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Analysis of a controversial decision process: The case of the pumped hydro storage power plant Atdorf in Germany

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Analysis of a controversial decision process: The case of the pumped hydro storage power plant Atdorf in Germany ¹

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Abstract:

A main problem of Renewable Energy Sources (RES) as solar and wind energy, which represent a main pillar of the German energy transition, is that they cannot supply constant power output leading to an increasing demand of backup technologies as pumped hydro storage. This study analyses in the first part the controversial large scale PHS project Atdorf in Germany. On the one hand this project is seen as a prerequisite for a successful energy system transition by the German government. On the other hand there is also a strong local movement opposing the project mainly due to environmental concerns. It is a difficult tightrope walk to immolate to a certain degree local interests of a few to achieve an ostensible higher goal as a sustainable energy system. Simultaneously an interpretative phenomenological analysis (IPA) orientated approach was conducted to understand the interest of the multi-stakeholders involved in this controversial case and contributed to the development of the story viewed by the ones living it. The IPA was conducted in detail for the citizen action group “Bürgerinitiative (BI) Atdorf) and offered the possibility to gather unexpected insight into the entire decision process. The Atdorf project remains in this sense very controversial and unveils several problems allocated to the entire process of the energy transition in Germany. It highlights how large infrastructural energy projects can become complex due to multiple stakeholder perspectives, beliefs and interests. The example of Atdorf was then used as a base to

¹ Based on the report for the unit “Métodos Interactivos de Participação e Decisão A” (Interactive methods of participation and decision A), coordinated by Prof. Lia Maldonado Teles de Vasconcelos and Prof. Nuno Miguel Ribeiro Videira Costa. This unit was provided for the PhD Program in Technology Assessment in 2015/2016.

build a hypothesis for a dynamic behaviour model of the ongoing decision process. It could be concluded that the project is stagnating due to uncertain market conditions caused by increasing shares of public financed RES, missing regulation and clear targets in combination with local protests. This general model was used to develop a qualitative system dynamics model, illustrated by a causal loop diagram (CLD). Aim of the CLD was to identify leverage points that lead to incentives for new energy storage technologies and allow the achievement of a renewable energy based electricity system. Three leverage points have been identified; 1) amount of Renewable energy which is influencing almost all other components of the system including markets, need for balancing, investment decisions etc. 2) development and the composition of electricity whole sale markets have to be adopted including EU-Emission trading system to avoid backfire effects; 3) higher level of coordination of energy policies, regulation and related targets to provide a better frame for decisions. The identified points could be confirmed via interviews conducted with experts from energy economics. Most participants concluded that there is a severe market problem at the moment facing a high acceptance problem regarding large pumped hydro storage projects. In general the conducted research helped to gather a better understanding of complex decision making processes and unveiled the importance of right communication within large infrastructural projects as Atdorf.

Keywords: Renewable Energy, energy policies, energy transition, Germany

JEL code: D74, D81, O25

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1 Introduction

Scarcity of fuels, changes in environmental policy and in society increased the interest in generating electric energy from renewable energy sources (RES) for a sustainable energy supply in the future [1]. This is also the case for Germany which has ambitious targets to produce 35 % of the needed electricity from RES by 2020 and over 80 % by 2050 within the so called “Energiewende” (energy transition) [2].

The main problem of RES as solar and wind energy, which represent a main pillar of this transition, is that they cannot supply constant power output. This can lead to temporary capacity problems regarding the high amount of fluctuating energy sources resulting inter alia in an increased demand of backup technologies as energy storage, demand side response and other technologies to assure electricity system safety [3]. Especially energy storage is an option that is highly publicly discussed. Electric Energy Storage is a process for converting electrical energy into a form that can be stored and later be converted back to electrical energy when needed [4]. Energy storage technologies can generally be divided into mechanical, electrical, thermal and chemical systems as well as hybrid systems. It represents an enabling technology which improves the remaining electricity system, consistent of RES, grid infrastructure, residential power generation, power plants and regulation. Vice versa it is dependent on other energy system developments (markets development, RES-share, policies etc.) as well dynamics and do not represent a separately identifiable dominant system [5].

This study focusses on pumped hydro storage technology (PHS). In general PHS consists of two superficial water reservoirs situated in different altitudes connected by a penstock. Usually during off-peak times (low electricity price phases), pumps are used to move water from the lower to the upper basin to be able to release it to the lower reservoir during off-peak times (low electricity periods, usually at night) driving Pelton turbines connected to a generator in the same way as in conventional hydro plants [6].

On the one hand PHS is the only commercial and economic viable available large scale storage technology available nowadays. On the other hand there are several issues related to this technology as e.g. nature conservation in legal senses or uncertain electricity market developments. PHS are additionally often opposed by local residents for a plenty of reasons as the past has proven e.g. in the case of Ried, the Blautal and Atdorf. These cases have shown that local pressure groups can be a main reason for investors to cancel big projects and that they are a serious factor for project planning in Germany within the planned energy transition. A prominent example is e.g. the 1.6 GW coal power plant in Ensdorf Germany which was stopped after local protests.

This type of local resistance is often related to the “Not in my back yard –NIMBY” phenomenon which also occurs for socially wanted as well as sustainable considered projects, as it has been extensively studied in On- and Off-shore wind power [6]. There is a high resistance of the local population through the so called “Wutbürger” (Angry citizen) against large scale projects in Germany leading to the necessity to implement new forms of conflict solving mechanisms to anticipate potential conflicts [7].

This study analyses in the first part the controversial large scale PHS project Atdorf in Germany, to highlight how large infrastructural energy projects can become complex due to multiple stakeholders perspectives, beliefs and interests and how potential local resistance can lead to severe delay or even

cancellation of energy storage projects perceived as necessary to assure a safe energy supply in the future German energy system.

The results obtained from this specific case are then used for generalization to develop a conceptual and qualitative causal loop model to better understand and to identify what variables influence the development of energy storage technologies in general. The conclusion shall then provide potential leverage points that can lead to successful project realization.

2 Case study: The Atdorf Project

The study refers to the largest pumped hydro storage power plant project (PHSPP) Atdorf in the State of Baden-Württemberg in Germany nearby the Swiss border. The project location is situated in the forested mountain range called black forest (Schwarzwald), which is well known for its extensive hiking and cycleway networks. The entire region is also situated in the seismic zone of the Rhine where small earthquakes can be observed yearly [8]. The project received a high attention in media when first demonstration of local citizens in Bad-Säckingen, Herrischried and Rickenbach began. The entire region is well known for tourism but did not gain much attention in media until the project was announced in 2008.



Figure 1: Location of the Atdorf pumpe hydro project in Germany/Baden Württemberg in the national park of the Blackforest (source: Google maps 2015)

The project was initiated by the Schluchseewerk AG, a company owned by two of biggest utilities in Germany (Energie Bades-Württemberg -EnBW 37.5 % share and the Rheinisch-Westfälisches Elektrizitätswerk AG - RWE 50 % share). The company Schluchseewerke AG owns following assets; 5 PHS facilities and two running hydro power stations [9]. The PHSPPA was planned with an output capacity of 1.400 MW and a storage volume of 13 GWh [10]. This represents about 32 % of the storage capacities available in Germany nowadays [11]. Predicted project volume is 1.7 billion Euros [9]. The project includes an artificial upper reservoir and a lower basin located in a valley about 10 km away. Both are situated in areas that are not protected regarding the habitants directive and might be affected during the construction. The upper basin requires an area of 0.6 km² and the lower basin about 0.5 km permanently [12]. Penstock and machines are planned to be situated in underground structures [6]. The project plans were published in September 2008, planning phase ended last year, it was planned to start construction in 2015 to 2019 [7].

2.1 Stakeholder analysis

The following chapters give an overview of the applied methodology of the research, the history of the Atdorf project and the related positioning, conflict and interests of the stakeholders involved.

2.1.1 Methodology: Actors, positioning & structuring of the process

The identification of stakeholders involved in this controversial infrastructure project was realized through a comprehensive literature and internet review using on the one hand non-scientific articles in newspapers, blogs, civil society websites and on the other hand scientific and business reports from project executing organizations somehow following [13]. First uncoordinated search attempts were realized by using general terms as “energy storage”, “resistance” and “controversial” in an internet search engine which unveiled the complexity and controversy of the ongoing discussion of the project in scope of this research. A first step was thus to systemize the approach was done by defining:

- actor positions obtained within the entire planning process (pro or contra)
- reason of positioning (drivers, interests and perceptions)
- setting of relation of actors to each other
- a chronological structure
- measures of communication

After defining the named points an interpretative phenomenological analysis is carried (IPA) out for one specific stakeholder group (the citizen action group BI Atdorf – which is introduced in a latter point). The IPA aims to understand the experiences of involved actors out of their perspective. It has to be mentioned that the interpretation of this experiences are highly dependent of the conducting researcher perspective. The conducted IPA follows socio scientific hermeneutics. This IPA is focused on the analysis of texts, in this case newspaper, articles, blogs and other non-scientific sources which are structured in the named way above. It (IPA) enables then to analyze syntax, grammar and related pragmatics. The optimum result is to understand and explain certain societal phenomena related to structural problems of involved actors [14].

The uncoordinated research was firstly structured by a mind map and was then transferred in a table including the named points (table 1). It can be said that attention of media was very high on a regional level (247 in the “Südkurier”, 545 articles in the “Badische Zeitung”), whilst national newspapers as the “Süddeutsche Zeitung” published about 86 articles [7]. A brief overview of actors and their positionings is given in the figure 2 and the following paragraph.

