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CIÊNCIA, IMAGINAÇÃO E VALORES NA VIRADA ENERGÉTICA ALEMÃ: UM EXEMPLO DA METODOLOGIA DE NEURATH PARA A TECNOLOGIA SOCIAL

SCIENCE, IMAGINATION AND VALUES IN THE GERMAN ENERGY TURN: AN EXAMPLE OF NEURATH'S METHODOLOGY FOR SOCIAL TECHNOLOGY

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RESUMO O utopianismo científico de Neurath é a proposta para que as ciências sociais se envolvam na elaboração, desenvolvimento e comparação de cenários contrafactuais, as 'utopias'. Tais cenários podem ser entendidos como peças centrais de experimentos de pensamento científicos, isto é, em exercícios da imaginação que não apenas promovem a revisão conceitual, mas também estimulam a criatividade para lidar com problemas vivenciados, já que utopias são esforços para imaginar como o futuro poderia ser. Ademais, experimentos de pensamento utópicos podem

oferecer conhecimento científico para informar debates e decisões políticas, contribuindo para formatar a sociedade. Este ensaio reconstrói um evento histórico como um exemplo da metodologia utopianista de Neurath. No final dos anos 1970 e início dos anos 1980, uma comissão científica e política designada pelo parlamento da Alemanha Ocidental inventou e comparou quatro cenários para políticas energético-econômicas futuras. Conclusões da comissão informaram decisões políticas que puseram a Alemanha Ocidental (e depois reunificada) em um caminho para se tornar uma potência industrial verde. Uma parte fundamental do trabalho da comissão envolveu um apelo à imaginação, permitindo a caracterização sob a metodologia de Neurath.
Palavras-chave: Empirismo lógico. Economia e ecologia. Filosofia das ciências sociais. Imaginação científica. Experimentos de pensamento. Ciência, tecnologia e sociedade.

ABSTRACT Neurath's scientific utopianism is the proposal that the social sciences should engage in the elaboration, development, and comparison of counterfactual scenarios, the 'utopias'. Such scenarios can be understood as centerpieces of scientific thought experiments, that is, in exercises of imagination that not only promote conceptual revision, but also stimulate creativity to deal with experienced problems, as utopias are efforts to imagine what the future could look like. Moreover, utopian thought experiments can offer scientific knowledge to inform political debates and decisions, contributing to the shaping of society. This essay reconstructs a historical event as an example of Neurath's utopianist methodology. In the late 1970s and early 1980s, a scientific and political commission appointed by the Western German Parliament devised and compared four scenarios for future energetic-economic policies. Conclusions of the commission informed political decisions that put Western (later reunified) Germany in a route towards becoming a green industrial power. A fundamental part of the commission's work involved an appeal to imagination, allowing for the characterization under Neurath's methodology.

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Keywords: Logical empiricism. Economics and ecology. Philosophy of social science. Scientific imagination. Thought experiments. Science, technology and society.

Introduction

Otto Neurath (1882-1945), a member of the Vienna Circle and proponent of the philosophy of logical empiricism, presents an interesting conception of the methodology of the social sciences that makes it possible to view them from a technological perspective. He saw in the

theories of this area a potential to develop proposals for social reform, providing knowledge for political debates regarding the transformation of our society. This essay will characterize a historical event that took place at the end of the 20th century in Germany in terms of Neurath's conception. That is, we will see that scientists developed proposals for social transformation, projected their future development and made comparisons between these proposals. With this, scientists fueled a political debate in which decisions were made that still have an impact on German society.

We are referring to the so-called *Energiewende*, the energy transition that Germany has carried out in recent decades, increasingly adopting renewable energy sources. This transition in energy and economic policy, as we shall see, was strongly influenced by a scientific and technological discussion held between 1979 and 1983 by the *Enquete-Kommission Zukünftige Kernenergie-Politik*, the Research Commission on Future Nuclear Energy Policy designated by the German Parliament. Hence, through an example, we hope to show that Neurath's methodological proposal for the social sciences in a technological perspective, despite having been presented about a century ago, can still help us to philosophically understand science and the contemporary world.

To accomplish this objective, the first section presents Neurath's methodology of social sciences, so-called scientific utopianism. Then, the second section outlines the German *Energiewende* and the third discusses the works of the *Enquete-Kommission*, characterizing them in the methodology proposed by Neurath. The fourth section focuses on the work of one of the members of the *Enquete-Kommision*, the physicist and philosopher Klaus Michael Meyer-Abich, who presented an important argument for the discussion not only to be guided by questions of economics and ecology, but also by social questions. We will see that Meyer-Abich's arguments requires imagination as a resource,

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which subsequently allows an approximation to Neurath's methodology, which, as we will also see, makes use of thought experiments. The fifth section conducts a discussion of science, technology, politics and values, preparing the way for the concluding remarks of the essay on the actuality of Neurath's philosophy.

1. Neurath's Utopias

According to Neurath, the object of study of the social sciences must be understood as something complex, composed of elements that can be studied by different disciplines, such as sociology, economics, psychology, anthropology, history, etc. and also by

disciplines of the so-called natural sciences, including physics, chemistry, geology, among others. Despite this methodological division, the interest of the social sciences lies in the complexity of the object, in its multifaceted character. To describe this complexity, Neurath uses the German term *Ballung*, which can be translated as aggregate or cluster, giving the idea that it is a complex block (Neurath 1944/1970; Cartwright *et al*. 1996; Cat 1995).

In spite of this difference in methodological orientation, it is important to note that Neurath was a defender of the unity of science, as were his colleagues in the Vienna Circle. However, for Neurath, as well as for other members of the group, this unity should not be understood in the form of reducing all sciences to physics, but in the understanding that all scientific disciplines deal, directly or indirectly, with objects and events around us. That is, even the most abstract theorizations of each of the specific branches of empirical science must be able to be referred back to something that can be experienced and described in everyday language. As a result, all areas of science are interconnected because they concern the empirical world, which is reflected in the ability of unified science to make successful predictions. In Neurath's words, "all laws of unified science must be capable of being linked with each other if they are to fulfill the task of predicting as often as possible individual events or groups of events" (Neurath, 1931/1983, p. 68). The methodological difference, hence, lies in the fact that social sciences tend to focus on phenomena of higher complexity. Thus, the approach from different disciplines becomes more relevant. In the natural sciences, in general, although they also take complex objects and events around us as their starting point, the disciplinary approach with a restricted focus is often satisfactory.

