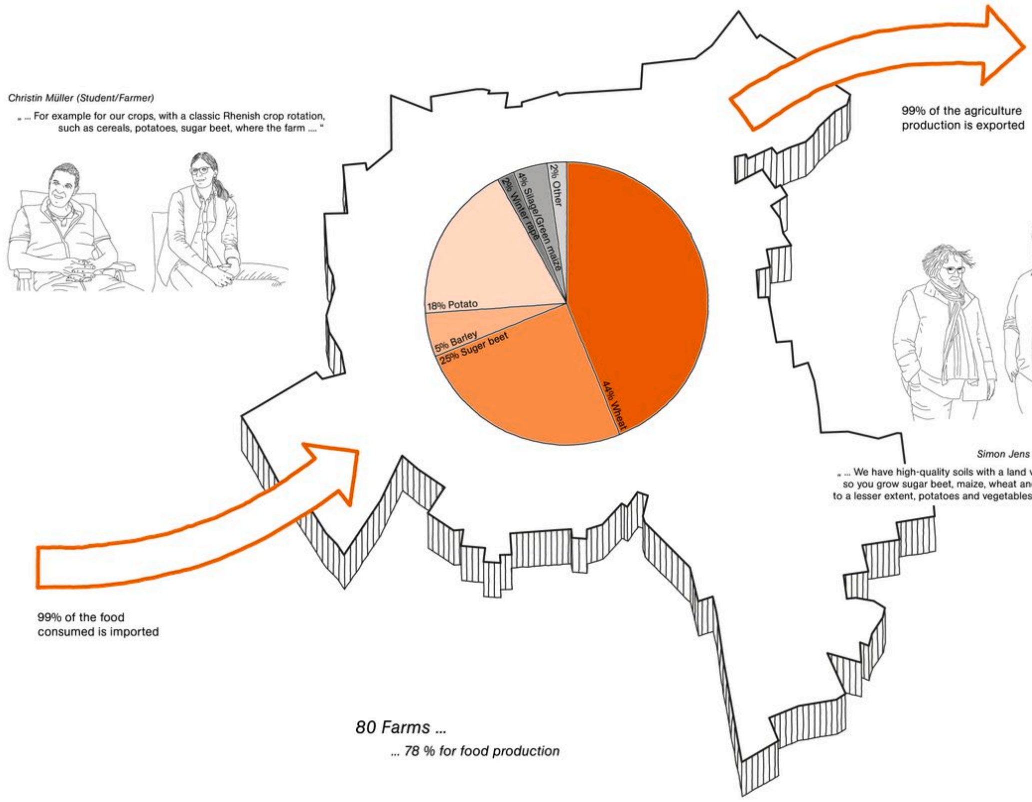
Case Study: Agriculture
Commune of Titz

THE RURAL COMMUNE OF TITZ.
https://www.youtube.com/watch?v=3SSRUQhRhv0

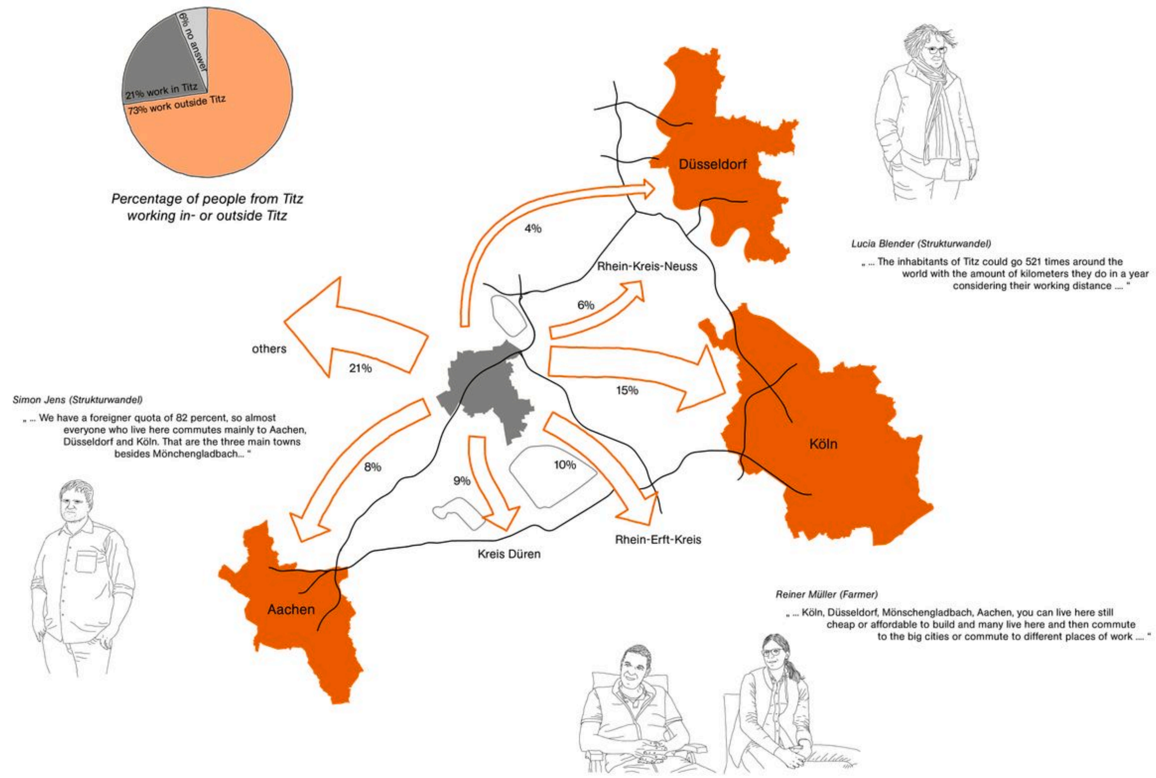
SATELLITE MAP OF THE COMMUNE OF TITZ.