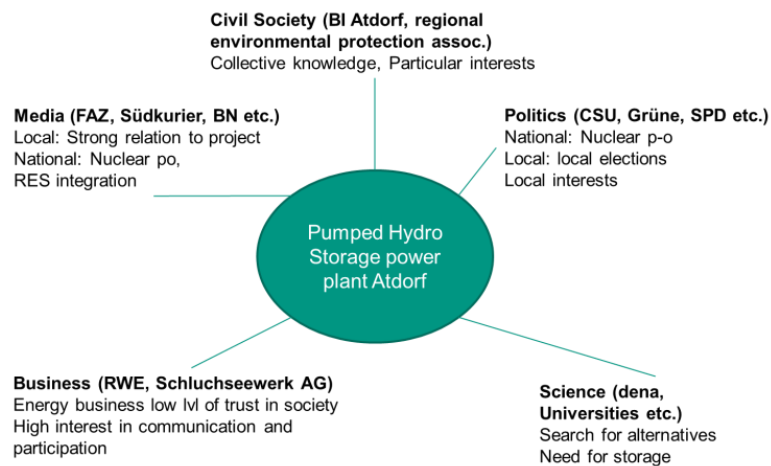


Figure 2: Overview of different Stakeholder groups (inspired by [7])

Other stakeholders, e.g. involved companies and regulation agencies required a more distinct search to understand certain positions in this complex conflict. The research had to be adopted in this case by using more distinct search terms. Most results were then related to the major shareholders of the Schluchseewerk AG, the two big utilities in Germany (EnBW and RWE). However it is not possible to include all positioning and interests related to Atdorf thus a focus on major events and the two most opposing groups, the Schluchseewerk AG and the citizen action group BI Atdorf, is given. A comprehensive analysis of all stakeholder found to be relevant including their positions, interests and most striking citations is given in the Annex.

2.2 History of the process

A better understanding of the single positions can be given by analysing the history of the entire process which is given in the following.

2.2.1 Renewables energy policy targets and measures

An ubiquity, highly reliable, sustainable and cheap availableness of electric energy is a precondition for economic productivity and life standard of a society. Therefore the EU aims to increase the share of renewable energy sources (RES) to assure security and diversification of energy supply, environmental protection and social and economic cohesion. A first step was done with the Directive 2001/77/EC of the European Parliament and of the Council of 27 September 2001 on the promotion of electricity from renewable energy sources (non-fossil renewable energy sources such as wind, solar, geothermal, wave, tidal, hydroelectric, biomass, landfill gas, sewage treatment gas and biogas) in the internal European electricity market [31]. Germany aims to produce 35 % of the needed electricity from renewable energy systems by 2020 and over 80 % up to 100 % by 2050 within the so called "Energiewende" - Energy transition [2] which is flanked by the German government. Within this transition solar and wind energy are the most promising technologies among other renewable energy systems providing about 75 % of the required energy in 2050 [32].

The high amount of fluctuating energy sources represents a technical challenge for the German electricity supply system. Stochastic energy productions fluctuations can lead inter alia to temporary capacity problems due to limited correlation of load and generation. This comes especially true for a future energy system with an increasing share of RES and less possibilities to balance these with conventional power plants [33]. This can cause blackouts if the gaps are not filled by suitable backup technologies as energy storage technologies. [34] and [28] report that the need for economic viable storage capacities could be > 15 GW of in 2040. However, it is clear that energy storage will play an important role in the future energy system. Thus PHS – as the Atdorf project are seen as a core technology to assure the success of the transformation of the energy system.

2.2.2 Public consultation and development of the process

The pumped hydro storage power plant Atdorf (PHSA) project was already presented by the Schluchseewerk AG in the early 70ies. It was initially planned to provide a possibility to increase the production rate of nuclear power plants by conducting load levelling² [35]. In 1976 the project was presented to the public resulting in massive local resistance of local citizen action and environmental groups leading to the cancellation of the plan. Still the main shareholder of the Schluchseewerk AG, the utility RWE announced in the late 70ies that they are still interested in realizing the Atdorf plans in a later point.

In 2008 the Schluchseewerk AG announced to pick up again the plans for the (PHSA) from the 70ies through its website [9]. The company and its main shareholders RWE and EnBW named the integration of renewable energy sources and the provision of grid services as motivation for reopening the project. The project was in a first step presented to a small council including the environmental minister of Baden Württemberg (BW), the regional council of Freiburg (the district town) and others groups from policy. The concrete planning was announced to be initialized in 2009. An official announcement or public consultation respectively including further local interest groups was planned by the Schluchseewerk AG for the 9th of October 2008 [36]. The project gained attention in the media which reported before the planned public consultation – that the Schluchsee AG is “secretly” planning a new “gigantic” PHS, with an upfront investment of 700 million € [37]. In spite of this announcement newspapers reported of the dimensions of the upper basin (0.9 to 1.1 km on length, 400-600 meters broad), the dam size (76 m high and 570 m long) and the potential impacts on local environment. The CEO’s of the Schluchsee AG Manfred Rost and Stefan Vogt immediately reacted to the media by confirming the plans for the project. CEOs claimed that the project shall be carried out in close cooperation and involvement of local citizens, tourism groups and environmental organizations [35] [38].

Environmental organizations as the Bund für Naturschutz Südlicher Oberrhein (Association for environmental protection in the south Area of the upper Rhine) and the Naturschutzbund Deutschland (environmental protection association Germany) [17] were completely surprised by the sudden announcement to reactivate the PHSA plans and claimed that they don’t have a position at the moment due to a loss of information. Having the process of the 70ies in mind the two environmental groups claimed that the topic is of major concern. Especially due to the possibility for

² Process of storing power during periods of low demand on the system and delivering it during periods of high demand

the utilities RWE and EnBW to perform load levelling for their nuclear power plants to gain from arbitrage businesses on spot markets [38]. The same concerns were shared by the local green party (Die Grünen), which initially also did not have a clear position regarding the project. The district leaders of the greens Ruth Cremer-Ricken, Iris Wallascheck and Bernd Biendl stated that PHS can be an important pre-condition for wind power, but that it also may be a reason for prolongation of nuclear power plants operation time leading to a delay of the planned German phase out of this controversial technology [24].

A first public consultation through the Schluchseewerk AG was realized in mid-October 2008. The local councils of Herrischried (2,634 habitants) and Rickenbach (3,854 habitants) were invited to participate in the council meeting together with officials from the Schluchseewerk AG. It was claimed to be one of the biggest councils of the history of both towns with about 200 participants. Local citizens were mostly concerned about the potential impact of the basins on land scape and local environment as well as stress for local population through construction works.

Another very relevant factor for citizens was the question of how sub-urban construction works might influence drinking water quality. Officials were able to respond to most expressed concerns, but have left some of the points blurry. Some citizens also stated that the project could be a bit benefit for local tourism, leading to higher visitor numbers to see the basins and dam, which has led to temporarily more positive positioning of the involved towns and their citizens [39]. After the meeting some newspapers reported that Germany had an extraordinary wind power output due to weather issues in the north of the country. This resulted in a complete oversupply on markets leading to negative wholesale market prices. These prices were mainly caused by so called must run power plants, as nuclear power plants (13 GW – input in that time). The cost of this must run power plants was distributed among end users leading to a temporarily 10 % increase of electricity cost. This event has triggered the discussion about the real aim of the PHSA to conduct load levelling for nuclear power plants in the public [40].

In 2009 the Germany government announced to release an incentive to support the investment of new PHS by releasing them from grid fees (representing saving of about 20 million euros per year) if new projects are finished until 2019 [41]. At the same time scoping dates took place for the Atdorf project in March and May 2010. The event had the aim to clarify what kind of documents have to be delivered through the project initiator for the necessary regional planning procedure. This documents then had to be delivered to the regional council of Freiburg (the district town) [42].

First geologic analysis was initiated in 2009 and planned until 2010 to start the regional planning procedure to be able to start with the plan approval procedure in order to finalize the project until 2019 due to the announced incentives through the German government. The regional planning procedure was finally initialized in April of 2010. At the same time first negative comments were stated by different interest groups – mainly citizen action groups. This was expressed by 234 statements against the PHSA signed by more than 800 citizens of the villages of Herrischried and Rickenbach (both town councils were mainly based on Christ democrats (CDU), greens (Die Grünen) and social democratic parties (SPD)). The statements were submitted to the regional board after the regional planning procedure was finished. Also the new founded citizen action group “Bürgerinitiative Atdorf” – with an obviously strong NIMBY attitude [15] - handed in a 74 page strong statement against the project signed by more than 3,000 people. The statements were related to the same concerns expressed in the first public announcement of the Schluchseewerk AG (impact of the

basins on land scape and local environment as well as stress for local population through construction works, impact on water reservoirs) [43]. Also the Bund für Naturschutz Südlicher Oberrhein (Association for environmental protection in the south Area of the upper Rhine) finally took a clear position against the project after discussing the issue with their local sub-divisions in Rickenbach and Herrischried [44]. Finally also the Schwarzwaldverein (association of the Blackforest) took a position against the PHSA. All groups agreed that energy storage is necessary to enable a renewable energy system but don't see the necessity to build it up in the region. In September 2010 the municipality of Herrischried decided to carry out a public opinion poll to gather citizens opinion on the PHSA which results in a standoff (50.5 against and 46.5 pro and 3.1 indifferent) [45].