In accordance with this view, scientific proposals for the improvement of existing social orders cannot be restricted to

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localized [reforms] and minimalist [reforms], but must take into account that such reforms can produce changes throughout the whole aggregate, or *Ballung*. In this way, Neurath proposes that social sciences deal with *utopias* in their technological endeavors, conceiving as many effects of the proposed reforms as possible. Neurath's utopias are comprehensive models of social situations (not necessarily encompassing society as a whole), in which one seeks to understand what implications a proposal may have. The objective is to promote social debate through the comparison between social orders. Going beyond the philosophical and literary exercises of imagining the ideal society, Neurath's *scientific utopianism* presents itself as a scientific effort to promote systematic comparison between existing, historically given social orders and imagined social orders. In this

process of *comparative utopistics*, scientists present and develop proposals for social arrangements that could be implemented and show how these proposals relate to the goals of a community (Neurath 1919/1979; cf. Nemeth 1982/1991; Uebel 2008). Based on these resources, the community would be able to politically discuss the proposals presented and evaluate them, identify whether they are adequate or inadequate, and make decisions about whether or not to implement the reforms.

The role of social science in Neurath's methodological proposal is not to provide plans to solve once and for all the problems of a community or society. The aim is to stimulate the imagination of people in a community to consider what their social arrangement might look like in the future. This stimulation of imagination through exercises with counterfactual scenarios, by promoting an increase in creativity, helps to form awareness that the situations we experience are not inevitable, that other social orders are possible. In addition, these exercises, by taking into account a plurality of aspects and proposals, help communities to make informed decisions. But the role of making these decisions does not belong to science in Neurath's proposal, but remains in the domain of politics.

This perspective exhibits a separation between facts, the domain of science, and values, the domain of politics. This separation comes from the realization that science is necessarily a plural enterprise that can support varied points of view. Science would not be able, in Neurath's conception, to offer univocal answers to questions of values, pointing out what would be the best social arrangement. Science's answers cannot even be conceived as absolutely correct. The role of science is only to increase the range of possibilities for dealing with an uncertain future.

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This is reflected in the famous metaphor created by Neurath according to which "we are like sailors who have to rebuild their ship on the open sea, without ever being able to dismantle it in dry-dock, and reconstruct it from the best components" (Neurath 1932/1983, p. 92). That is, we cannot build what we conceive of as the best possible social arrangement – we need to remain in the old structure and deal with heavy gales and thundering waves (Neurath 1944/1970, 47). At the same time that we produce something with our best efforts, we must be aware of the possibility of alternatives and the possibility that we can change our future. The stimulation of imagination and the gathering of information and conditions to consider the implementation of what is imagined are the contributions of science, as Neurath conceives it, to the improvement of society.

Thus, by placing social science in a technological perspective, that is, in an effort to imagine social orders and help communities to implement them, Neurath makes us realize a

limitation of science itself. Understanding this limitation of science is important for us to conceive the space of politics in efforts to improve society. Even if strongly supported by our best scientific knowledge, social technology has a political dimension, a domain of decisions, which cannot be taken by science.

This relation between science and politics also appears in an aspect emphasized by recent scholarship on Neurath's scientific utopianism. Linsbichler & da Cunha (2023), emphasizing the role of creativity in Neurath's proposal, trace a relationship between Neurath's scientific utopianism, the methodology of thought experiments, and scientific policy advice. From this perspective, utopias, the counterfactual models of society, play a role in arguments that seek to unveil contradictions in our conceptual apparatus. The utopias and the deliberations we use them for show us, according to this point of view, that theoretical aspects that we take as given in our reasoning are problematic and need revision. We see this throughout the utopian tradition in philosophy and literature: for example, in the discussion raised by Thomas More that there might be another way of organizing society; and also in Aldous Huxley's *Brave New World*, which showed that a society organized with techniques of genetic improvement may not be a paradise on earth. And we see this in the natural sciences too, when Galileo asks us to imagine falling bodies in situations that go against what our theories tell us, or when Schrödinger convinces us that macroscopic objects (like cats) cannot behave in the same way as quantum objects. However, in these

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exercises of imagination, the need for decisions remains: it is well-known in the philosophy of science since the beginning of the 20th century (cf. Duhem 1906/2007) that experiments, conventional or in-thought, do not necessarily commit us to a specific decision, to accept or reject a theory, for example. With regard to the implementation of social science proposals, there always seems to be room for political debate.[1]

It is worth highlighting, following Linsbichler & da Cunha (2023), that the methodology of thought experiments fits into Neurath's philosophy of science – although we can reasonably question how it is possible for exercises of the imagination to produce knowledge (cf. Brown; Fehige, 2022), especially from an empiricist perspective (cf. Norton, 2004). As we have seen, an important characteristic of unified science, in Neurath's conception, is the ability to make predictions. However, how can science be differentiated from a mere creation of the imagination, a

[1] It goes beyond the scope of this essay to discuss the various philosophical issues involving thought experiments. For introductory approaches to the topic, cf. Islas Mondragón (2020); Nyland (2020); Brown & Fehige (2022).

fantasy that, by pure luck, makes successful predictions? This is a complicated issue, because, given the fallible nature of science, illustrated by the boat metaphor, we do not have an absolutely certain or guaranteed way to make this differentiation – we cannot "disembark" or even dock to be able to evaluate the vessel from an external point of view. In this effort, we use our own imagination, as Neurath writes: "one fully recognizes the real only when one surveys the possible as well" (Neurath, 1919/1979, p. 240). That is, understanding and comparing knowledge in relation to what could be the case is an instrument to keep the ship sailing. As Thomas Uebel (1996, p. 109) comments on the passage we cited, "the very discussion of the possibility of alternatives can reshape an entire intellectual landscape". In this direction, also Elisabeth Nemeth (1996, p. 12) states that "the scientific approach to reality is, according to Neurath, inevitably utopian: the science which he proposes to us cannot say anything about the 'one' reality, since it analyzes the 'given' reality by juxtaposing it with other possibilities […]". By conceiving alternatives to existing arrangements, we confront our conceptual and theoretical references with scenarios that we consider possible and, thus, we have the opportunity to reorganize these references. Considering that it is from these references – from unified science – that we produce predictions, we are able to improve scientific knowledge.