GENERAL INFORMATION ABOUT THE COMMUNE OF TITZ
Source: geofy.de [https://geofy.de/en/titz/2756]



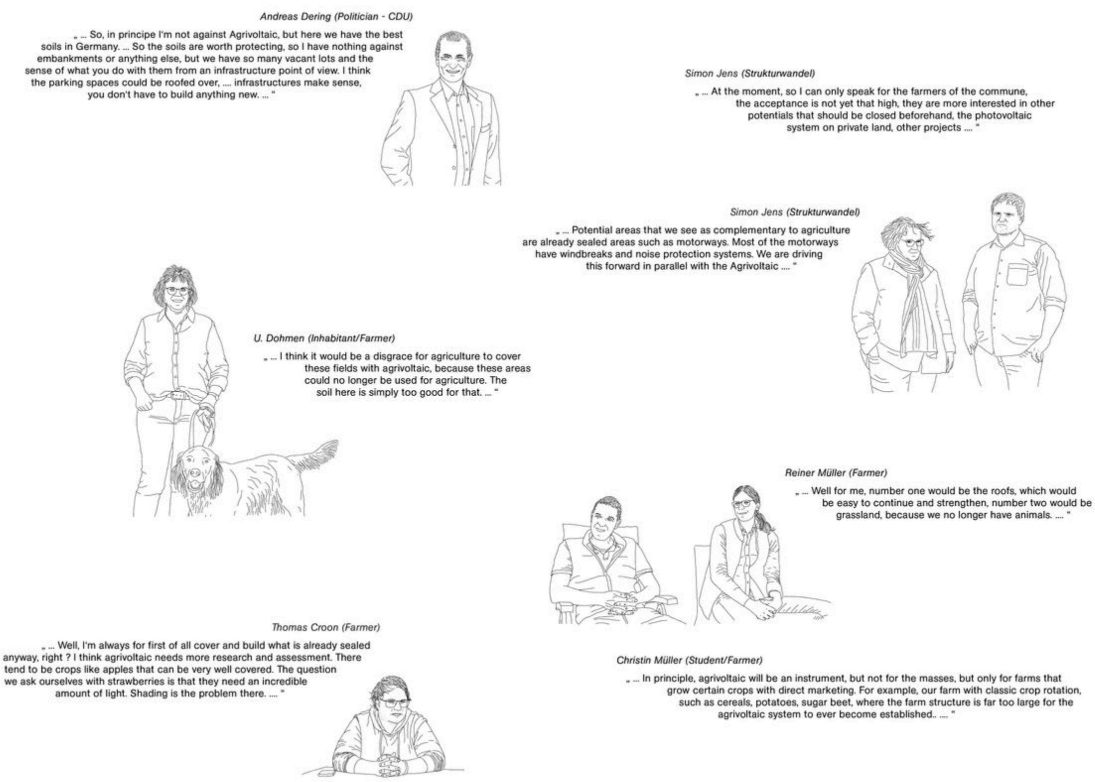
THE AGRICULTURE IN THE COMMUNE OF TITZ.
Source: Bioökonomie Revier, 2022
[https://www.biooekonomierevier.de/lw_resource/datapool/systemfiles/elements/files/53650dd2-3dae-11ed-9086-dead53a91d31/current/document/BiooekonomieREVIER_Kommunale_Profile_Titz_final.pdf]



THE LABOUR IN THE COMMUNE OF TITZ.
Source: Landgemeinde Titz, 2022 [https://landgemeinde.de/wirtschaft/Ergebnisse-OnlineUmfrage-Strukturwandel-Titz-web.pdf]

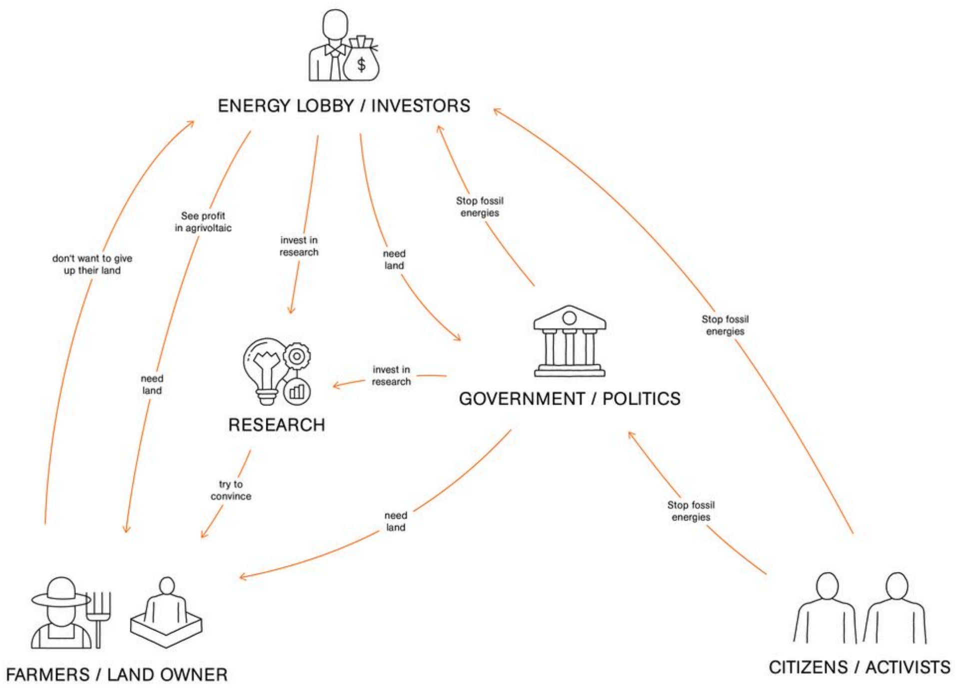
With just 8361 inhabitants in a land size of 68.3km^{2}, Titz has a unique landscape as it functions almost like a productive hinterland. 85.9% of Titz is highly fertile farming area. Heavy industrialised agriculture with just 5 main crops (cereal, wheat, winter wheat, sugar beets and potatoes) are being heavily produced due to their strong economic incentives. The heavy outflow of labour (79% of working population) from Titz also challenges the manpower needed to cultivate crops under Agrivoltaic systems. This contrasts with the existing mechanised landscape, filled with tractors to harvest crops.