During this period the German government started to initiate several programs for energy storage research and demonstration by providing about 2 billion €. One of the main targets of these efforts was (and still is) to improve the economic performance of energy storage technologies. The German energy agency (Deutsche Energie Agentur - dena) (a private company founded in 2000 by the green and red government of that time) soon released a study which earned certain attention in the end of the year 2010. The report stated that PHS is a precondition for the success of the planned German energy transition toward renewables. It also provided a comparison of various storage technologies as batteries or compressed air energy storage. The study concluded that PHS, more specifically the project of Atdorf, provides the most advantages in relation to other available technology options. It also concludes that centralized energy storage as the planned pumped hydro storage power plant might play a significant role in the future of the German energy system in combination with decentralized energy storage. The dena study was ordered and payed by the Schluchseewerke AG [10]. At the same time several concepts for energy storage where presented by research centers and universities as e.g. aquatic pumped hydro storage facilities or new types of electro-chemical storage or decentralized storage concepts [46]. This new concepts were picked up for the contra arguments of most resistant groups as the BI Atdorf. The regional planning procedure for the PHSA was nevertheless successfully finished in December 2010.

The municipality of Rickenbach also decided to carry out a public poll as in the case of Herrischried in February to March 2011. The result was contrary to the opinion of citizens in Rickenbach. About 52.3 % were in favour and 43.9 % against the project. This was seen as a clear sign for the start of the Atdorf project by the local party CSU (conservative party) and was also recognized with favour by the Schluchseewerk AG [47].

An event that had a strong impact on overall project development was the melt down of three of the five Fukushima Daiichi reactors on 11th of march in 2011 through the catastrophic Tsunami caused by an undersea earthquake [48]³. This happened just two weeks before the planned regional elections of two of the richest states of Germany, Baden-Württemberg and Rheinland Pfalz. On Monday morning the 12th just one day after the incident, steering committees of all political parties of Germany started to discuss about the potential consequences of Fukushima on the planned elections. Discussion was mainly based on the former national policy of Mrs. Merkel to prolong nuclear power operation for more than 10 years beyond the initial planned phase out in 2020 [49]. At the same time the top actors of the German industry, including major CEOs from RWE and EnBW reunited in the "Haus der Deutschen Wirtschaft" (House of the German industry). During this time

³ Before this event Germany has planned to prolong the running time of its nuclear power plants based on a set of scientific energy scenarios

the national media mainly reported about the catastrophic situation and the ongoing melt down of multiple nuclear reactors in Japan. Around 1 pm of the same Mrs. Merkel announced a moratorium for nuclear power plants. Power industry announces to take the oldest nuclear power plants of grid due to tactical reasons. At the same time industry claimed that political decisions are not always rational and represent pure election campaign strategy in this case [25]. The project has soon become a main topic of the election campaign of the CDU, the greens and others on a state level.

Two weeks later regional elections took place in the state of Baden-Württemberg and Hessen. Elections in Baden-Württemberg ended in a change from CDU (conservative party) to a social democratic and greens coalition (SPD & die Grünen). The local greens took in contrary of their colleagues on a state level, a clear a position against the project, whilst the local conservatives and social-democrats claimed that it is a milestone for German energy transition and climate change fight [22]. However, external factors as regional elections and Fukushima had only a limited impact on reports in local media about the Atdorf project [7] which was still strongly supported by the state and national government.

In July and June 2011 a round table was initiated to discuss the PHSA project. The aim of this participative procedure was to figure out if the project could trigger nuclear power phase out and energy system transition towards renewables and local interests regarding environment, tourism and other concerns. Participants of the round table were selected representatives from the municipalities (majors, representatives from political parties), citizen action groups (Bürgerinitiative Atdorf), the environmental organizations (BUND and NaBu), local tourism association as well as the investors of the project (Schluchseewerk AG) and representatives of all political parties from the state parliament. The entire process was observed by the regulation agency responsible for permission of the project [16]. A second round of this round table was carried out in September and October 2011 [7]. The Schluchseewerk AG agreed to postpone the final submission of the final plan approval procedure until the second round table was finished [16]. The intention of this delay was to include the concerns of all included interest groups. Finally five round table meetings were carried until august 2011.

The perceptions about how successful the roundtable was were highly different among participants. The citizen action group BI Atdorf stated that the entire meeting was a farce representing an illusion of participation and that they felt "unheard". The Schluchseewerk AG was highly satisfied with the event and considered it as a big possibility to discuss on eye height with other groups and to expunge major concerns of the citizens. Environmental organizations (Nabu and BUND etc.) had ambivalent impressions, but agreed that the round table did not completely fulfil its aims and was more a measure of crisis intervention. Still, they claimed that discussion was very objective and informative. The Schwarzwaldverein (association of the Schwarzwald) has left the round table with a more moderate perspective, agreeing that the PSHA is an important step for the energy transition. The "Unternehmer pro Atdorf" (companies pro Atdorf) had a positive impression of the entire event with a good discussion and were satisfied with important information that was provided by the Schluchseewerk AG. This impression was also shared by the involved municipalities. The latter strongly supported the chosen dates of the round table between the regional planning procedure and the plan approval procedure [21]. The local greens party took an position against the PHSA in contrary to the greens state minister for environment Franz Untersteller which favours the project as die the state government of Baden-Württemberg [50].

Fukushima has triggered Germany's *Energiewende*, or "energy transition until the end of 2011. It has finally led to a radical shift of national politics to force a faster phase out of German nuclear power plants until the year 2022". This has hammered the four big country's utilities (of whom two are shareholder of the Schluchseewerke AG) which did not expect such drastic steps [51]. The following RES rush has caused wholesale electricity prices to tumble due to overcapacity of conventional base power plants built up before. Some conventional plants cannot make enough money to cover fuel costs and are being shut down by the utilities. This has led to severe losses for RWE (2.8 billion € deficit) [52] as well as EnBW (753.1 million € deficit) [53] and has forced them to adopt company strategies resulting in a decreasing number of investments and their financing in the field of electricity generation only two years later after Fukushima in 2013. Soon major industrial associations, utilities and economists started to complain about missing structures, regulation and objectives through the government regarding the transition of the energy system towards renewables [54].

In the end of 2013 the main shareholder of the Schluchseewerke AG, RWE announced that the company will put the project on ice – but that they may start it at any time when conditions of energy market become more favourable again. EnBW did not comment this statement and just announced that it may be difficult to realize such big problems under given market conditions. BUND and the citizen action group BI Atdorf stated that this announcement can be considered as a company strategy to pile on pressure on national government to achieve certain financial benefits for the Atdorf project. The government of Baden-Württemberg, the socio-democratic and greens coalition still wants to bring forward the project [29]. In total RWE and EnBW invested over 60 million € in the project until that point.

In 2014 RWE finally stated that they will quit the Atdorf project due to severe economic pressure on electricity markets. EnBW took over the financing share of RWE and announced that it wants to bring the project to an end. Still the Atdorf project is strongly supported by the state government. Some local citizens, especially the BI Atdorf and some environmental associations strongly oppose the project [26]. The Schluchseewerk AG finally submitted all documents for the plan approval procedure to the rural district office Waldheim on the 30th December 2014. This means that the entire proposal procedure is almost finished nowadays. Final approval of the project is expected for end of 2015 [9] but there is a delay until eastern 2016 leading to further delays of the project approval. Citizens are legally allowed to protest on court after the final submission of the documents and final decision regarding Atdorf. The BI Atdorf announced that they will raise public attention and that they will fight the positive decision on the plan approval procedure of Atdorf on court [23]. Potential construction activities are now predicted to start in 2023 due to the unexpected events and high local resistance [55].

2.3 Summary of the decision process

The pumped hydro storage power plant Atdorf was already presented in the 70's as a possibility for load levelling in combination with base load power plants (mainly nuclear and lignite). The project was cancelled due to local resistance. In 2008 plans were presented again to the public, naming RES integration as a major motivation for the project causing again strong resistance from local population. Investors and state government thus initiated a participative round table that has led to ambivalent results. Whilst some groups changed their opinions due to objective arguments for the

project, others still have deep concerns regarding the project. This has led to a delay in the entire planning process until 2023. Furthermore electricity market conditions have changed significantly during that time due to political decisions related to the Fukushima incident leading to the egression of one of the major investors RWE from the project.

These unforeseen changes were mainly caused by radical shifts of policy as well as complex market dynamics that have led electricity whole sale market prices to tumble. Still the other main investor – EnBW - is still willing to continue the project, despite its growing deficit. However the Atdorf case unveils several major systemic problems when it comes to the necessary investment into balancing technologies as Atdorf in frame of the planned energy transition towards a greener electricity system.

Figure 2 gives an excerpt of the historic process, related decisions and the most important incidents which are highlighted in red.

