ENERGY INFRASTRUCTURE AND EXPLORATION AREAS:

CHARACTERISTICS, RELATIONSHIPS, AND LOCAL ACCEPTANCE

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1. INTRODUCTION

The term “energy infrastructure” designates any building, machine, or structure which is connected with the energy industry – from a bucket chain excavator in a lignite quarry to the support facilities in a uranium mine and from a cooling tower of a coal power plant to a power socket in an ordinary home. That means that energy infrastructure is extremely extensive and to completely describe it in detail is beyond the possibilities of this book. Besides, this is not the aim of this book, because it is mainly concerned with the issue of exploration areas. There are several issues connected with exploration areas which directly affect the lives of people, because exploration areas are the first stage in the chain of energy infrastructure. Such issues include, for example, how exploration areas are determined when looking for reserved minerals (such as uranium, natural gas, or black or brown coal) or how exploration areas are evaluated when determining whether they are suitable for a repository. In addition, issues such as granting of an exploration area, deciding rights, and public participation are central to the present discussion.

The aim of this book is to contribute to this discussion, but in a manner rather different than many other publications which have already been written about this issue. It has been authored by the members of the newly created Center for Energy Studies – an inter-disciplinary, university-based platform which aims to provide unbiased information to all parties connected with energy infrastructure. These can include government authorities (rang-
ing from the local to the state level), the general public, but also organizations which build certain parts of energy infrastructure.

This book aims to describe exploration activities, their methods, and the impact they have on their environment. In an accessible manner, it will also try to explain the legislative framework surrounding the issue of exploration areas and to explain how activities connected with building energy infrastructure may influence the public. The book deals with energy infrastructure on two levels: First, it looks at exploration areas when used to look for energy raw materials (natural resources which can be used as sources of energy), focusing on oil, gas and the front end of the nuclear fuel cycle, i.e. uranium prospects and mining, and the geological aspects of the rear end, i.e. localization and prospecting sites suitable for geological repository of the decommissioned nuclear fuel. Second, it focuses on the issue of local acceptance and local oppositions. It introduces the phenomena of local opposition, its most influential reflections in social science theory, and methodological tools to provide deeper understanding of the particular opposition movements.
The term “exploration area” designates an area of specific dimensions where the state can allow geological exploration to take place and issue a permit to this effect. A detailed geological exploration is the first step which can (but does not have to) lead to the construction of certain types of energy infrastructure, whether the aim is to look for energy raw materials or to determine a potential location for a repository. It is often said that geological exploration is in fact not needed, that everything has already been found, that the geological structure of the region is well-known, and that by being granted an exploration area, an organization just seizes an area through legislative means and is preparing to mine for natural resources or to build infrastructure.

While it is true that the Czech Republic is well explored (through exploration boreholes or using geological, hydrogeological, geochemical, or other exploration methods), the specific data required to determine the potential of a given locality (for example for building infrastructure or for mining) do not exist. Each exploration starts with a research phase. This phase involves collecting the available information from past surveys which were connected with the given locality or the specific mineral deposit and this information is again interpreted. This is important because the older
surveys were often carried out using outdated methods, because the knowledge about the geological structure of a given region becomes more accurate over time, and because many models which were valid at the time of the earlier surveys are now considered inaccurate or outright wrong.

A modern geological survey is therefore a necessary first step before the construction of energy infrastructure can begin. This survey is necessary to determine whether a mine or a repository can even be situated at a given place. The survey must answer the following questions: Is the locality or deposit suitable so that construction can follow the correct technological procedures? Will the infrastructure be effective? And also: Is it feasible in terms of its impact on the surrounding landscape and lives of the people?

The current legislature divides exploration areas into several categories. For the sake of simplicity, this chapter divides them into two groups: First is an exploration area designated for mineral exploration (in precise legal terms known as “prospecting for and exploration of a reserved deposit”). The second category is an exploration area designated for a special encroachment on the Earth’s crust. This legal definition encompasses, among other things, the search for a repository location. Even though the stipulations for this kind of exploration area are often the same as in the case of mineral exploration, there are several differences and specificities, particularly when the exploration area is to be used to construct a repository.