THE IMPORTANCE OF RENEWABLE ENERGY IN THE COMMUNE OF TITZ.
Source: Landgemeinde Titz, 2022 [https://landgemeinde.de/wirtschaft/Ergebnisse-OnlineUmfrage-Strukturwandel-Titz-web.pdf]



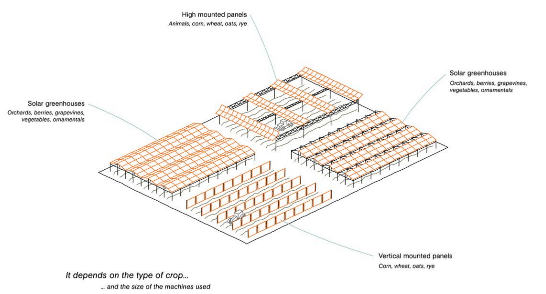
THE SOLUTIONS PROPOSED BY THE INHABITANT OF THE COMMUNE OF TITZ.

Yet, there is a general “solar-rush gaze” on the agriculture commune of Titz observed as the state, the commune intends to expand its photovoltaic, both in types and in numbers. However, the common consensus of the interviewed professionals in the agricultural sector in Titz is also one that is profit driven. With priority going to their individual crop cultivations, the topic of Agrivotaics is hardly considered.

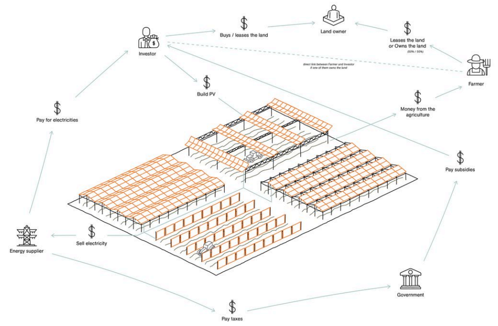


PRESSURE FLOW BETWEEN STAKEHOLDERS REGARDING AGRIVOLTAIC.

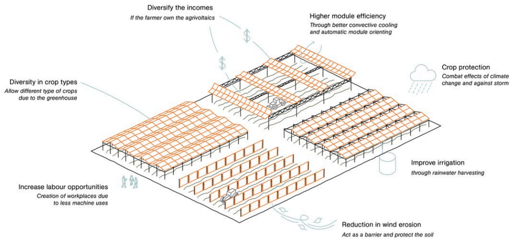
The challenge is then the pressure between the various stakeholders to implement it. To investigate the reason behind the uninterested sentiments, tracing both the hardware and software of Agrivoltaic system is necessary. To date, there is only one Agrivoltaic infrastructure in the region near Titz, it would explain the possible lack of understanding and potential it has despite the visit organised by the municipality for the farmers.



THE DIFFERENT TYPE OF AGRIVOLTAIC.



SKETCH OF THE OWNERSHIP MODEL FROM AGRIVOLTAIC.



THE BENEFITS OF AGRIVOLTAIC.

First, based on the agricultural habits and the type of machines used, farmers who cultivate wheat and corn, would adopt the elevated photovoltaic panels for his combine harvester to operate under it. Furthermore, tracking the business model of a farmer who is considering renting the land for farming, from an investor who owns the land, would show that the farmer would barely profit from this system. A decrease crop yield by a margin of 80% would also reduce the agricultural profits.

We postulate that such cases are especially prevalent in a similar large-scale industrialised agriculture landscape, as companies with substantial capital see Agrivoltaic as a major investment opportunity.

Regardless, Agrivoltaic would be beneficial if carefully implemented. Farmers would reap ecological benefits through crop-protection measures from its system, as these microclimatic structures improve irrigation channels and reduce wind erosion. Should farmers share a piece of the agrivoltaic pie in terms of ownership, they would be able to diversify their income between electricity and agriculture. Futhermore, the diversity of crop types that are encouraged by Agrivoltaics would be able to improve the labour opportunities in the agricultural scene. Economically, this also allow the commune to reduce the number of imports they need for crops that are normally unsuitable for growth within the region.

ECOLOGICAL IMPACT ON AGRICULTURE LAND.

SOCIAL IMPACT ON COMMUNITIES.

CHANGE IN LIFESTYLE OF PROSUMERS.

However, should investors call the shots in Agrivoltaics, farmers be at a disadvantage as agriculture land would not be treated from an ecological standpoint, but rather from an economic standpoint. Socially, these systems would just be potential “dead zones” which are made for energy production and potential communal benefits would be neglected. Ultimately, whether Agrivoltaic is deemed as good or evil, depends on who owns the farm and where does the excess resources go to.