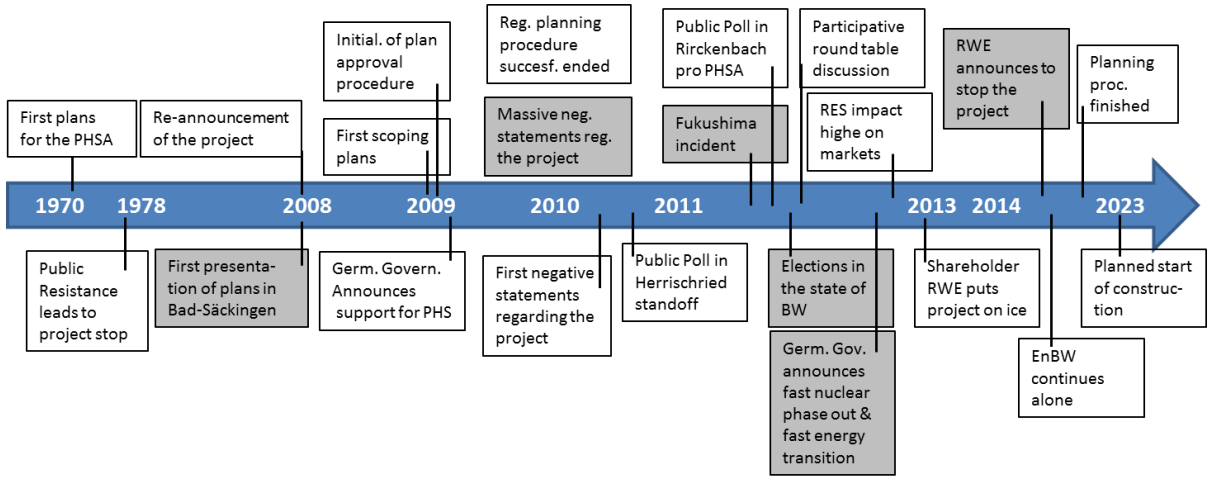


Figure 3: Chronological summary of the entire decision process of the pumped hydro storage power plant Atdorf

2.4 Public consultancy, measures of communication

The Schluchseewerke AG has conducted a participative process in order to avoid a second denial of the project as in the late 70’s and to create trust in the local population. Main arguments are that the project is a contribution for a secure and sustainable electricity system and that they will minimize potential damages to the local environmental during the construction phase. A website, flyer as well as a journal (“Spitzenstrom”) were presented/provided to the public containing all major information related to the project. All were designed for non-experts through a very narrative writing style in combination with simple pictures.

Both provided subtle influence by citing experts and significant research institutes (as the Germany energy agency “dena” which was paid by themselves) [10] and tended to emotionalize facts in combination with several adjectives and adverbs. It could be observed that the company had a more or less well prepared strategy for communication as they have already learnt from past errors. Acting of the Schluchseewerk AG was very proactive (flyers, round tables, website, public consultation etc.). They were also open for a optimization of the project planning process through external ideas [7]. In

total the company seemed to very interested in bringing forward an open process for project planning.

Still stakeholder positionings, especially from local environmental groups, citizens, local political parties and citizen actions groups were very diverse during the consultation phase. Two conducted public polls in the town of Herrischried and Rickenbach resulted in a standoff [47]. Whilst the state government of Baden-Württemberg and most political parties supported the project, perceptions of their own political subdivisions on the local level were completely different as in the case of the greens (Die Grünen) and initially for the social democrats (SPD) [7].

Some groups that had a very strong “not in my backyard – NIMBY” position, as the BI Atdorf recognized scientific studies that claimed that the pumped hydro storage power plants are an important element of the planned energy turn-over. But still they were not willing to accept the Atdorf project in their region due to concerns related to tourism, environment, potential earth quakes and the planned five year long construction period.

These groups presented technological alternatives to the PHSA, which they thought to be more sustainable and acceptable on a regional level. In general it was interesting to visit the official websites of these groups which were designed in a very striking way through pictures that suggested that there is a strong resistance movement. Taking a closer look unveiled that there are only around 300 participants. A guess is that the work carried out by these groups is designed to gather attention and to find followers. Further the website did not seem to have a structure and included several accusations e.g. greediness, extortion, missing intellectual honesty etc. against the Schluchseewerk AG [7]. It appeared somehow that the BI Atdorf has a general contra position against the project and that they are not interested in any compromise regarding the planned pumped hydro project in the region. Reasons named are always the same, to maintain local biodiversity or environment in general but it is always phrased different on the official website of the citizen action group [15].

The round table was initiated by the state minister for environmental issues (Mr. Franz Untersteller), and NABU. Organization and provision of moderators was conducted by the Schluchseewerke AG. All relevant groups were invited to the event (for detail see chapter history of the process) with the aim to discuss about perceived problems (e.g. necessity, emissions, danger of earth quakes etc.) related to the Atdorf project. The entire procedure was seen as a useless event and participation was perceived as compulsory. In contrary the Schluchseewerke AG claimed that the event is a possibility to provide information, to carry out an objective discussion and to generate optimization recommendations. After participating in the round tables some groups shifted opinions recognizing that Atdorf is an important part of the planned energy transition of the German electricity grid towards renewables [21]. This was considered as a success by the state government and the project planning company the Schluchseewerke AG. Still the event was seen very critically by some participants that thought that it is a kind of crisis intervention. Participation activities started indeed very late when first negative opinions were recognizable in the media and when the project planning was already finished. Furthermore only 5 participative events took place which was seen as a too low number by some groups for such a big project. In general the measure was seen as good possibility to participate in the entire process [7].

The review of local media led to the impression that reporting was not always neutral and focused on the Atdorf project using a more striking language comparable to the BI Atdorf. The topic was not addressed that strongly on a national level. Newspaper on the national scale tended more to report

about the energy transition itself using the Atdorf project as a symbol for the entire project. Reports on the project itself seemed to be very objective.

2.5 Power and positionings of actors

It was of major concern of the company to provide an honest and open planning procedure that can be followed by all involved actors. The research unveiled that e.g. the participation process – the roundtable – has led to a certain shift of attitudes. Most groups felt heard during this process and could express their major concerns which could be answered by the company specialist. Thus it was more a appeasement measure than a real crisis intervention as it was perceived by e.g. the BI-Atdorf. It was obvious that the company sought to illuminate the entire project in order to create a certain level of understanding and sensitization of all involved groups. Of course the final aim was to create a higher acceptance for the project. Still the company severely depends on the decisions taken on a policy level which remain uncertain and not always rational.

The measures of communication also gave an insight to the level “power” of certain actors. The BI Atdorf – as small citizen action group does e.g. not own the financial possibilities as the Schluchseewerk AG. Another psychological crux might be that the group is confronted with experts from the field and may feel misunderstood or in an inferior position from them. They might, even worse, attribute them simply a manipulative character. This might have led the group into a kind of self-driven underprivileged situation, leading to a more defensive behaviour. This was recognized through the statements of the group e.g. after the participation at the round tables which could be “carefully interpreted” as highly emotional leading to irrational argumentation against the pure “greedy attempts” of the company trying to generate profit based on the cost of local environment and population. There might no proper solution to find a consensus regarding these two complete different positions of the BI Atdorf and the Schluchseewerk AG.

2.6 Interpretive phenomenological analysis of the BI Atdorf

The conducted comprehensive literature review offers the possibility to obtain a certain insight into the entire process related to Atdorf. These insights are used to conduct to a certain degree an interpretive phenomenological analysis (IPA). Admittedly it is still a very rough analysis which scratches the complexity of the entire process and does not substitute a detailed IPA.

The IPA is focused on the BI Atdorf trying to better understand the experiences of this small citizen action group trying to oppose a large infrastructural project which is strongly supported by government. It might furthermore lead to unexpected insights or serve as a validation of some assumptions taken before regarding the entire process. Thus some of the most interesting statements of the group are picked up and interpreted regarding the history of the process and the results of the round table.

The “digital echo” of civil society – mainly of the citizen action group “*Bürgerinitiative (BI) Atdorf*” - was found to be the highest using the before mentioned search term with a clear positioning against the project. They were followed by another citizen group called “The Blackforest” which was first against the project and then changed opinion in favour of the PHS if certain conditions are fulfilled.

Other actors were different German political parties as the CDU (conservative) in favour of the project, the social democrats (SPD) who changed positions and the greens (die Grünen) strongly against the project. It is important to distinguish here between the local and the national level of the named political parties. The latter are all in favour of the project, whilst on local level opinions are very different. This comes especially true for the local greens, which are also strongly involved in the citizen action group “*Bürgerinitiative (BI) Atdorf*” [20].

It is interesting why the group was founded 2 years after the official announcement of the Atdorf project. There was a public consultation in 2008 and it seemed that there is a high level of acceptance. A guess is that after the start of regional planning procedure activities represented a first “realization” for the opponents that the project is coming. Resistance started at this point, not with the initial announcement. Citizens and other members of the BI Atdorf as the local greens started to organize themselves after publicity had the possibility to legally protest against the project during the regional planning procedure which has always have to be presented to the publicity within large construction projects. It’s interesting that soon after the announcement the group started to organize itself. First they made a press release and soon after that they founded a registered association to react to the activities of the Schluchseewerk AG. A statement by the BI Atdorf at that time validating this assumption is:

“There is no decision yet if the Schluchseewerke will build. They want for sure to finally submit now the regional planning procedure documents.... Let’s see if they really will start construction... that is a completely other issue” - [7]

At this point (year 2010) the members are convinced that they can influence the outcome of the project and started first actions as local protests and the design of an own website as a reaction to the activities of the Schluchseewerk AG. The group claimed that they are interested in proper formal process of the entire project and that they want to inform other concerned citizens. It seems that they also see themselves as a kind of guarding element in the entire process by asking unpleasant questions. The website of the group itself uses placated terms as:

“humans as subject of protection ... the construction site [] a landscape of craters ... success bought by the gigantic destruction of nature” [15], [7]

Another mentioned motivation of the group is (local) environmental protectionism. Mentioning this they also addressed the dichotomy of local and national environmentalism. The latter is in their eyes not achievable if local environment is sacrificed. This local environmentalism is expressed by statements as:

“Yes to the preservation of the living space of our birds, no to the planned PHS” [15], [7]

Another major point of the group is that they question the motivation of the Atdorf project to store RES. This might be due to old plans of the power plant to conduct load leveling for nuclear power. This assumption of the BI Atdorf can be seen as somehow reasonable when the generation portfolio of EnBW and RWE is considered at that time (several old nuclear power plants already completely depreciated acting as pure cash cows) as well as the nearness of French and Swiss nuclear power plants [15].