### 2.1 MINERAL EXPLORATION

The aim of exploration is to determine or to verify the presence of mineral deposits. According to the *Mining Act (Act No. 44/1988 Coll., on the Protection and Utilization of Mineral Resources)*, all deposits of energy raw materials (radioactive materials, all types
of oil and flammable natural gas, all types of coal and bituminous rocks) are considered reserved deposits. This means that the raw materials in a reserved deposit are not part of the land and therefore they do not belong to the owner of the land but to the state (Mining Act, Part 1; Paragraph 3; Section 1). Only the state can issue a permit to explore for reserved minerals or a permit to explore an already existing reserved deposit. Binding regulations, terms of exploration, and granting of an exploration area fall under the authority of the Ministry of the Environment.

An exploration area can be granted to any legal person, natural person, or state company (all these entities will be referred to as “organizations”) if they fulfill the legal requirements. The main requirement is for the organization to have a Certificate of Professional Qualification and Performance to carry out geological works (according to Act No. 62/1988 Coll., on Geological Works and the Czech Geological Authority) or a permission to carry out mining activities (according to Act No. 61/1988 Coll., on Mining Activities, Explosives and the State Mining Administration). In some cases, both these acts are concerned with the same issues and it has long been called for the unification of this legislation.

The application to delimit an exploration area in order to survey and explore for reserved minerals (or deposits) must contain all the provisions stipulated by law:

1) The organization must submit the exact location and dimensions of the exploration area for which it is applying. This must be an absolutely specific area plotted on a map where the exploration area is delimited by straight lines which connect vertices with specific geographical coordinates.

Active and approved exploration areas, reserved deposits, mining areas, and other such localities are registered by the Czech Geological Survey (an agency of the Ministry of the Environment) and they can be accessed using the Mineral Information System (Surovinový informační system, SurIS – Fig. 1.).
2. EXPLORATION AREAS

Fig. 1. SurlIS The Mineral Information System (Czech Geological Survey 2015)
2) The application must also state which raw material the organization wants to explore for or which of the existing reserved deposit it wants to explore further.

3) The organization must provide the general information about itself and it must submit all the required documents such as a statement of criminal records, a business license, and other documents which certify that the organization can do business in the field of mining.

4) A description of the proposed exploration process which includes its stages, its aims, methods, and the amount of time for which the exploration area should be granted.

This is the main part of the application because at this point, the organization must specify the proposed exploration methods. The problem is that this must be done beforehand, before the organization can even set foot in the exploration area. And in some cases it is difficult to determine in advance which methods will be used in which stages.

5) If the organization is looking for oil or natural gas, it must also prove that it has the required financial and technological capabilities.

6) And finally, the application must include how the exploration area is divided between the cadastral areas of the surrounding municipalities (i.e. cities, towns, and villages). This distribution is then used to proportionally estimate the payments which are paid to the specific municipalities affected by the exploration. In the case of mineral exploration, a municipality will get 2,000 crowns per year for every square kilometer of the exploration area in its cadaster area. If the survey takes longer than one year, the fee for one square kilometer increases by 1,000 crowns at the beginning of each year. This money belongs to the municipalities which cadastral area is part of the exploration area.

Applications are accepted and registered by the Ministry of the Environment which then begins the evaluation proceedings of the
applications and notifies all the involved parties of this fact. By law, the involved parties include not only the applicant (i.e. the organization which wants to explore) and the state (represented by the Ministry of the Environment), but also the municipality or municipalities which are located within the proposed exploration area. In accordance with Act No. 114/1992 Coll. on the Conservation of Nature and Landscape, additional parties can also participate in the proceedings. This includes associations or organizations with legal personality which have stated environmental protection in their statutes. It is odd that the law does not grant the right to participate to land owners whose land lies in the exploration area. They can express their view through the municipality where they own land and they have some rights vis-à-vis an active exploration area, i.e. an exploration area for which an application has been approved (see the section on the obligations of organizations in active exploration areas).