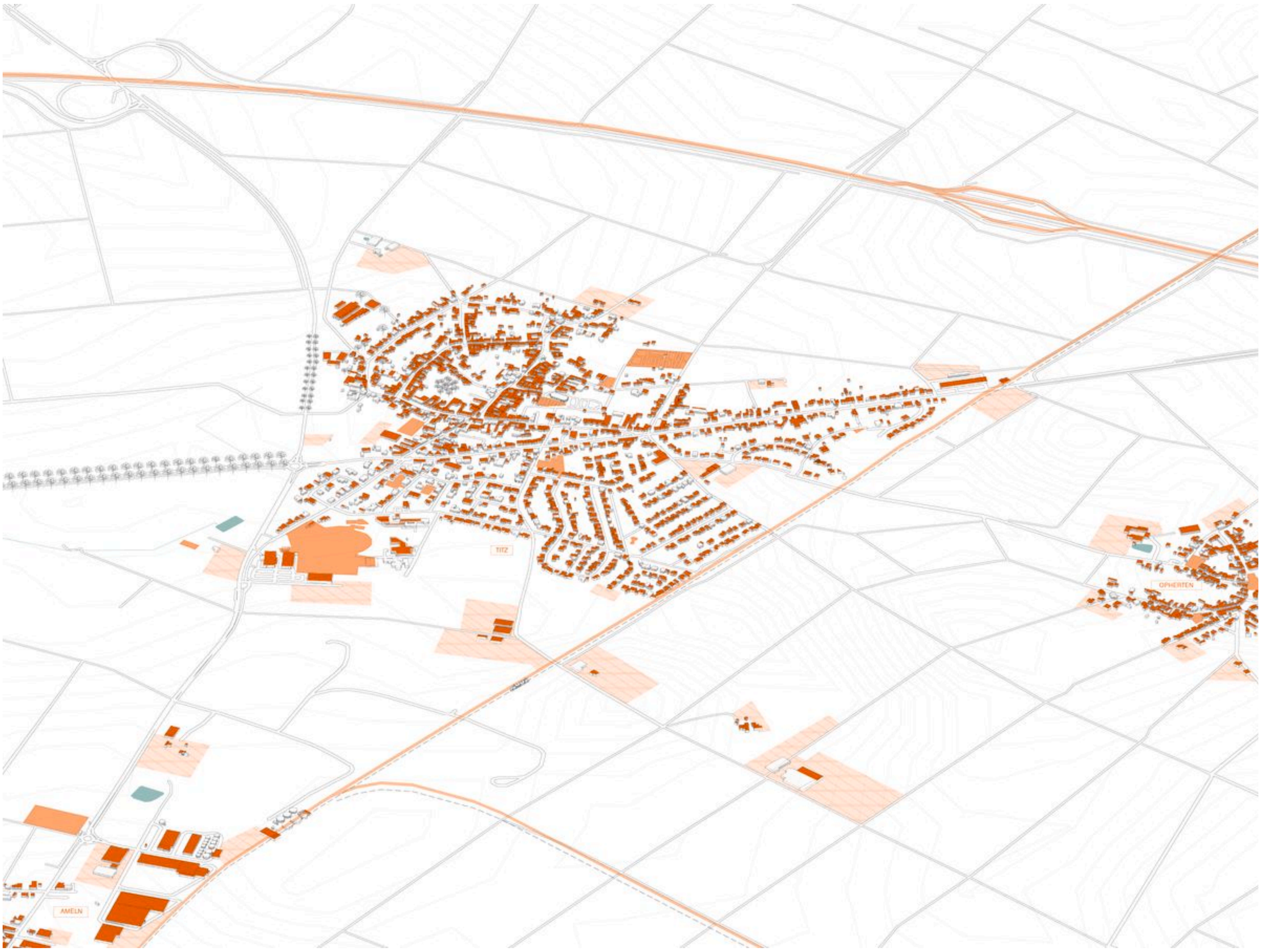
IMAGE OF PHOTOVOLTAIC LANDSCAPE ON FIELD AND ROOF.

IMAGE OF PHOTOVOLTAIC ON ROOF ONLY.

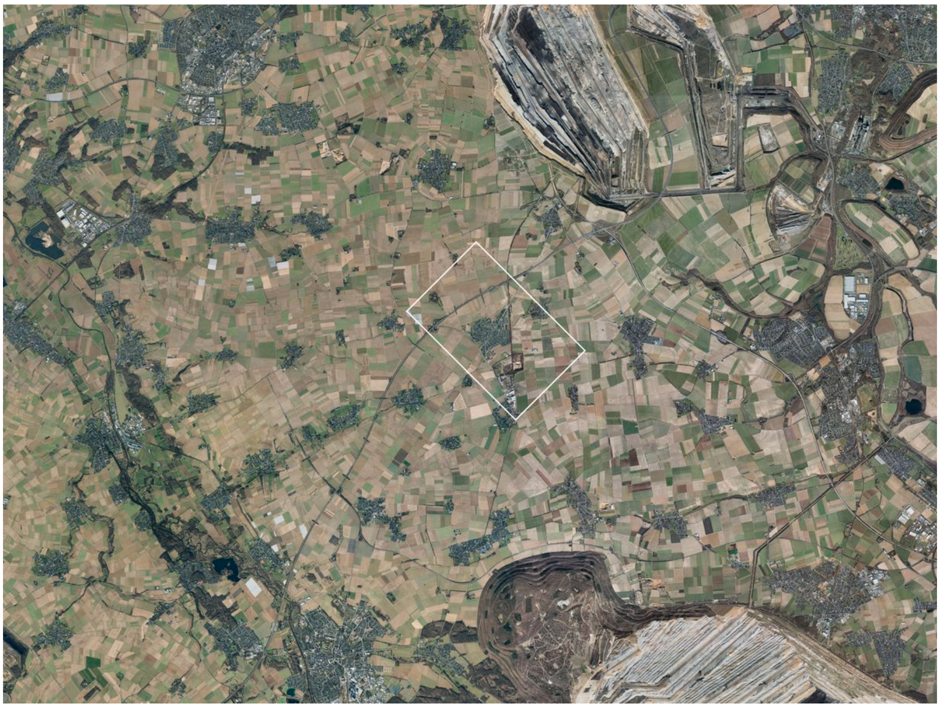
As we attempt to debunk the myth of energy transition directly relating to an increase in Agrivoltaic, we observe that the image on the left might not be deemed as more ecological beneficial or economically equitable than the right image.