The group tries in this polemic way to capture as much attention as possible by the use of “exaggerations”. The information material distributed by the Schluchseewerk AG company is seen as

very critical as a measure (of course) to convince people that the project is necessary. The BI Atdorf names the information material as a “*high-gloss journal Spitzenstrom*” [7] (“*Hochglanzblättchen*” has a negative connotation in German). As stated before, the information material provided by the company has a very informative and professional character using a corporate design due to the financial possibilities of the Schluchseewerk AG. In contrast the BI Atdorf is based on voluntarism and has only very few financial possibilities leading to a certain limited potential of spreading information. This might lead to a certain pressure on the group regarding the distribution of information.

As described before the BI Atdorf was not very happy with the results of the roundtable sessions. It seems understandable that the group was under certain pressure or not be taken seriously. It does not seem surprising that the group entered the participative process/ round tables with certain doubts when the national government announces before the round table sessions:

„...The construction of Atdorf or Forbach will not fail due to the citizen action groups or the greens...” Franz Untersteller state minister for environment [20]

It is understandable that this statement and the fact that almost all relevant planning and initialization steps were already concluded by the Schluchseewerk AG led the entire event ad absurdum in the eyes of the BI Atdorf. The fact that the Schluchseewerke AG was willing to wait with the submission of the final documents until the end of the second round table for some kind of participation reasons led the following participation events to a completely maculation of the round tables as this statement shows:

“A roundtable that takes place after the regional planning procedure doesn’t make sense as it comes to late.... It is dedicated to fail” [16]

In this sense the negative positioning of the group within the round tables is comprehensible. It is furthermore reinforced by the impression that the round table only serves to clarify not if the project will come but only how it will be realized. Still the group took the possibility to address critical issues regarding the project to somehow achieve their interests. This was especially the case in fourth round table meeting. Interestingly the Schluchseewerk AG announced that they will solve this certain question with the affected circle of persons. This has of course led to further suspicions of the group against the Schluchseewerke AG. Finally after the fifth meeting the group stated that:

“We unfortunately observe that the Schluchseewerk AG aims to consequently continue their project and that it is not possible to stop them to create potential dangers as the construction of dams in a seismic active region, the release of arsenic or the endangering of the thermal baths of Bad-Säckingen. They furthermore ignore that the construction will endanger the life quality and working places of several people as well that they will destroy in an irrecoverable way local nature. They furthermore said today that they will not provide compensation payments as they announced at the beginning of the round table.... Hower they shows that they know how to use their position based on financial power in a very cold way” [16]

This statement validates in th authors opinion the assumption that the group perceives itself in an inferior position in relation to the Schluchseewerk AG by just minimizing the successful project planning phase to the financial capacities of the company. Still the group is active even if the participation activities did not lead to a stop of the project. It seems that they really take their

perceived role as a guarding element of the process serious. Another reason to continue with their activities can be described by the following statement or more (in the authors opinion striking) analogy respectively:

“It is like if you would throw a stone into the water... the biggest waves are directly here. When you go more far away waves come smaller and people don’t care anymore.” [7].

The representative of the group Mr Stöcklin made this statement during an interview adding that the project is *“not acceptable for the BI Atdorf in this region”*, leading to following dialogue:

Interviewer: *How would it (a PHS) be for another location?*

Stöcklin: *“That is not our topic.”*

This is somehow descriptive for a not in my backyard mentality and completely validates the assumption taken before regarding the citizen action group Atdorf.

2.7 Lessons learnt

In general it could be seen that all groups are aware of the “greater good” to enable a higher share of renewables in the future grid e.g. [18]. This was especially the case after the Fukushima incident where politics completely shifted opinion. Still people act to bring forward their own interests. There might be no objective character behind these actions. Perceptions of these groups are shaped by their daily lives and remain in a not accessible psychological realm. In this mode it can also be questioned if the companies purely act in terms of the greater good or just aim in optimizing their conventional generation portfolio (this can be suspected when looking at the history of the process). The Atdorf project is at least the most economic viable option but by far not the only one to enable the changes desired by the Germany government. It is at least the easiest way in a technical and economic way [11]. These circumstances make it so important that groups as the BI Atdorf (and others as the local greens) oppose these projects in a strong way by asking critical question.

The IPA offered the possibility to gain better insights into the entire process out the perspective of the BI Atdorf and unveiled somehow that the participative round table event seemed to have a rather informational than a real participative character.

It is a difficult tightrope walk to immolate to certain degree local interests of a few to achieve an ostensible higher goal as a sustainable energy system. The NIMBY phenomena is something that cannot be rationally explained in this case. The Atdorf project remains in this sense very controversial and unveils several problems allocated to the entire process of the energy transition in Germany. On the one hand there is the need for to bring forward unpopular infrastructure projects as Atdorf on the other hand you have to be aware of eligible local concerns. It can nevertheless be concluded that the unclear position of the state government does not lead to a solution of this controversial project. It has more led to increasing uncertainties for investors as well as growing criticism in population. A major point is that suitable goals have to be defined by policy as well as a better coordination of measures to enable large and necessary investments.

The analysis of the case of the Atdorf project can be considered as a mode inductive reasoning that took place. Starting with an empiric case led to the understanding of dynamics inhibited in it enabling

to construct a theory and hypothesis regarding the dynamics on a systemic level which is carried out in the following sections.

3 Qualitative system dynamics approach for a holistic perspective

In the first section of this work the controversial decision process of the Pumped Hydro Storage Power Plant Atdorf (PHSA) was analysed in detail, chronological structured, major stakeholders (see Annex I) and ways of communication were identified. It allows for deductive reasoning – applying a theory to an empiric observation.

The attempt was to understand how complex a controversial decision processes can become in an evolving socio-technical system. Still the process appears blurry, difficult to structure and interrelations might not be obvious. Major variables influencing energy storage projects as in the case of PHSA remain uncertain and have to be unveiled in a systematic approach. This approach should enable a combination of our physical with our social world and capture the dynamics of interrelations and inter-dependency of events, markets and actors. Thus the approach of system dynamics [56] more specifically closed loop diagrams (CLD) [57] is applied based on literature reviews and the findings obtained in the chapter before. CLDs can help to identify influences of variables on a system over time [58] and to uncover potential counterintuitive leverage points (LP). Such LPs represent points where a small shift in one thing can produce big changes in the entire observed system or process [59]. CLDs consist of positive and negative feedback loops which are the base for system dynamics models and enable to easily communicate essential components and interactions of a system [60]. More details about the method can be found in [57] to [60].

3.1 System boundaries and identification of variables

A first step to create a CLD's is to understand what influences the demand for energy storage. This requires a rough understanding of energy market mechanisms as well as changes happening on a systemic level of the (German) energy system. Further it is important to have a perception of how the system will probably evolve in a socio-technical sense. Still it is not possible to include all factors of such a large and complex system. Thus it is important to set up system boundaries by setting proper research goals. In this case the scope of the observation is to understand what drives the successful investment for storage technologies in relation to the example of Atdorf. The time horizon for this work is until 2023 (planned start of construction) as it represents a feasible time horizon.

Furthermore two kinds of variables have to be defined. These are on the one hand endogenous variables that are elements that influence all other elements in the observed system (in this case spot markets, local resistance, system stability etc.). On the other hand exogenous factors represented by variables that are not included in the analysed system but influence it (e.g. political goals, growing demand of electricity, Fukushima incident etc.).

One of the major variables identified in the research is the planned development of renewable energy sources up to share of 80 % until the year 2050 through the German government. The rising shares of RES represent a technical challenge for the German electricity supply system. Stochastic energy production fluctuations can lead inter alia to temporary conventional capacity problems due

to limited correlation of load and generation and may lead to an increased demand of flexibility options as energy storage technologies including large PHS. An overview of a certain generation portfolio development of Germany is given in figure 3.

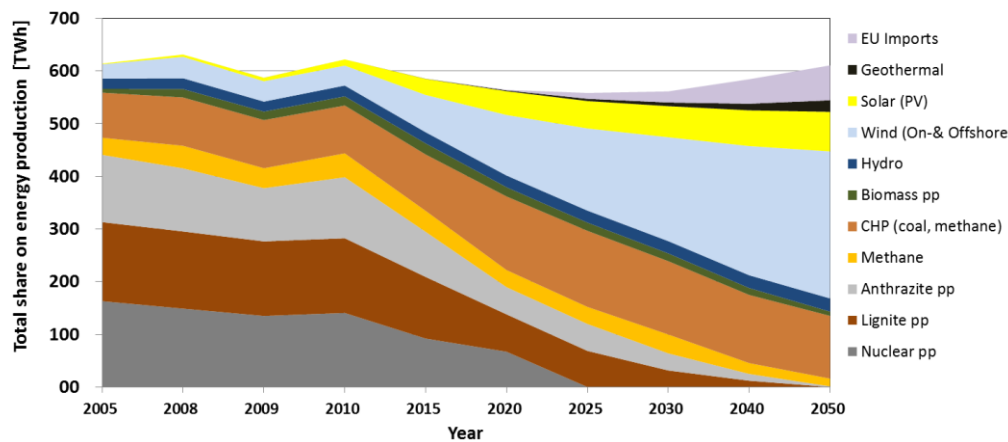


Figure 4: Development of RES in Germany 2005-2050 – own figure based on [61]

Stille there are several more variables to be included. 22 variables were identified based on the given literature and the information gathered from the historical decision process of the pumped hydro storage power plant Atdorf as presented in table 1.