The involved parties have the right to inspect the documents relating to the proceedings and they have the right to give inducements and to voice their views throughout the proceedings. Before the final decision is made about whether to grant the exploration area or whether to reject the application, all the involved parties have the right to comment on the reasons given for the decision.

By becoming involved in the proceedings, it is possible to influence the nature of the proposed exploration process and of its phases. It is possible to regulate the extent of the exploration process and to influence what the organizations can and cannot do in the exploration area. It is also possible, as is often the case nowadays, to demand that the application be rejected and that no exploration area be granted.

The Ministry of the Environment will reject the application: 1) if the applicant does not fulfil the stipulations mentioned above; 2) if the applicant had another application for an exploration area
granted in the last ten years and this was subsequently cancelled by law; or 3) if delimiting the exploration area is in direct conflict with the state’s energy policy, environmental protection policy, national defense, international commitments, or if another public interest exceeds the interest in exploration.

The main documents considered when the Ministry of the Environment decides whether to grant an exploration area or whether to reject the application are: the documents connected with the mineral resources policy published by the Ministry of Industry and Trade (the documents are available here); the current Mining Act (Act No. 44/1988 Coll., on the Protection and Utilization of Mineral Resources), and the two other acts mentioned above (Act No. 61/1988 Coll., on Mining Activities, Explosives and the State Mining Administration and Act No. 62/1988 Coll., on Geological Works and the Czech Geological Authority).

An organization which had its application approved and was granted an exploration area can begin the exploration process in accordance with the proposal submitted with the application. However, the organization still has certain obligations towards the state institutions.

If the organization wants to enter a plot of land which belongs to a third-party but is part of the exploration area, it must conclude a written contract with the landowner. The contract stipulates the conditions under which the organization can enter the plot of land and all the details relating to the survey and any other activities which will be carried out by the organization (such as land use, building a road, connecting an energy or a water supply, etc.). If the landowner is significantly limited by the exploration activities, he is legally entitled to compensations for loss of profits (these compensations are paid by the organization which is exploring the area). When the survey is finished, the organization is also obliged to return the area to its original state or to carry out remediation. If there is a disagreement between the organization
and the landowner, the district court has the authority to resolve it. If the court finds that the exploration process is a public interest which is in accord with the state’s mineral resources policy, it can restrict the rights of the landowner.

Even after this point, the organization is obliged to inform the given municipality that it will begin exploration activities involving land encroachment; it must do so at least 15 days in advance. If the organization plans to use machinery to dig more than 30 meters deep, it is also obliged to inform the District Office. If the organization plans to explore using underground mining works, it must provide all the documents relating to the proposed exploration activities to the State Mining Administration for approval. The State Mining Administration will then stipulate in a legal statute how this exploration is to be carried out and how the exploration galleries and shafts are to be liquidated once the exploration is over. It will also determine in which cases this type of exploration has to be permitted and supervised by the District Mining Administration.

All the exploration activities are of course paid for by the organization, they must be properly documented, and the organization is obliged to submit annual reports about the extent and the results of the activities. Within two months of finishing the exploration, the organization must – free of charge – submit a report on the exploration results to the Czech Geological Survey, an agency of the Ministry of the Environment. The Czech Geological Survey then permanently archives these reports to be used in the future by state institutions, for example to update the state’s mineral resources policy.

The report contains the description of all the activities which were carried out and if the existence of a reserved mineral deposit has been ascertained, the report must also contain the classification of the mineral and an estimate of its amount. This estimate must then be authorized by the Ministry of the Environment, by
the Ministry of Industry and Trade, and by the District Mining Administration.