Agrivoltaic need not be the first step in energy transition.

Step-by-Step: A Model for an Equitable Solar Development



The priority of the implementation of PV systems play an important role to developing a step-by-step model which safeguards the welfare of the people. It also makes known that there is no urgent need for the rapid expansion of PV types in the landscape if the sole purpose is to provide energy for the community. There should be no trade-offs between soil and PV as the model seeks to value-add the landscape rather than depleting its resources.

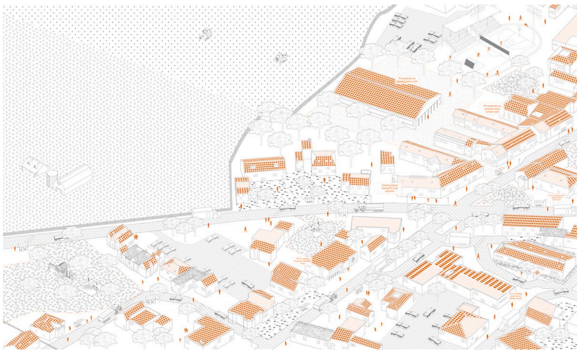


SATELLITE IMAGE OF THE AREA OF INTEREST

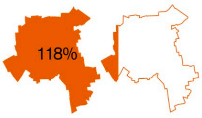
Looking at the industrial agriculture nature of Titz, it is more important to ask how we can empower the local community first, for fear of exploitation of the people in Titz, before thinking about producing for other cities. Hence, a proposed step-by-step layering of solar infrastructure seeks to ensure that these homogeneous landscapes are not ecologically detriment.

Step 1: Installation on All Un-adopted Roofs

STEP 1 - AXONOMETRIC OF THE POTENTIAL ROOF PHOTOVOLTAIC INSTALLATIONS.



STEP 1 - AXONOMETRIC ZOOM IN OF THE POTENTIAL ROOF PHOTOVOLTAIC INSTALLATIONS.

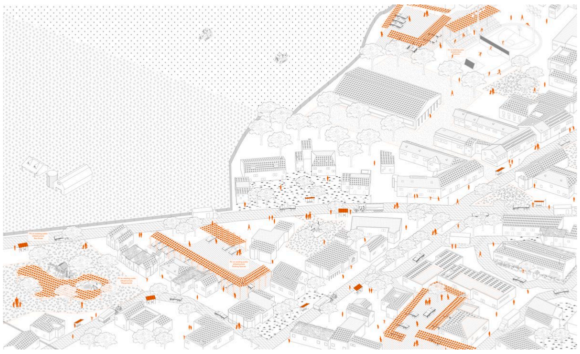


STEP 1 - ROOF PHOTOVOLTAIC POWER POTENTIAL IN RELATION TO ELECTRICITY CONSUMPTION OF THE COMMUNE OF TITZ.
Roof photovoltaic can provide 1.18 times the electricity needed.
Potential: 77 GWh/a on a surface of 0.5 km2.

The first step includes the remaining 92.4% un-adopted roofs of small-scaled homes, independent shopping complexes, and state-owned infrastructures, to ensure that inhabitants themselves receive a share of the electricity tenant pie. In the context of the commune of Titz, it is estimated that occupying all the roof PVs would produce 77 GWh/a, which would be sufficient to serve the entire population that only requires 65HWh/a.

Step 2: Installation on Public Infrastructures

STEP 2 - AXONOMETRIC OF THE POTENTIAL PHOTOVOLTAIC INSTALLATIONS ON PUBLIC INFRASTRUCTURES.



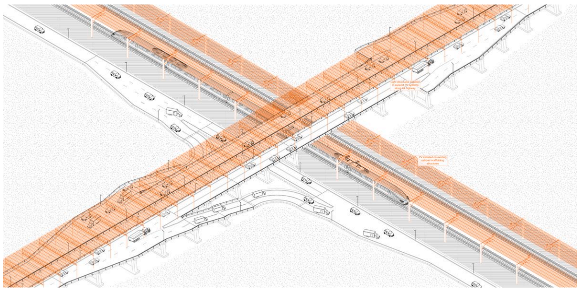
STEP 2 - AXONOMETRIC ZOOM IN OF THE POTENTIAL PHOTOVOLTAIC INSTALLATIONS ON PUBLIC INFRASTRUCTURES.

STEP 2 - PHOTOVOLTAIC INSTALLATIONS ON PUBLIC INFRASTRUCTURES POWER POTENTIAL IN RELATION TO ELECTRICITY CONSUMPTION OF THE COMMUNE OF TITZ.
Photovoltaic installations on public infrastructures can provide 0.14 times the electricity needed.
Potential: 9 GWh/a on a surface of 0.05 km2.