Table 1: Selection of variables

Nr.	Variables	Description	Unit	Source
Endogenous variables				
1	Development of RES	Growth rate of non contr. RES	GW/a	[62], [28]
2	Share of conventional generation	Mainly baseload (e.g. nuclear plants)	GW/a or %/a	[11]
3	System stability	Black outs	h/a	[11], [28]
4	Grid reinforcement	Reinforcement of grid	No. of errors	[10]
5	CO2 prices	EU-ETS CO ₂ Certificate prices	€/tCO ₂	[28]
6	Reformulation of market structure	Capacity markets	€/MW	[63], [64]
7	Spot market prices	Day-ahead prices (arbitrage possibilities)	€/MWh	[64]
8	Demand	Electricity demand	TWh/a	[33], [11], [62]
9	Margin	Expected winning from whole sale markets	€/MWh	[11], [62]
10	Support schemes	e.g. renewables support laws	€	[65]
11	Market structuring and regulation	e.g. for the use of fuel rods	€/MWh	[34]
12	Moratoria	e.g. phase out of certain technologies	Loss of MW/a	[62]
13	Acceptance	Local citizens	Qualitative	[66], [67]
14	Local added value	Job creation	Qualitative	[66], [67]
15	Environmental impacts	Impact on local environment / land use	m ² /kWh	[66], [67]
16	Energy storage costs	Levelized cost of energy	€/kWh	[68]
17	Adjustment gradients	Ability for load following	MW/min	[11]
Exogenous variables				
18	RES share targets	% on total generation		[11]
19	Moratoria	Phase out of conventional. Power plants	%/a	[62], [28]
20	Economic growth	Development of national economy	%/a	Own consideration
21	Population	Development of national population	%/a	Own consideration
22	Resource availability	Coal, Gas, Uranium	t/a	Own consideration
23	Unexpected events.	Catastrophes as Fukushima	Several	

3.2 Reference to the Atdorf case

There are some major variables that influence the Atdorf project which are explained in the following. A overview of the dynamics is given in figure 4. The most important one is the national energy policy which aims to achieve a RES share of 80 % until 2050. This target, which is strongly supported by the government leads to an increasing share of RES represented mainly by wind and

solar power in the electricity grid (RES system integration → energy fluctuation). This leads to increasing fluctuations of electricity generation and makes it difficult to match demand and supply which has always to be in balance. This leads in the long term to a higher demand of balancing options as energy storage for the grid. Pumped hydro storage power plants have a high track-record and represent the only economic viable storage technology available nowadays. Furthermore plans for the Atdorf project were already available from the 70ies and it was seen as a time near feasible solution to tackle problems related to RES. Thus utilities decided to invest in the project naming better renewables system integration as a motivation whilst they had the support of the state and national government. The Atdorf project also represented a good possibility to optimize in an economic sense the existing utilities conventional electricity generation assets through load levelling.

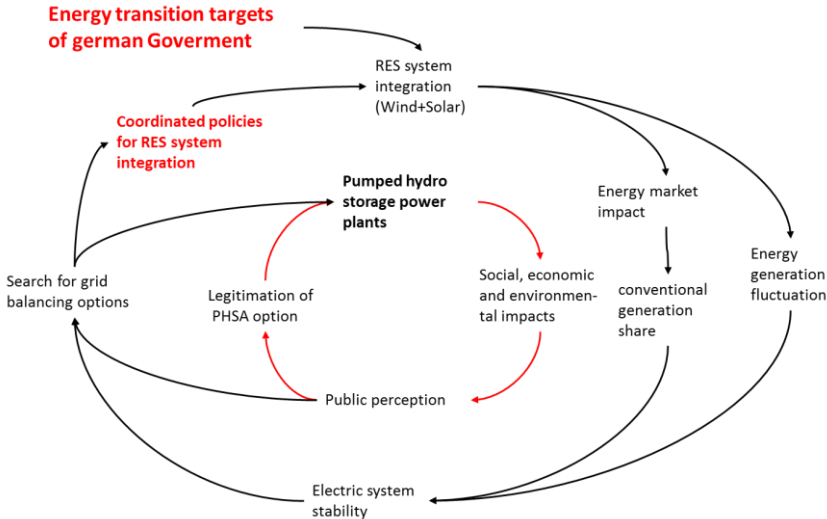


Figure 5: Rough aggregation of dynamics related to the case study of the Pumped hydro storage power plant Atdorf (inspired by [13])

It was not expected that local resistance would be so strong due to the perceived massive impact of the project on the landscape, environment and local tourism (market in red). Thus utilities and state government decided to start participation measures in order to increase local acceptance for the project what has led to certain delays in the entire process instead of looking for potential alternatives (search for grid balancing options). During this time markets changed dramatically due to the Fukushima incident leading to a paradigm shift of the German government towards an moratoria of several nuclear power plants including a faster phase out of these until 2023. Additionally new RES share targets and a reduction of coal power plants was announced. The increasing shares of RES have led markets to tumble causing high losses for utilities, who had to adopt company strategies due to the uncertain investment situations. The Atdorf project was finally postponed until the year 2023.

This in turn leads to the hypothesis for the dynamic behaviour in the Atdorf project where investment incentives in new controllable power conversion technologies as PHS go back due to uncertain market conditions caused by increasing shares of public financed RES, missing regulation and clear targets. In this mode the Atdorf project can be seen as a good example for the absence of political measures and coordination within the German Energy turn-over (indicated in red in the graph). The German government has to provide a clear and coordinated policy regarding the integration of RES including clear targets for energy storage technologies and energy markets to be

able to tackle increasing system stability issues in combination with decreasing conventional energy generation capacities that will occur in the mid- to long term.

3.3 Causal Loop Diagram

A purely qualitative CLD is built up by the use of the Vensim, a free downloadable modelling software developed by Ventana systems inc [69]. The aim of the CLD is to identify at least three main variables that can be considered as leverage points and principal feedback loops. Still the developed CLD only captures the dynamics in a very aggregated and is not claimed to be exhaustive. In the following major interrelations will be described whilst major feedback loops (FBL) are named by their Index (A to L). The entire CLD is given in figure 5. Exogenous factors as the motivation for RES policies in Germany have been described in the former chapter and will not be included here.

- FBL A to C: RES in Germany are strongly supported by the government through the German Renewable Energy Sources Act (Erneuerbare Energien Gesetz – EEG). In frame of this law RES are fed in with priority into the grid, often in combination with a fixed feed-in tariff. This RES generated electricity is mainly sold by transmission network operators in day-ahead markets or spot markets respectively (see FBL A). Price deltas are compensated through consumer through electricity prices (see FBL B) [65]. This mechanism boosted investment in RES, as assets are out of market risks. This leads to increased rates of RES generation, substituting – with a certain time delay -conventional generation in a physical way (FBL C).
- FBL A to G: In general produced energy (conventional and RES) is traded at the EPEX Spot (a wholesale market for electricity) (See FBL A, F). Electricity is offered on this market place at short-term marginal costs (dominated by CO₂-certificate costs, and fuel costs) [11]. These offers are lined up from lowest to highest resulting in a so called merit order. RES have a close to zero marginal cost, followed by nuclear energy, lignite, anthracite, gas and pumped hydro storage. The spot market price is based on a clearing price for each hour, based on the marginal plant that is needed to tackle demand in the respective hour [64]. The result is at least on the short term, that the more RES are integrated into the grid, the higher the impact on the merit order, the lower prices on day ahead spot markets become (e.g. 10.13 € reduction through RES in 2012) [64] (See FBL A & F). It is obvious that in extreme situations when RES generation is low and demand supply balance is tight prices would spike. Still such events are rare but might become stronger in the long-term. Thus nowadays achievable margins become lower, and uncertainty for investment becomes higher as investment and fixed operating costs might not be covered anymore [63]. This dynamic causes a stagnation of investment in conventional electricity generation (FBL E) as in the case of Adorf. This comes also true for energy storage, which is normally always ranked as last option in the merit order (FBL G) [64]. However, research in frame of this work has shown that actual market structure inhibits high inefficiencies (e.g. strategic bidding or extreme peaks) when high shares of RES appear [63].
- FBL G to H: Energy storage technologies can be used to conduct load levelling for both, conventional and RES as in the case of Atdorf. The latter is strongly supported by government and could help to enable a better market integration of RES Renewables by e.g. capturing

excess energy from RES and dispatch it during high demand times (see FBL G). Such dynamics could serve a measure to achieve a better market integration of RES, e.g. through direct marketing in the long-term [70], [12], [33] (see FBL K) and allow a reduction of subsidies guaranteed by the EEG and lead to lower electricity consumer prices. The case of Atdorf has shown that there are concerns that energy storage could also be used to economically optimize conventional base load power plants (e.g. fired through lignite) (FBL H). Such problems could be tackled by reformulation of the EU-Emission Trading System (EU-ETS) by reducing available certificates to boost marginal costs of conventional generation and thus reduce earnings (FBL D). At the same time it would enable to integrate more RES into the grid, helping to fulfil policy targets until 2050 and would make measures as moratoria excrement (FBL C).