If the quality and quantity of the reserved mineral is such that it might be exploited, the Ministry of the Environment will issue a reserved deposit certificate. If detailed information about the deposit is available, the Ministry of the Environment in coordination with the Ministry of Industry and Trade and with the local authorities (district offices) will proclaim that the given locality is a protected deposit area. A protected deposit area is proclaimed above the mineral deposit and its aim is to regulate all activities in the area (such as construction) which are not directly connected with deposit exploitation and which could potentially hinder future mining.

Even through it is not part of the first phase of mineral exploration which is the main focus of this book, it is necessary to briefly mention the permission to mine a reserved deposit. This is a situation which follows after mineral exploration, if a mineral was found of such quantity and quality that would facilitate subsequent mining. This is not automatic, since many explorations are negative in terms of finding an economically exploitable mineral deposits.

A question which is often discussed is the connection between exploring a deposit and mining it. Of course, an organization which invested huge sums of money into exploring a mineral deposit will want to appreciate their investments and will want to mine and sell the minerals which it found. In reality, however, exploration does not automatically equal mining and these two activities are regulated by different laws or by different sections of these laws. When a company wants to obtain a mining permit for a reserved mineral deposit, it must again submit an application which contains many more requirements than the application to be granted an exploration area. An organization which wants to gain a mining permit for a reserved mineral deposit must supply
permits issued by the Ministry of the Environment and by the
Ministry of Industry and Trade (which examines the application
vis-à-vis such issues as the state’s mineral resources policy or the
potential return on the money the state invests in exploration). In
addition, the organization must solve any conflicts of interests in
the mining area. The only advantage gained by an organization
which was financially involved in the exploration of a reserved
mineral deposit is that it has a preferential claim to apply for a
mining permit. The organization can do so only after the estimate
of the amount of the mineral has been authorized and it must do
so no later than one year from the date when the exploration area
stipulation expired. If the organization does not do this within
the given time limit, other organizations can apply for a mining
permit.

2.2 EXPLORATION AREA FOR A SPECIAL
ENCROACHMENT ON THE EARTH’S CRUST

Act No. 62/1988 Coll., on Geological Works and the Czech Geo-
logical Authority also mentions an exploration area for a special
encroachment on the Earth’s crust. This definition includes one
very topical question – the search for a repository locality. When
establishing this type of exploration area, the legal terms and reg-
ulations are the same as when establishing an exploration area for
mineral exploration. But there is a difference in the fees for the
exploration permit – these fees are higher and are defrayed using
the Nuclear Fund. This special fund receives financial contribu-
tions from all organizations which produce spent nuclear fuel or
any kind of radioactive waste: this includes nuclear power plants,
but also hospitals which use X-ray machines. Government Decree
No. 416/2002 Coll. from 2002 fixes the fees connected with han-
dling radioactive waste as follows:
1) if a municipality has in its cadastral territory: a) a radioactive waste repository; or b) a protected area for a special encroachment on the Earth’s crust for storing nuclear waste in underground locations (this is similar to a protected deposit area – it is an area which has been explored and which has been ascertained as suitable for a repository), it will receive 3,000,000 Czech Crowns annually;

2) if a municipality has a cadastral territory which overlaps with an exploration area for a special encroachment on the Earth’s crust for storing nuclear waste in underground locations, this fixed fee increases by 0.30 Czech Crown annually for every square meter of exploration area which is located in the cadastral territory of the municipality;

However, there is a peculiar provision in paragraphs 3 and 4 of the decree. These stipulate that municipalities must inform the Radioactive Waste Repository Authority (RAWRA) about the “beneficial activities” for which they will use the subsidies.
3. THE GEOLOGY OF OIL AND GAS

3.1 FORMATION OF PETROLEUM AND GAS RESERVOIRS

Petroleum and gas reservoirs form as a result of long and correctly timed processes which last millions of years. The easiest way to explain these processes is using the petroleum system (Allen – Allen, 2013).