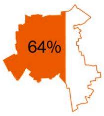
The second step includes parking spaces, bike lanes, playgrounds, stadiums, and bus stops. By building over the existing livelihood of these spaces, it seeks to prevent “dead spaces” under hybrid photovoltaic systems such as Agrivoltaic. Existing supporting structures can also save the cost and energy used to install new scaffoldings. New PV technologies are also able to keep these spaces rich in natural light and perforated, preventing the sealing of spaces.

Step 3: Installation on Highways and Railroads

STEP 3 - AXONOMETRIC OF THE POTENTIAL PHOTOVOLTAIC INSTALLATIONS ON HIGHWAY AND RAILWAY.



STEP 3 - AXONOMETRIC ZOOM IN OF THE POTENTIAL PHOTOVOLTAIC INSTALLATIONS ON HIGHWAY AND RAILWAY.

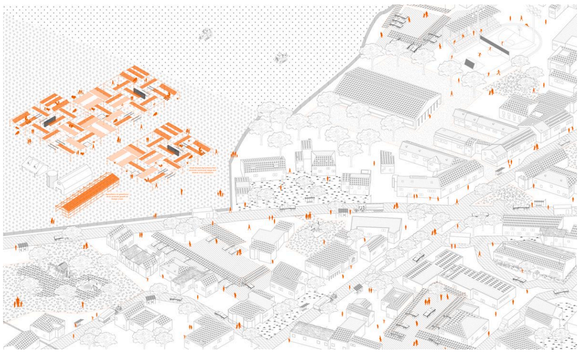


STEP 3 - PHOTOVOLTAIC INSTALLATIONS ON HIGHWAY AND RAILWAY POWER POTENTIAL IN RELATION TO ELECTRICITY CONSUMPTION OF THE COMMUNE OF TITZ.
Highway and railway covered with photovoltaics can provide 0.64 times the electricity needed.
Potential: 41.6 GWh/a on a surface of 0.27 km2.

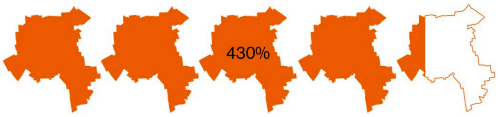
The A4 highway runs through the commune of Titz and offers great opportunities for energy production. The road-integrated PV (RIPV) can also act as sound barriers, benefiting the wellbeing of the local community. Given that highways are state-owned, and the state could manage the excess energy (41.6 GWh/a) and profit generated to circulate to the welfare of its people.

Step 4: Installation of Agrivoltaics

STEP 4 - AXONOMETRIC OF THE POTENTIAL AGRIVOLTAIC.



STEP 4 - AXONOMETRIC ZOOM IN OF THE POTENTIAL AGRIVOLTAIC



STEP 4 - AGRIVOLTAIC POWER POTENTIAL IN RELATION TO ELECTRICITY CONSUMPTION OF THE COMMUNE OF TITZ.
2% of agriculture fields covered with photovoltaics can provide 4.3 times the electricity needed.
Potential: 278.7 GWh/a on a surface of 1.81 km2.

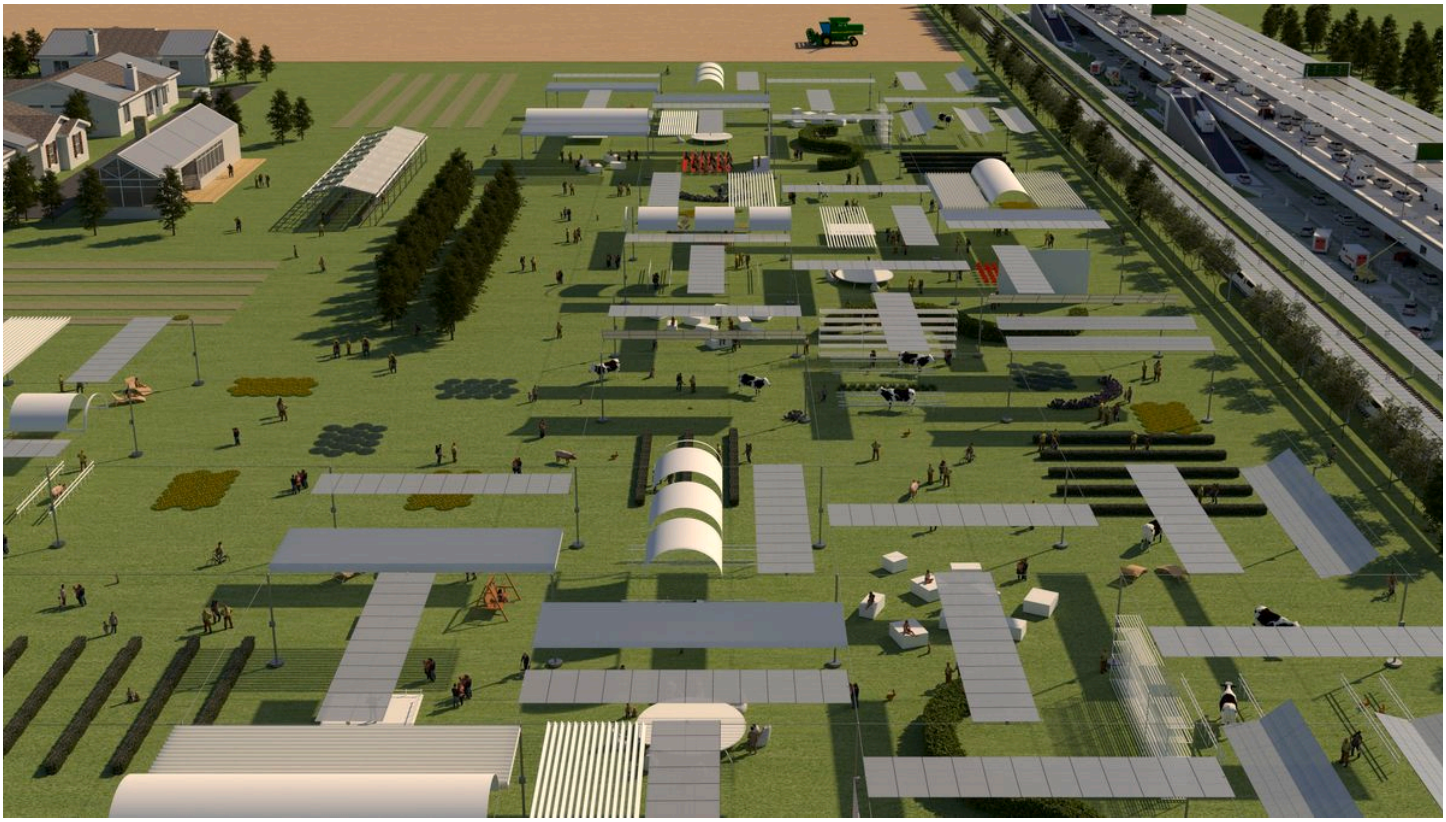
Agrivoltaic should only be used for production of crops that are not favourable under existing climatic conditions in Titz. These small microclimatic zones offer crops that were once imported to grown locally instead. The size of Agrivoltaic permittable should only be in relation to the size of farm (in terms of their production), where larger occupation of agriculture land, offers larger Agrivoltaic space allocated. Furthermore, farms are generally located at the periphery of a particular district. This allows Agrivoltaics to be installed near the district centres and allow for much easier access and mobility. These spaces can then be easier to realise as public spaces to be shared with the people of the district.