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For Neurath, this is particularly important in the social sciences, as in this area the repertoire of existing and past social arrangements is quite small compared to what we can imagine. As an example, Neurath mentions that "we have very fine studies on market correlations, but we do not know under what conditions these correlations remain valid […]" (Neurath, 1944/1970, p. 30). Such an understanding could only emerge from the study of a large number of similar situations, which may not be possible in the social sciences if the research is limited to social arrangements that currently exist or that we know existed in the past. Thus, scientific utopianism is the way he proposes to overcome this limitation. In this proposal, he is inspired by what happens in mechanics: he explains to us that mechanical engineering, if it deals only with existing arrangements, "deals with a selection of certain aggregations, e.g., historically given steam engines and certain planned steam engines, but not with all possible steam engines; whereas scientific mechanics tries to deal with all kinds of possible levers" (Neurath, 1944/1970, p. 31). Completing the analogy, to understand the extent to which our knowledge of society works, we need, according to Neurath, to check how this knowledge is articulated with imagined possibilities. Thus, in the process of imagining, developing and discussing possible scenarios, we have the opportunity to expand our

knowledge in general. It is this knowledge about what is possible that, in Neurath's view, fosters political debate.

As presented in the introduction, this essay brings, in the next sections, a reading of an event in the political and economic history of Germany at the end of the 20th century reconstructed as an example of Neurath's methodology. We will see that scientists from different fields gathered at the request of the German Parliament and conceived of a variety of alternatives on how society could be organized for the future. In view of the development, comparison and discussion of these alternatives in the scientific sphere, Parliament was able to develop a debate to make political decisions.

2. The *Energiewende* in Germany

A topic that has made the news in much of the world recently is the energy issue in Germany, the main industrial power of the European Union and one of the main economic superpowers in the world. The reason for the attention given to the German energy issue was that, with the beginning of the war between Russia and Ukraine, it became evident that Russia had an asset against economic sanctions by the European Union: the fact that, more than

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other countries of the bloc, Germany depends on natural gas imported from that country to keep its industry running. While this text is being written, diplomatic tension escalates as Russia threatens to reduce or cut the supply of fuel if its expansionist intentions do not receive assent from European countries (cf. Deutsche Welle 2022; McGuinness 2022).[2]

About ten years earlier, the German energy issue had already caught the attention of the news when the country decided to abandon the use of nuclear energy, phasing off a large part of its reactors and committing to deactivate all of them by the end of 2022 (cf. BBC. News 2011).[3] This decision followed a change in public opinion regarding atomic energy that occurred after the accident at the Fukushima nuclear power plant in Japan in 2011. This decision was just a course adjustment in the process called *Energiewende*, "energy turn", which designates the transition to renewable energy sources carried out by Germany since 2010. Other *Energiewende* goals are the

[2] As a revised version of this text is produced, the situation, as reported in the news, is that Germany remains dependent on natural gas imports, but not anymore on Russian fuel. The fragile situation contributes to a wave of inflation in the country, as well as in other members of the European Common Market (cf. Hill, 2022).

[3] For a detailed account of the early history of nuclear power in Germany, see Radkau (1983). Radkau & Hahn (2013) provide an abridged and updated account.

deactivation of coal-fired plants by 2038 and the drastic reduction of greenhouse gas emissions by 2050 (cf. Reis 2017).

Between the deactivation of nuclear plants and the recent tension with Russia, the German energy issue has also received attention, not so much in the front pages of the news, but in the more specialized economics sections. This happened in 2015, when Germany announced the so-called "decoupling" between its economic growth and its energy consumption (cf. Eddy 2015). According to Gross (2017, pp. 514-515), this represented a break with a pattern in developed countries, in which GDP growth follows the growth in energy use. By decoupling the two measures, Germany showed that its *Energiewende* was not affecting its status as an industrial superpower: even in the process of shutting down its nuclear reactors and, in fact, using *less* energy, from whatever sources, the German economy continued to grow.

This achievement, which appears to be a watershed at the intersection of economics and ecology, was neither the result of a natural evolution of the German economy nor of short-term planning. On the contrary, as Gross (2017, p. 515) explains, decoupling "stands at the end of a long chain of developments that made Germany a global leader in energy".

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According to the author, the end of the 1970s was decisive for Germany to differentiate itself from other superpowers, such as the USA, the United Kingdom and France: in reaction to the oil crises of 1973 and 1979, these countries reacted "by prioritizing the expansion of their energy supply", either by expanding its network of nuclear power plants or ensuring access to fossil fuels; West German political leaders and experts, on the other hand, "began to think seriously about reducing energy demand" (Gross 2017, p. 515).

The motivation for this differentiated path in West (and later reunited) Germany, still according to Gross (2017), seems to originate from three factors. First, we can mention the well-known international crises in the energy sector, such as the already mentioned oil crises in the 1970s; the accident at the Chernobyl nuclear power plant in 1986, which raised questions in various sectors of society about the safety of nuclear energy; and large-scale forest degradation in the northern hemisphere since 1980, the phenomenon known in German as *Waldsterben*, which has been attributed to the deterioration of the environment. This first factor seems to have affected the great industrial powers in a similar way. A second factor is the emergence of grassroots environmental movements that occurred in many developed countries, especially in Europe. In this case, we have a differential in Germany in relation to other developed countries, which was the early entry of the environmental movement into the German political system, which took place in

1983, when the Green Party (*Die Grünen*), founded three years earlier, managed to elect representatives to the country's parliament.[4] However, in addition to these two factors, Stephen Gross points out a third, which is what interests us the most in this text:

> The spread of a new body of energy-economic knowledge helps us understand Germany's divergence from other large, industrialized states in responding to the challenges of the 1970s and 1980s. This third explanatory framework complements the narratives about exogenous crises and the Green movement by showing how *new economic expertise prodded West Germans to reconceptualize the relationship between growth and energy, enabling them to imagine*

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> *a future where decoupling was possible, technologically as well as politically.* (Gross, 2017, p. 517, our emphasis).