- FBL J to L: At the same time RES cause higher fluctuations, creating a higher demand for balancing in order mitigate fast output changes. Some conventional technologies as combined cycle gas turbines (CCGT) with high adjustment rates are able to provide balancing (See FBL L). Such capacities would have to be installed according to increasing needs of balancing. A problem is that the growing number of RES and their impact on the merit order reduces overall utilization ratios of CCGT as well as PHS and other balancing technologies drastically (FBL's A to G). This situation reduces margin expectations for potential investors (as in the case of RWE in Atdorf) in these technologies, opening the danger of potential balancing capacity gaps in the future. At the same time market conditions lead to severe economic pressure on utilities. This makes large projects with high upfront volumes as in the case of Atdorf very difficult due high market risks (FBL J). One possibility to tackle this problem could be to introduce a capacity component to existing "energy only" markets as in the case of Great Britain or the US and Brazil through "market policy changes". In this case balancing options would receive an remuneration for being kept online which on the other hand would lead to negative impacts to electricity consumer prices (See figure 5 market policy changes). Though such measures have to be realized very carefully to avoid an increase of emissions through keeping e.g. CCGT online. Of course energy storage would minimize the demand for balancing. The demand for balancing is furthermore highly dependent on other development as e.g. electricity grid reinforcement measures and flexibilizing demand (e.g. tariffs or demand side response). A major problem is that there is no clear position or more accordingly coordination of detailed policies regarding these measures reinforcing market uncertainty of utilities.
- FBL: J: When it comes to investment decisions or the planning of a project respectively not only economic motivations should be considered. Investment decisions should be based on social, economic and environmental aspects to assure that local acceptance is given. The events in Atdorf showed how important local support can be. Still NIMBY is a not avoidable phenomenon especially when considering as conventional perceived technologies [71] as pumped hydro storage .

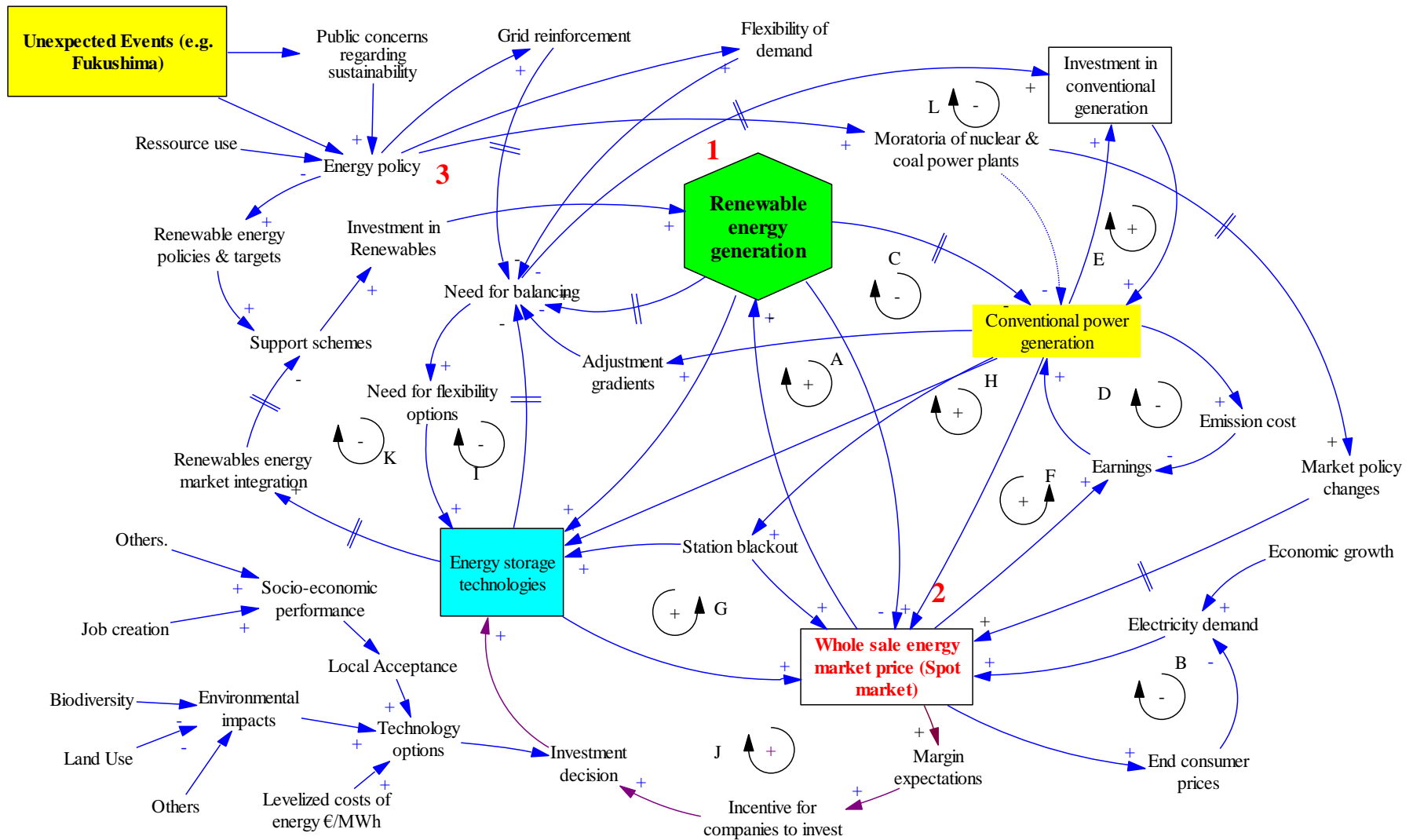


Figure 6: Simplified and qualitative CLD for energy storage and RES system integration in Germany

3.4 Identification of leverage points

There are several possibilities to intervene in a system with different grades of effectiveness [59]. The following three leverage points (LPs) have been considered as main variables in spite of the qualitative research - their order implies their grade of effectiveness to influence a system based on [59]:

1. The most important LP is a change of the predominant paradigm. This kind of LP reformulates the paradigm out of which the old system consisted including its goals, structure, rules and delays as well as parameters. The amount of Renewable energy production or the German Energy transition itself respectively is the key element influencing almost all other components of the system including markets, need for balancing, investment decisions etc. Yet it is a result of an unexpected exogenous variable, the unforeseeable incident of Fukushima which represented a complete game changing (or paradigm changing) event. The latter event triggered RES development and caused a faster transition towards a more sustainable renewable energy production [59].
2. The development and the composition of electricity whole sale markets in Germany represents a key to guarantee further investments in balancing technologies as pumped hydro storage and requires a market change policies – this has to be conducted in way that it does not lead to backfire effects e.g. new CCGT power plants. Thus CO₂ certificates within EU-ETS should be adopted, become more expensive to minimize incentives to invest in this technology. Instead alternatives could be found that make sense in relation to emission mitigation costs. In this sense it represents a certain change of the rules of the system [59].
3. The level of coordination of energy policies, regulation and related targets on a state and national level have to be intensified in order to give potential investors at clear sign – which was not the case as in the Atdorf project. A clear definition of goal can help avoid potential gaps regarding the availability of balancing technologies facing a growing share of RES. It allows also companies to adopt their investment strategies. This leverage point can be referred as goal definition which is somehow missing in the concept of the energy turn over [59].

The named leverage points can be found in their respective numbering in figure 4 and have been already explained in the former section.

4 Further considerations regarding energy storage

The German energy transition is complex socio-technical process that involves a lot of stakeholders. A major challenge in this process is to compensate the increasing shares of fluctuating renewables as wind and solar in order to assure system stability. Thus balancing options have to be identified that allow large scale system integration of RES. The Atdorf project is perceived as a viable technological option by state government and main investors but the situation of what kind of technology to use is very blurry. Thus several surveys and interviews were carried out in line of [72] to gather a better understanding of what kind of technology is considered as most important for the energy transition in Germany including pumped hydro storage in relation to other balancing options. For this reason over 80 experts and non-experts were consulted on a global level. In total 13 groups were involved: civil society (NGO, Citizen action groups etc.), Utilities, Energy storage developers, renewable energy

retail and system integration and others. The result was that there is no clear answer to this question and that stakeholders are deeply uncertain about future developments of the entire electricity system due to unclear regulation and goals communicated by government. An aggregated version of the opinions is given in figure 6 and shows that there is no perfect technology available. Batteries are thought to be the most important technology with 25 %. Central energy storage as the Atdorf project was ranked on the last place with 19 %. Admittedly results are somehow ambivalent due to a high number of stakeholders from the field of stationary battery storage, still it allows to get interesting insight using disaggregated data.