AXONOMETRIC OF THE FINAL POTENTIAL DEVELOPMENT.

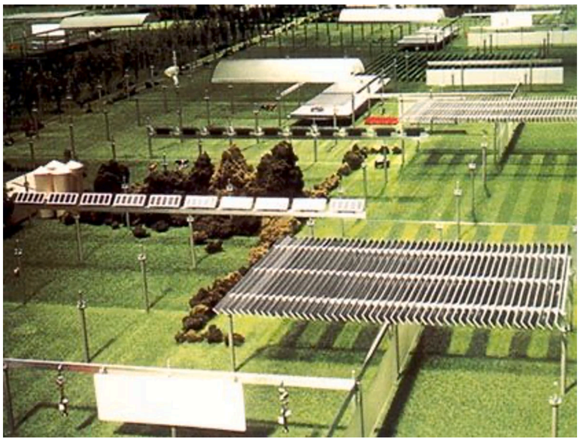
DIAGRAM OF THE EXPORTED FINAL POWER POTENTIAL ENERGY.

Testing out an average of 2% of photovoltaic covering agricultural fields would already generate 4.3 times the needed energy for the inhabitants of Titz. As a potential energy productive hinterland, the excess energy generated from this proposal could be exported to neighbouring cities that are big energy consumers to offset the backlog of renewable energy production. However, limiting the scale of large-scale, private-owned solar farm such as Agrivoltaic is necessary to limit the potential for big investors to exploit this system as an investment tool. In delaying the occupation of the soil, communities can also have more buffer time to rethink their communal spaces and to what extent this photovoltaic growth should be.

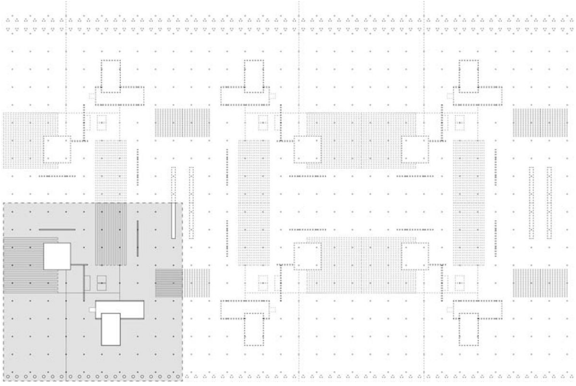
Conclusion: Producing Solar Energy Communally



To produce solar energy communally, strong collaboration between farmers, the state and the people is necessary. PV goes beyond the aesthetic notion of renewables and its technocratic role in energy transition. Rather it is heavily linked with the ground and where it is placed.