The highlighted part of the passage quoted above traces a relationship between the notions of *reconceptualization* and of *imagining a future*. We have already seen above that the idea of imagining what the future *could* be like is part of Neurath's scientific utopianism. We also mentioned that Neurath's utopias can be understood as part of thought experimentation processes, which precisely promote reconceptualization, that is, the reorganization of scientific concepts to deal with possible situations that were not originally foreseen in the theories. We will now see how the economic expertise mentioned by Gross entered the German political debate of the 1980s and we will develop our description of the process based on Neurath's methodological proposal.

3. The Commission on Future Nuclear Energy Policy

Since the early 1970s, the German Parliament has organized commissions, called *Enquete-Kommissionen*, which bring together parliamentarians and experts to discuss a wide range of controversial and relevant issues for the country's politics. The aim is to balance the different interest groups in society and reach agreement on guidelines for future decisions by the Parliament.

[4] We can mention an example of achievement by grassroots anti-nuclear environmental movements in Austria. In 1978, the Austrian government reacted to ongoing vocal protest by holding the countries first ever referendum, in which citizens were asked whether they approved a law that allowed the peaceful use of atomic energy, in particular with regard to the activation of the country's first nuclear power plant, newly built in the township Zwentendorf. Quite surprisingly at the time, the result of the popular consultation was negative, with 50,5% of voters choosing to reject the new law. Until this day, there have never been operating nuclear power plants in Austria. This event shows that environmental pressure was present in other countries in the region, even without the differential of the presence of the green movement among the elected representatives of the population.

In 1979, in the face of crises in the energy sector and intense popular demonstrations against nuclear energy, which until then was widely regarded as the optimal alternative to fossil fuels, Parliament designated the *Enquete-Kommission* on Future Nuclear Energy Policy [*Zukünftige Kernenergie-Politik*] (Bundestag s/d).[5] The commission was composed of seven parliamentarians, four representing the coalition of the Social Democratic Party (SPD) with the Liberal Democratic Party (FDP), the group that was in power at the time, and three representing the coalition of Christian Democratic Union (CDU) with Christian Social Union (CSU), the opposition group. Alongside

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these, the commission brought together eight specialists: three researchers in the area of nuclear physics, two of them working in universities and one working in industry; two researchers on environmental issues; a researcher in the field of economics, specializing in energy issues; a representative of the German trade union federation; and a philosopher-physicist, Klaus Michael Meyer-Abich, whom we shall discuss below (cf. Enquete-Kommission 1980, p. 4)

According to Gross (2017, p. 540), this plural composition meant that the issues raised by the commission "drew directly on the new paradigm, thus giving the latter a new legitimacy". That is, the commission took the direction of those new economic ideas, which we talked about in the previous section, which promoted the conceptual change in the German scenario. Furthermore, as Gross continues, the commission did not limit itself to giving technical advice on whether or not to encourage the development of new atomic technologies, but also sought to make recommendations that take into account

> the effects that different energy technologies had on social life. And the criteria used to judge Germany's options included Meyer-Abich's concept of social compatibility alongside economic viability, compatibility with international norms, and environmental sustainability (Gross, 2017, p. 540; also see Enquete-Kommision, 1980, pp. 12-13).

[5] The immediate reason for the formation of the commission was the possibility of funding research to develop a new technology and build a new type of nuclear reactor, the *Fast Breeder Reactor*, which would be more efficient in the production of energy, using less atomic fuel and, consequently, producing less pollutants; however, even with these promises, not much was known about the safety of this technology, which contributed to the escalation of anti-nuclear protests. Faced with the uncertain situation, the Parliament appointed the commission to investigate the pros and cons of the reactor. However, due to the political climate at the time, with the strengthening of environmental groups, the investigation was expanded "to include the effect of energy technology on society in general" (Gross 2017, p. 540).

The commission was active until 1983, producing three reports and making recommendations to the Parliament. The aspect to which we would like to draw attention here is that the most important part of the commission's work was the elaboration, simulation and discussion of four economic-energy scenarios and their comparison in projections for fifty years (from 1980 to 2030). Interestingly, "[The] objective was to make clear the underlying premises and consequences of the scenarios" (Conrad, 1982, p. 246), not to choose a specific scenario, as we shall see. In a nutshell, the four scenarios are:[6]

(C1) A first scenario envisaged the maintenance of economic growth rates through a strong expansion of the use of nuclear energy and the maintenance of the availability of energy from fossil fuels. This scenario was just the continuation of the country's economic and energy matrix at the time and, therefore, it was called the "'official' scenario".

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(C2) The second scenario envisaged a moderate reduction in economic growth rates, introducing energy conservation measures and reducing the use of fossil fuels, but, at the same time, moderately expanding the use of nuclear energy.

(C3) The third scenario foresaw a radical change in the economic structure, increasing the importance of the service sector without increasing the role of basic industry; the rate of economic growth would have the same moderate reduction as (C2) by introducing energy conservation measures and shutting down nuclear power plants by the year 2000.

(C4) The fourth scenario predicted the reduced economic growth rates of (C2) and the major structural change of the (C3) economy, leveraging the maximum use of renewable energy sources, strongly reducing the use of fossil fuels and deactivating nuclear plants as soon as possible.