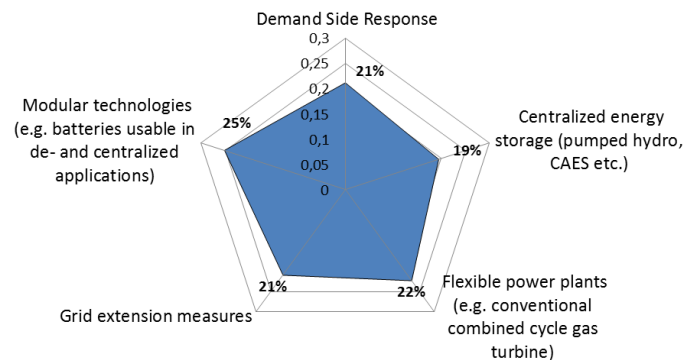


Figure 7: Perceptions of technology relevance to assure a successful energy transition in Germany (n=52)

The conducted interviews made it possible to understand in a better way what are the concerns of stakeholders regarding potential technologies or measures that have to be implemented for the energy transition in Germany. Some statements are given as an example in the following and might give an impression of driving concerns of actors (translated from German):

Demand Side Response (utility, higher management): „I don't see a high potential in this technology, smart meters are too expensive, no valuable business case.....acceptance problem also in industry“

Centralized storage/Pumped hydro storage (project manager for hydro power plants): „Difficult..., really very difficult to implement new projects due to high environmental standards..... and public opinion against new projects.... No real alternative... markets are not sufficient“..... “public consultation is very difficult.... Atmosphere can become very emotional.... People are not open for objective argumentation“

Grid extension (utility, higher management): „Well very necessary... but I think we all know the problems.... NIMBY...“

Battery storage (municipal utility project manager & project manager for hydro power plants): „We are already at the minimum edge of profitability with pumped hydro – how should new concepts as batteries then be economically viable?“...“Building up high capacities of e.g. redox-flow batteries will also cause a high degree of local resistance... pretty sure“

The interviews showed that acceptance was one of the main points named in all cases. However, the statements underline the relevance and findings gathered within this research. The development of a

CLD model with the involvement of stakeholders would be a very interesting point for further research.

5 Conclusions & lessons learned

The conducted research in the first part of this work showed how important public consultation can be and how strong positions can get or shift in such a process. A major point was that during work a process of inductive reasoning took place, starting with an empiric case – Atdorf - to construct a theory regarding the dynamics of the process.

In general it was interesting to understand different interest groups and their positionings. It unveiled how diverse opinions can be in controversial projects as Atdorf and allowed it to identify methods of communication of different groups also offering the possibility to gather different views on one topic. An interesting point was to see how media reported about the project on local level (e.g. local newspapers) in a more emotional way in relation to the national level – where a more distant or objective reporting could be observed. The interpretive phenomenological analysis (IPA) which was applied to the citizen action group Atdorf served as a good reference for this dichotomy. The IPA offered some interesting insights into this phenomenon that can be described felicitous by the following analogy:

It is like if you would throw a stone into the water... the biggest waves are directly here. When you go more far away waves come smaller and people don't care anymore.” [7]

The use of system dynamics and causal loop diagrams (CLD) related to the reference case offered the possibility of deductive reasoning – applying theory to an empiric observation. It was possible to get a more structured view by first visualizing the relevant dynamics of the entire decision process of Atdorf in a more abstract way. The development of a causal loop diagram (CLD) made it then possible to understand and link the dynamics and interrelations of various factors related to the energy turnover in Germany and the reference case of Atdorf. The development of the (CLD) made it possible to identify potential problems and leverage points regarding the investment in energy storage. It showed especially how intense the impact of unexpected exogenous variables as is the case of Fukushima can be. The entire research development was considered as valuable learning process for the author.

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7 Annex 1

Table 2: Summary of involved stakeholders, their positioning and their interests

Stakeholder subregime	Actors	Position	Interests	Source		
Civil society	Bürgerinitiative Atdorf / Citizens action group	Contra	Driven by not in my backyard behavior, want to maintain environment, fight against centralization of energy system, think that the companies investing in the project are greedy and that participation measures are only a way to convince people from the project, they name several reasons against the project as earth quakes arsenic pollution of drinking water etc.	[15]	<i>"We unfortunately observe that the Schluchseewerk AG aims to consequently continue their project and that it is not possible to stop them to create potential dangers as the construction of dams in a seismic active region, the release of arsenic or the endangering of the thermal baths of Bad-Säckingen. They furthermore ignore that the construction will endanger the life quality and working places of several people as well that they will destroy in a irrecoverable way local nature. They furthermore said today that they will not provide compensation payments as they announced at the beginning of the round table.... Hower they shows that they know how to use their position based on financial power in a very cold way"</i>	[16]
	BUND	Contra	Sees the need for energy storage in general but do not see the Atdorf power plant as a necessary part of the German energy turnover	[17]	<i>The BUND asks for a 5 year moratorium for the PHS Atdorf. Within this time a concept should be established for the energy transition which included grid extension measures as well as the need for storage</i>	[16]
	Schwarzwaldverein	Initially against now pro	The Schwarzwaldverein did not have a oppinion at the beginnen, then took a position against the project, after the roundtable the group had a more moderate perspective and was in favour of the project	[7]	<i>"If PHS are so necessary for the european grid, they also have to search for locations on a european level. Each region has to contribute to a more sustainable European energy syste. We, the Schwarzwaldverein thing that upper rhine region already has sufficiently contributed to this process."</i>	[18]
	NABU	Indifferent	The association is convinced that the pumped hydro storage power plant Atdorf is a prerequisite for a successful energy turn-over , still they also have a somehow critic position against the project refereeing to huge impact on local environment	[17]	<i>„We, Nabu, are obligated to support the climate change targets through a increasing renewable energy share. Still it is questionable if the Schluchseewerk AG, regarding all the disadvantages and advantages of the Atdorf project supports this overall goals"</i>	[16]
National government	CDU-CSU, SPD, The greens etc.	Pro	They see a strong need for energy storage for the energy turnover and support the project strongly - support became even stronger after the Fukushima incident	[19]	<i>„...The construction of Atdorf or Forbach will not fail due to the citizen action groups or the local greens..."</i> Franz Untersteller state minister for environment	[20]
Citizens	Herrischried, Rickenbach	Pro and Contra	See the need for storage, concerned about impact on local life quality and tourism		<i>The untypical large dimension of the project, that affect the communities of Rickenbach [], Herrischried [] and Bad-Säckingen [] is a complex thing to handle. This in combination with the question of the need of storage for the energy transition, impact on nature, landscape, issues of earthquake security and stress for habitants through the construction site as []...has a high conflict potential. It is not possible to tackle this with the available legal measures as a citizen information []....."</i>	[16]
Local Government	Die Grünen /The greens	Contra	Recognize the need of the project but do not accept the large impact on local environment	[19]	<i>„We, the greens in the Hotzenwald have intensively discussed about the need for storage for renewables. Result: Nice to have but not really necessary" the local greens of Rickenbach and Herreschried"</i>	[20]

	SPD - Social democratic party of Germany	Contra	The social democrats were initially against the project but shifted opinion after participating on the round table	[21]	<i>We agree that energy storage is a prerequisite for the energy turn-over. But our central question is where and how to combine central and decentral energy storage. It is unclear what magnitude of storage is required. The problem is that a national energy concept is just absent. This comes also true for the state of Baden-Württemberg as our environmental state minister was not able to present such a concept.</i>	[16]
	CDU Christian party Germany	Pro	The local party follows the line of the state level policy and would welcome a soon realization of the project	[7]	<i>"PHS is the only available technology nowadays on a large scale that is economic viable. There is still a lot of research required to bring new storage technologies into the market. Thus there is no other way then to build up Atdorf"</i>	[16]
	Regional council	No position	- no opinion could be identified	[22]	No comment found	
Media	Local Newspapers	tendency against the project	In general they appeared more contra to the project as reports always seemed to be emotional more orientated to the language of the BI Atdorf	[29], [23]	Often used titles as <i>"Does Atdorf really have to be realized?"</i>	[24]
	National Newspapers	Neutral	The interest on a national level seemed to be more neutral, more focussed on issues of energy turn-over and not specifically about Atdorf	[25], [26]	Often used titles as <i>"Energy transition in the south east"</i>	[27]
Science	dena	Pro	published a scientific report about the importance of the Atdorf project for the success of the German Energiewende - the study was sponsored by the Schluchseewerk AG	[10]	<i>"The location of the planned PHS Atdorf is of high value for the safe operation of the grid in the future"</i>	[10]
	VDE	Neutral	The VDE published a new report about energy storage comparing several technology option they do not favour one of them but state that pumped hydro storage is the only economic viable option available nowadays	[28]	<i>"PHS is the most economic viable technology nowadays"</i>	[28]
Stakeholder subregime	Actors	Position	Interests	Source		
Companies	Schluchseewerke	Pro	Seeks to invest and to enlarge its own generation portfolio in close cooperation with its two main shareholder RWE and EnBW - want's to initiate a participative process during the planning phase in order to increase acceptance among local population regarding the Atdorf project	[9]	<i>"We are convinced that we are doing the right thing in the right time!"</i>	[9]
	RWE	Pro - later contra due to severe economic pressure	The company owns a large amount of conventional power plants and already announced in the 70ies that they are still interested in the project. It seems that one main interest is not RES integration but to conduct load levelling for their base load power plant. However the stopped activities in the project	[29], [26]	<i>"We just have another perspective on the entire situation" – only comment found after the announcement of the company to stop the project</i>	[21]
	EnBW	Pro	Has a comparable interest as RWE and is still motivated to invest into the project also in face of the exit of RWE from the Project Atdorf	[29], [26]	It is challenge to tackle energy policy issues to even better explore the chances of Pumped hydro storage	[30]

Other	IHK Hochrhein	Pro	No website found		<i>"The project has to be realized due to the optimal topographic situation of the upper rhine. It allows us to make our necessary contribution to assure a successful German energy turnover"</i>	[21]
	Unternehmer pro Atdorf	Pro	See a possibility to increase local trade and receive strong economic incentives, they expect that the Atdorf project may also increase the rate of tourists due to their interest to see the basis of the power plant	[7]	<i>"In our opinion low acceptance is not a result of missing transparency. It is more the fact that society thinks that it has to take a stance regarding specific topics"</i>	[16]