ANDREA BRANZI, AGRONICA
EXHIBITED AT VENICE BIENNALE, 2010
Source: Christoph Lieder, Journal of Architectural Education
[https://www.researchgate.net/publication/271929881_Diagram_Utopias_Rota_and_Network_as_Instrument_and_Mirror_of_Utopia_and_Agronica]



ANALYSIS OF FIELD AND KALEIDOSCOPIC MIRRORING.
Source: Source: Christoph Lieder, Journal of Architectural Education
[https://www.researchgate.net/publication/271929881_Diagram_Utopias_Rota_and_Network_as_Instrument_and_Mirror_of_Utopia_and_Agronica]

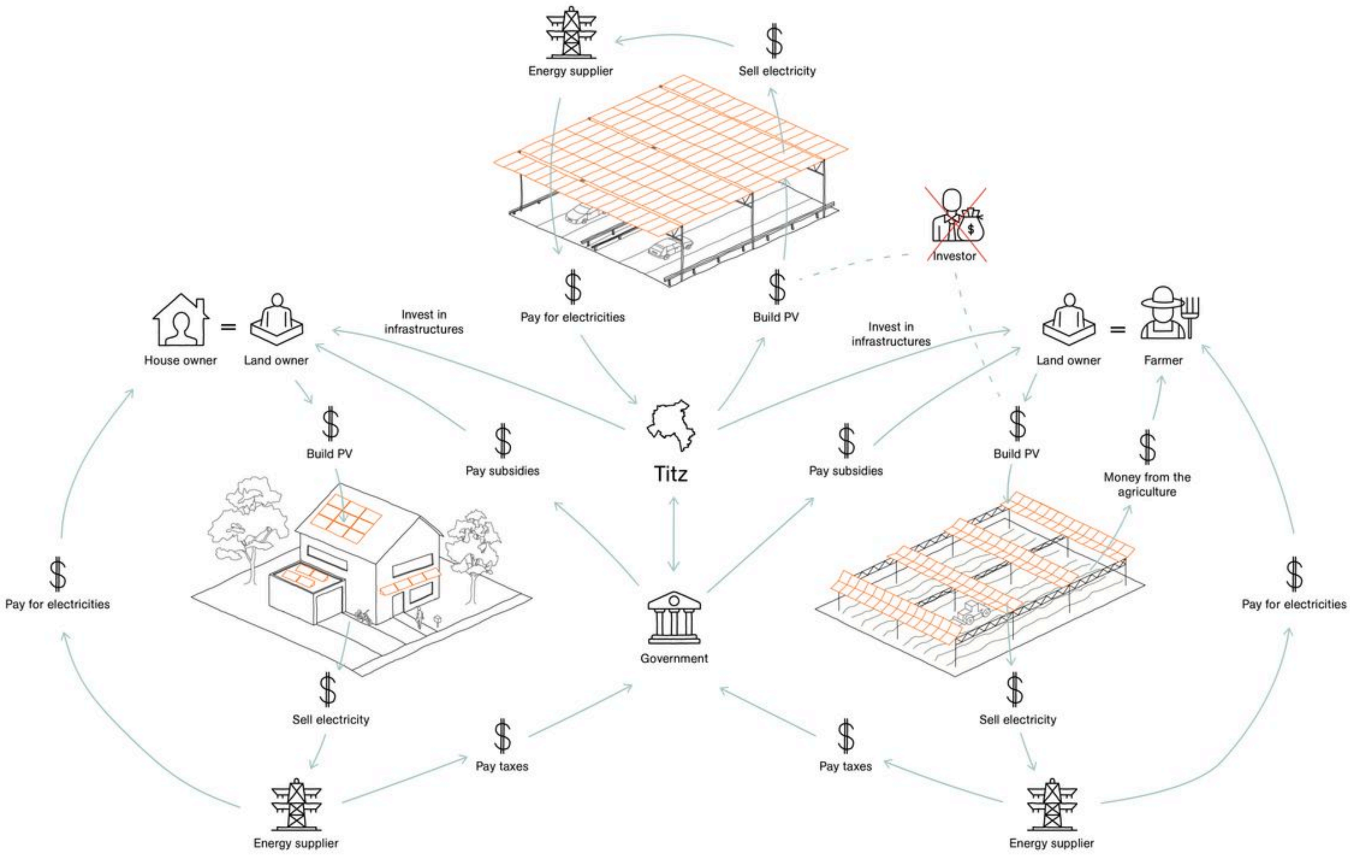
Learning from Branzi's Agronica, we propose a photovoltaic landscape that looks beyond the rigid infrastructure, but what is underneath and around as an ideal future. Even prior to the 90s, Branzi already had this vision which explores the potential relationships among agricultural and energy production, and the cultures of consumption they produce. And today, we see it much applicable in the context of a highly industrialised agriculture landscape such as Titz. "A functionoid therefore that responds positively to the changing of necessities" is what the land of an industrialised agriculture needs to address economic inequality, social justice, and environmental health.

2 Criteria Are Proposed to Set the Boundaries for Solar Energy to Be Produced Communally.

IMPRESSION OF A SOCIALLY BENEFICIAL SOLAR LANDSCAPE

Criterion 1: Socially Beneficial for Local Community.

Photovoltaic infrastructure should prioritise community spaces and the promotion of regenerative values. Photovoltaic on existing infrastructure like playgrounds and parking spaces should value-add these spaces, such as providing shelter. This can also be achieved through direct communication of farmers and the people. For example, the utilisation of Agrivoltaic as a multifunctional public space.



OWNERSHIP MODEL FOR THE STEP-BY-STEP MODEL

Criterion 2: Economically Beneficial for Local Community.

Circulation of resources between the stakeholders are crucial. Is the excess wealth generated from energy pumped back as investment towards public infrastructure and welfare? Or is it going to the big companies? By minimising the significance of investors in the business cycles also ensure that ideas and welfare (for example, job opportunities) could be easily flowed to between the farmers, state, and the people. A rewiring of resources is necessary to break form the potential profit-driven cycle. This could be achieved by seeing the different types of photovoltaic systems as a single entity, where farmers, the state and the people are all within the same business cycle.

However, such a system would require the strong collaboration between farmers, the state, and the people. To conclude, photovoltaic goes beyond the aesthetic notion of renewables and its technocratic role in energy transition. Rather it is heavily linked with the ground and where it is placed.

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