The four scenarios developed by the *Enquete-Kommission* can be considered Neurathian utopias in the sense discussed in this text because they are counterfactual models that relate a plurality of aspects, forming what Neurath called *Ballungen*. That is, the scenarios cross data and extrapolate information from different sources, describing an aggregate of interconnected possibilities: while the scenarios emphasize the energy issue, proposing transformations in this

[6] This presentation of the four scenarios is adapted from the abridged version by Conrad (1982). The full version can be found in the first report of the *Enquete-Kommission* (1980, pp. 37-50). There is also a presentation and discussion by Meyer-Abich (1981). Gross (2017) also presents the four scenarios in a contemporary perspective.

domain, they point out consequences in other domains, such as the structure of the economy of the country, which can be carried out by industry or services. The discussion took into account that the economic structure has implications for the job supply in the country, which attests to the importance of also considering demographic characteristics, such as age group and level of education, as well as the population's lifestyle.[7] To be able to estimate these implications and

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consequences as objectively as possible, the commission used state-of-the-art computer simulation techniques, which was a major novelty in the late 1970s and early 1980s (cf. Gross, 2017, pp. 525-527).

Thus, we notice that the *Enquete-Kommission* elaborated scenarios that project what the future of the country could be like. In addition, the commission developed the consequences and implications of each of these scenarios in a variety of domains, projecting the proposed paths 50 years into the future using the best available technical efforts. And these scenarios, with their consequences and implications, were submitted to the discussion and evaluation of the population (supposedly) represented in a democratic way, firstly within the commission itself, whose composition reflected that of the German Parliament at the time, alongside experts considered relevant to the topic. At this stage, as mentioned above, the adequacy of the four paths was considered according to four criteria, or values, chosen by the commission: (Ka) economic growth, (Kb) compatibility with international norms and conventions, (Kc) environmental compatibility and (Kd) social compatibility. A considerable part, almost half of the 200 pages of the commission's first report (cf. Enquete-Kommission 1980) discussed precisely the adequacy of each scenario in relation to these values.

The committee considered that a balance between these values was desirable and, therefore, suggested discarding the first scenario (C1), considering that it consumed too much energy and excessively valued the value (Ka) of economic growth, practically disregarding the

[7] All scenarios predicted a population reduction in West Germany, as the fertility rate was decreasing. The scenarios also predicted an increase in electricity consumption in households, as people would acquire new appliances. These two assumptions seemed plausible in the early 1980s, but today they seem like predictions that missed the mark, as the trend is for population growth as life expectancy increases, and for household electricity consumption to decline as more efficient consumer electronics are available on the market. This does not take away the value of the reasoning developed from the comparison of scenarios, but only shows that such scenarios have the character of *models*, with simplifications, idealizations, abstractions and *ceteris paribus* conditions. The most recent conclusions on the subject (cf. Cartwright 1999; Elgin 2022) indicate that it is precisely by presenting these simplifications, idealizations, abstractions and special conditions that the models allow scientists to develop their reasoning, paying attention to what theories consider most fundamental in the analyzed system and understanding the relationship of such system with the contingencies of its operation. In other words, it is by dealing with the very counterfactuality of the models that scientists are able to extract indications for dealing with the empirical world (cf. also Dutra 2021; Cani 2022). Cunha (2015) shows that Neurath's utopias can be taken as models in this sense that we are using.

other three values. The commission also suggested discarding the fourth scenario (C4), as it seemed to represent too radical a change for German society, which would have to undergo many transformations in a short time, strongly impacting both production and the labor market, and thus, unbalancing the values (Ka) of economic growth and (Kd) of social compatibility (cf. Gross 2017, p. 540). In view of this, the commission reached a recommendation to the Parliament, suggesting that there be a mediation between the two intermediate scenarios (C2) and (C3) (cf. Enquete-Kommission 1980, p. 100). The difference between the two lies in the progressive or regressive use of nuclear energy (cf. Meyer-Abich & Schefold 1981). The commission suggests in its report that the Parliament encourage more research into the feasibility and risks of advances in this area and that it postpone the decision on whether to advance or reduce the use

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and development of nuclear reactors until 1990 (Gross, 2017, p. 540; Enquete-Kommission, 1982; 1983).

4. Appeal to Imagination

To determine that the balance between the four criteria or values was desirable, the contribution of Klaus Meyer-Abich seems to have been fundamental (cf. Gross 2017). As mentioned above, Meyer-Abich was a member of the commission and had a background in physics and philosophy. He was a Professor of "Natural Philosophy" at the University of Essen, Germany (Enquete-Kommission 1980, p. 4). While serving on the commission, Meyer-Abich, in partnership with economist Bertram Schefold, wrote the book *Wie möchten wir in Zukunft leben* (Meyer-Abich & Schefold 1981), in which the commission's proposals are presented to a wider academic audience, explaining the technical issues and discussions in order to enable dialogue with different audiences. We will deal with one of the chapters of this book, entitled "Energiepolitik", written by Meyer-Abich (1981), in which we find a defense of the importance of the criterion of social compatibility.[8]

[8] The social compatibility criterion [*Sozialverträglichkeit*] as a tool for evaluating proposals for social and economic development had been developed by Meyer-Abich himself a few years earlier (cf. Meyer-Abich 1978; cf. also Meyer-Abich & Dickler 1982). It is interesting to note that Meyer-Abich had already discussed the value of social compatibility in an article published in the journal *Evangelische Theologie*, "Evangelical Theology", in a special issue devoted to the issue of the energy crisis (Meyer-Abich 1979). The organizer of the special issue, Günter Altner, was, like Meyer-Abich, a member of the *Enquete-Kommission* on Future Nuclear Energy Policy, as a researcher in the field of biology and ecology (Enquete-Kommission 1980, p. 4). The question was of interest to theology, according to Altner, who was also a Protestant theologian, for "the energy crisis […] has something to do with our dismay in the crisis of modern progress" and theology, by its professional duty, must contribute to what "gives hope in the hour of crisis, so that we can stand up against fear and destruction" (Altner 1979, p. 1). It is interesting to note

Meyer-Abich's idea is that economic planning cannot be guided only by the values of economic growth and environmental preservation: aspects of life in society and culture must be taken into account. To exemplify, he briefly mentions two perspectives that we can characterize as *dystopian*. The first represents the fear, on the part of critics of the use of nuclear energy, that the safety of the power plants could only be guaranteed in the long term by the strength of certain institutions. The use of nuclear energy depends, for example, on reputable administrators who do not try to economize on safety issues, as well as on good professionals in the

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fields of physics and engineering, trained in good universities. The concern is that the need to ensure that these and other institutions have a long life could eventually lead to "a strengthening of authoritarian structures at the expense of the free social order, even leading to a police state" (Meyer-Abich 1981, p. 97). The second dystopian perspective that Meyer-Abich mentions is at the opposite extreme: if, in the name of energy conservation or the use of renewable energy sources, we completely abandon the use of nuclear energy, we run the risk of moving towards a dirigistic state, which controls the smallest aspects of energy consumption and, consequently, of people's lives. This is because the German energy matrix at the time was not able to meet the demand of the population and industry without the use of nuclear energy.[9] In an ironic tone, Meyer-Abich speaks of "block inspectors, [who] take care so that no one overuses the heater" (Meyer-Abich, 1981, p. 97).

By making us imagine these exaggerated consequences, Meyer-Abich is raising the question that there is an inadequacy in the two extreme scenarios presented – (C1), in which the existing energy matrix at the time is maintained, and (C4), in which the use of nuclear energy is immediately abandoned. This inadequacy is due to the incompatibility of these scenarios in relation to the way of life of people in Germany (or in Europe and the West as a whole), who tend to reject direct and authoritarian measures, and to cherish individual freedoms. The values of economic growth and environmental compatibility, if taken in an absolute way, seem to generate a polarization, a tendency to extreme situations incompatible with culture and life in society as we know it. As Meyer-Abich argues, it is necessary to add a value, a criterion that contemplates this perspective that there is an effort on the part of society to implement a scenario. An estimate of this effort is what he calls social compatibility.

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that the discussion about the energy crisis was taking place in several sectors of society and also, as pointed out by Gross (2017), that the new ecological-economic knowledge was spreading through these various sectors, including a cocern for the issue of the criteria to evaluate the scenarios that unfolded brought forward by Meyer-Abich.

9 Even today, as can be seen in the current energy crisis, after phasing off most of its nuclear reactors, Germany is still unable to maintain itself exclusively with renewable energy sources, depending on the import of fossil fuels.

This estimate, however, should not be understood as a purely quantitative measure. In the words of Meyer-Abich (1981, p. 99), “quantifications are not, as a rule, possible, since social relations are only very imperfectly described by social indicators – at least in the current development of efforts in the social sciences”. However, he defends the importance of this qualitative criterion for evaluating scenarios, saying that “‘only qualitative’ answers to the right questions are

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anyway more useful than quantitative answers to wrong or uninteresting questions” (Meyer-Abich 1981, p. 99). With this, the author is advocating that the evaluation of scenarios be made based on not only more varied criteria, but also with a greater degree of complexity, also including values that are not so easily measured in a quantitative way. We note, therefore, that this concept should not replace the others, but complement them – just like the criterion of compatibility with international norms and conventions.

In this exposition it is clear that Meyer-Abich appeals to the imagination of his audience to argue against the initiative of evaluating scenarios only in terms of economic growth and environmental compatibility. He invites his readers to imagine extreme situations arising from scenarios (C1) and (C4). While it is debatable whether he proposes a typical thought experiment, given that he is not so dedicated to developing a narrative to describe these scenarios, it is certain that his argument depends on an imaginative effort. Furthermore, the argumentative structure can be described in the way proposed by Linsbichler & da Cunha (2023) for thought experiments (involving Neurathian utopias). According to this conception, a (utopian) thought experiment can be rationally reconstructed as an argument that attests the inconsistency of a set of sentences $\{T, \Diamond C, T \rightarrow (C \Box\!\!\rightarrow W), C \Box\!\!\rightarrow \neg W\}$.[10] In our example, the elements of this set are:

(1) T: the current conception, that the criteria (Ka) and (Kc), respectively, of economic growth and environmental compatibility, are the only criteria to inform an assessment of the stability, adequacy and desirability of the scenarios.

(2) $\Diamond C$: a possible scenario. In this case, we have the four possible scenarios (C1)-(C4), which we can represent more fully as $\{\Diamond C1, \Diamond C2, \Diamond C3, \Diamond C4\}$.

[10] The template for the argument reconstructed from a thought experiment proposed by Linsbichler & da Cunha (2023), as the authors explain, is a reformulation of a template proposed by Häggqvist (2009). Instances of this argument are valid in usual counterfactual logics.

(3) T → (C □→ W): the statement, derivable from the current conception T, that if any of the scenarios were implemented, we would have a situation that we consider adequate, a stable social order. In this case, the

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current [conception] T leads us to choose either (C1) or (C4), that is, either a scenario that maximizes the value of economic growth or a scenario that maximizes the value of environmental compatibility, leaving aside (C2) and (C3). According to the current conception T, in this way, both (C1) and (C4), if implemented, could lead us to a stable, adequate, desirable social order, which we express with W, in the form T → ((C1 ∨ C4) □→ W).[11]

(4) C □→ ¬W: at the key point of his argument, Meyer-Abich leads us to imagine that if one of the scenarios (C1) or (C4) were implemented, we would reach a situation where there is an increase in state control about society and culture, which contradicts the ideal of an adequate society expressed in W. Thus, representing with D the increase in state control over society and culture, the argument makes us realize that (C1 ∨ C4) □→ D and also that D → ¬W.

That is, Meyer-Abich's argument can be formulated in a version of the Linsbichler & da Cunha (2023) template, that is, as an argument that highlights the inconsistency of the set {T, {◊C1, ◊C2, ◊C3, ◊C4}, T → ((C1 ∨ C4) □→ W), (C1 ∨ C4) □→ ¬W}. For a strong enough logic of counterfactuals, such as *VCA*, the formula ¬(T ∧ ◊C1 ∧ ◊C2 ∧ ◊C3 ∧ ◊C4 ∧ (T → ((C1 ∨ C4) □→ W)) ∧ ((C1 ∨ C4) □→ ¬W)) is indeed valid and provable.[12] Faced with this inconsistency, a decision must be made to reject one of the four elements of the set. Meyer-Abich's suggestion, as we have seen, is for us to abandon the current concept T and adopt a more comprehensive concept of criteria to guide the implementation of some of the economic-energy scenarios, say, T', which includes the criterion of social compatibility (Kd). This broader conception T' would lead us to choose either (C2) or (C3), scenarios that, if applied, as far as

[11] We understand that (C1) leads to a different social order from (C4), since the first scenario values economic development and the second values environmental compatibility. However, it is possible to affirm that the current conception T considers that both social orders are W, that is, stable, adequate, desirable.

[12] For logics of counterfactuals, cf. Lewis (1973), Girlando et al. (2017), Girlando et al. (2022). Given the input '-(t and (-(false<c) and -(false<b)) and ((false<(b or c)) or (((b or c) and w) <(b or c))) and (t-> ((false<(b or c)) or (((b or c) and -w) <(b or c)))))', the online theorem prover tuCLEVER (http://193.51.60.97:8000/tuclever/) confirms the validity of the formula in the logic VCA. For a syntactic proof, see the suplementary document to the online version of this essay. Similarly, the VCA-inconsistency of the four elements of Häggqvist's original template can be proved, as stated in Linsbichler & da Cunha (2023).

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we know at the moment, would not necessarily lead to an increase in state control, expressed in D, and thus avoid ¬W.[13]

5. Science, Imagination and Activism

In the article "Energiepolitik", which we are discussing, Meyer-Abich also develops a reflection on the relationship between science and politics. He states that in the social sciences, "the point of view is sometimes taken that scientists are not responsible for evaluations and that, therefore, they can only carry out opinion polls, […] empirical surveys on the evaluation of fact by populations" (Meyer-Abich 1981, p. 99). At this point, the author is discussing the separation between facts and values in the social sciences, the perspective that scientists should stick to facts and refrain from evaluative judgments. However, he argues, if we take this restriction too far, we run the risk of "ignoring an important contribution of science to the formation of political opinion" (Meyer-Abich 1981, p. 99). The point is that the criteria or values by which the proposed scenarios are judged relate to a plurality of broader social objectives, so that it is not possible to categorically state that a given proposal is or is not acceptable or adequate. What can be done, strictly factually, is to show that a proposal *may be* or *may not be* compatible with certain previously established objectives. Thus, in the words of Meyer-Abich (1981, p. 100), someone seeking a particular political or economic development "can, by assessing social compatibility, learn which political-technological decision is consistent or inconsistent with the desired development". Policy decisions, in this way, can benefit from what Meyer-Abich calls a "catalog of implications", which factually indicate the compatibility of proposed scenarios in relation to determined objectives. Political discussion can develop from this scientific basis.

Thus, we notice that, in proposing the criterion or value of social compatibility to guide the political discussion on the four scenarios proposed by the commission, Meyer-Abich is not leaving behind his role as a scientist

[13] Meyer-Abich's suggestion is to reject element (1). As Linsbichler & da Cunha (2023) show us, other decisions are possible in light of this argument. It would be possible, for example, to deny that scenarios (C1) and (C4), if implemented, would necessarily imply (D), the increase of state control. Another possibility would be to assume that increasing state control over society and culture is worthwhile, considering the benefits of scenarios (C1) or (C4), thus rejecting the implication of ¬W as an implication. Another option would be to reject the possibility of the scenarios presented.

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and crossing the border towards activism. He is actually verifying that certain social objectives are not being contemplated by the current criteria. By proposing to add a new evaluation criterion, he is proposing an expansion of the catalog of implications of each of the scenarios, providing more data to the people who will make the relevant decisions. As a scientist, he shows what those implications are, compares them with the goals set, and indicates which scenarios lead to which paths. By developing this "catalog of implications", the commission, with its plurality of members, provides information for the Parliament to take a decision. This description fully matches the scientific utopianism or comparative utopianism that Neurath proposes, as described briefly at the beginning of the text.

As an activist, on the other hand, Meyer-Abich had his own inclinations: he was active in the environmental cause, opposing the use of nuclear energy. But we note that his recommendation as a scientist is to be cautious in abandoning atomic sources of energy, taking into account precisely the goals of society.[14] As Gross (2017, pp. 540-543) points out, the work of Meyer-Abich and his group had great influence in an ideological turn in the German Social Democratic Party (SPD): this party feared that the energy transition could cause mass unemployment, perceiving an incompatibility between the labor cause, the party's traditional objective, and the environmental cause. Meyer-Abich's argument, in inviting us to imagine a more comprehensive set of criteria, including social compatibility, was well received by the SPD. This ideological turn has opened the way for dialogues with environmental groups and for future coalitions with the German Green Party. In particular, this coalition governed the country between 1998 and 2005, when the gradual phase-out of nuclear reactors was finally put into practice,[15] taking a decisive step towards establishing the decoupling of economic growth and energy consumption as an objective for the future.

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6. Concluding Remarks

[14] It is reasonable to assume that the other scientists and technicians who were part of the commission also had their political leanings, as did, obviously, the parliamentarians who were part of the group representing the fractions of the government. In theory, this plural composition should reduce the risk of bias in the elaboration of the catalog of implications.

[15] The theme is recalled today, when voices appear in the German Parliament and society in general proposing the restart of some reactors or that the shutdown of those that are still in operation be postponed (cf. Reiber 2022). Critics of the *Energiewende* e.g. argue that a reduction of the use of fossil fuels in Germany merely leads to price reductions on the world market. Consequently, overall consumption remains steady while Germany hampers its own economy, consumers, and tax-payers.

In this essay, we present the work of the *Enquete-Kommission* on Future Nuclear Energy Policy and, more specifically, the work of Klaus Meyer-Abich in that commission, reconstructed in the form of an example of Otto Neurath's methodological proposal for social science and technology. If our argument has been successful, we can consider that the economic-energy scenarios elaborated by the commission can be understood as utopias in the Neurathian sense, that is, as models that bring together a plurality of aspects from a variety of domains in order to stimulate our imagination about what the future might look like. In addition to having developed these ecological-economic models, we saw that the *Enquete-Kommission* also developed, discussed and compared these scenarios having as parameters four criteria or values that represented the sociopolitical objectives and interests at stake at the time. This discussion of the adequacy of the models to the values provided knowledge for the commission to carry out a comparison between the different scenarios, in what can be described in Neurath's proposal as comparative utopianism. The commission's first report shows how each scenario contributes to achieving economic growth, compliance with international conventions, environmental compatibility, and social compatibility. Finally, the commission presented its work publicly,[16] making a recommendation to the Parliament, that is, to the body responsible for taking the relevant decisions.

In this process of developing utopian models and discussing their adequacy to facilitate comparisons of adequacy relative to given values, we find the elements of the characterization made by Stephen Gross (2017): the discussion

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explored new ways in which economy, energy and ecology could be related and, thus, helped the people involved to imagine possibilities for the future of their society. By expanding the data and knowledge on the subject, the commission allowed the political positions involved to become clear:

[16] It is possible to sketch a Neurath-inspired critique of the work developed by the commission with regard to the presentation or dissemination of the data obtained. Although the discussion was clearly democratic, with representatives of the ruling and opposition parties, as well as other influential groups, such as industry and environmental movements, we can question whether the discussion was not restricted to a relatively small group. It is also true that the members of the commission sought to take the debate to broader academic circles, as well as the grassroots movements they represented. Even so, it is reasonable to assume that Neurath would have advocated a more didactic dissemination of the works: For instance, Neurath devoted much of his career to the development of a pictorial language, called ISOTYPE, to express statistical data and other socioeconomic relationships. Neurath's objective was to promote the education of a large part of the population that often does not have the time or conditions to inform themselves about sociological and economic data that are relevant to their daily lives and to participate more actively in political decisions (cf. Neurath 1996; Burke, Kindel & Walker 2013; Nemeth 2019). Our impression is that, from Neurath's point of view, a greater effort should have been made to take the discussion to more sectors of society. For Neurath, the main addressee of the social scientific knowledge obtained by thought experimenting should be the general public, not politicians. The development of this discussion exceeds the possibilities of this text (see e.g. Linsbichler 2023 for the contrast between Neurath and Tinbergen on the role of experts).

it was possible to imagine which scenario would have which impact on the job market, the environment, industry, etc. – in fact, as we have seen, the commission's conclusion was that scenarios (C1) and (C4) could be discarded, but that more knowledge was needed so that the debate on (C2) and (C3) could be more effective; hence the recommendation that the decision on the use of nuclear energy be postponed for another decade.

We also saw, particularly in the work of Meyer-Abich, that an imaginative effort is fundamental in this methodological proposal, since it is by imagining the future that we are able to think about whether a scenario will have the impacts that we would like or would not like it to have. Meyer-Abich adopts an argumentative framework that can be reconstructed in the same way as the thought experiments characteristic of Neurath's utopias. This imaginative effort promotes a connection between the development of *facts* relevant to each of the proposed scenarios, scientifically obtained, and the *values* that guide the political discussion. The gap between facts, between what is the case, on the one hand, and values, what shall be the case, remains: there must be no conflation between the two domains. However, the technological discussion needs to trace relations between the two and Neurath's methodology of scientific utopianism allows us to understand these relations. The methodology proposed by Neurath, as we saw in the example we built from Meyer-Abich's argument, also helps us to understand the role of policy in scientific and technological research: scientific reasoning leaves open the space for decisions; thus, political agents need (ideally) to be aware of their role and to make the appropriate decisions in a responsible and well-informed manner.

It is interesting to note, moreover, that the example highlights an important characteristic of Neurath's scientific utopianism, namely that such a methodology allows for a reflexive reconstruction of the very criteria initially adopted to judge the scenarios. As discussed by Linsbichler & da Cunha (2023), Neurath's methodological proposal allows a community not only to debate which possible scenario seems most appropriate, but also allows a reflection on what the community itself understands about the adequacy of a scenario. In our example, we saw precisely that Meyer-Abich used imaginative exercises to show that we need the value of

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social compatibility. That is, the very reasoning to which Meyer-Abich led us indicated that our choice should not be guided exclusively by the criteria of economic development and environmental compatibility.

By understanding the work of the *Enquete-Kommission* in terms of Neurath's methodology, we notice that the plural character of scientific knowledge has been preserved,

something that Neurath emphasized as a way of acknowledging the need for political decisions based on scientific knowledge: if knowledge does not necessarily imply a specific decision, so, however informed, that decision is due to political agents. At the same time, when articulating the example, we noticed that Neurath's methodological perspective protects the political dimension from technology, which cannot be seen as mere applied science: if the implementation of technology, particularly social technologies, were a mere application of scientific knowledge, there would not be so much room for political decisions.

With this discussion, we realize that plural scientific research, focusing not only on technical-economic, but also on ecological and social issues, was able to contribute to the development of Germany, which, as mentioned above, is on the way to becoming a superpower fueled by clean and renewable energy. Of course, as in any utopia, the established order is maintained by a very delicate balance, so that new developments can bring the risk of a dystopia. This risk seems to have appeared on Germany's horizon, as the country ended up dependent on the importation of fossil fuels and now finds itself in an uncomfortable situation in the face of Russian imperialist policy.[17]

This does not invalidate the scientific and technological methodology that we present; on the contrary, we have the opportunity to notice that Neurath was right in comparing us to sailors who need to rebuild their boat while sailing on the open sea. Utopias are plans to rebuild the ship, plans that are being implemented with the materials we have at our disposal. As Neurath (1944/1970, p. 47) says, "a new ship grows out of the old one, step by step – and while they are still building, the sailors may already be thinking of a new structure […]". If the storms we are facing require other plans, another structure for our ship, perhaps it is time to rethink or readapt our utopias. Science, conceived in a plural way and taking into account the demands of society, is fully capable of serving this objective once again.

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[17] See also footnote 15.

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Anexo