A petroleum system consists of several types of rocks which are significantly different from each other. At the beginning of a petroleum system, there are source rocks in which petroleum or gas is created. These are usually shales and what is crucial is the amount and type of organic matter they contain. Organic matter content must be at least 2 per cent; if the organic matter is of terrestrial origin, gas is formed; if it is of maritime origin, petroleum is formed. If sedimentation processes transport the source rocks deep enough where the required temperatures occur, the formation of petroleum or gas can begin (Allen – Allen, 2013).

Petroleum and gas are small compounds which are pushed out of the source rocks due to the pressure of the overlying rocks and because of this pressure, petroleum and gas start to migrate (move). They migrate through rocks which are porous and permeable, meaning that there are spaces between the grains of such rocks and petroleum and gas migrate through these spaces. Rocks which are both porous and permeable are called migration rocks.
It is noteworthy that petroleum and gas can migrate great distances, even kilometers from the source rocks.

In an ideal case, petroleum migration ends in a petroleum trap. A petroleum trap is a place in the Earth’s crust which is shaped like an anticline (also known as a fold trap) where petroleum and gas can accumulate (see Fig. 2.). Properties of rocks are important, particularly their porosity. The pores in reservoir rocks are filled by petroleum, natural gas, and water, but for the hydrocarbons to accumulate, their migration must stop. In order for this to happen, the place where the hydrocarbons accumulate must be covered by seal rocks – this is layer of rocks with very different properties: their porosity and permeability must be as low as possible so as not to allow petroleum and gas to migrate further, for example to the Earth’s surface. Incidentally, there are places where petroleum reaches the surface, such as the natural petroleum well in
Korňa in northern Slovakia (see Fig. 3.). If seal rocks are present, a petroleum trap is created and these traps are the targets of exploration (Allen – Allen, 2013; Hantschel – Kauerauf, 2009).

Reservoir rocks and seal rocks can be covered by other rock layers which can be hundreds of meters thick. These layers cause the pores of the seal rocks to close and also increase the temperatures in the source rocks.

Fig. 3. A natural Petroleum Well (Korňa, Slovakia)

### 3.2 HYDROCARBON EXPLORATION

In recent years, hydrocarbon exploration techniques have advanced greatly. In the early days of petroleum and gas extraction, prospectors were looking for petroleum smudges in wells or for places where petroleum reached the surface through a natural well. In these places, exploration boreholes were drilled. In the Czech Republic, this was done at the end of the 19th century in
Bohuslavice nad Vláří, a village in the Zlín Region. The success rate of this method, however, was very low and given current drilling costs, it would be unfeasible anywhere in the world. Due to the fact that drilling a single exploration borehole costs millions and that the information gained by geologists is minimal (limited to the few dozen centimeters of the borehole’s diameter), seismic exploration plays a crucial role. During seismic exploration, a sound signal is emitted and its reflection is then detected. As the signal travels through rock layers, it is reflected and absorbed, depending on the types of rocks it encounters. When this data is recorded and analyzed, it is possible to create a two-dimensional seismic profile or a three-dimensional seismic “cube”. Seismic exploration thus allows geologists to gain information about a much larger area than they would get using an exploration borehole (see Fig. 4.).

A question which is often discussed is the impact of seismic exploration on the everyday lives of the people who live in the area. In a village, for example, the vibrations created by seismic exploration are not felt more strongly than the vibration caused
by a passing truck. The main difference is, however, that trucks pass through every day and will continue to do so; while seismic exploration, on the other hand, only takes a few weeks. Older people might still remember when seismic signals were created by detonating explosives underground, but this method is no longer used today (Allen – Allen, 2013; Littke et al., 2008).

3.3 DRILLING AND POTENTIAL EXTRACTION

The Czech Republic is well explored though exploration boreholes (Pícha et al., 2006) and these boreholes, when combined with other data, can be used to verify the information acquired through seismic exploration. By processing these data, geologists try to locate petroleum traps which could potentially be exploited. Seismic profiles (both 2D and 3D) allow researchers to obtain a very accurate model of rock layers of different ages, even deep underground.

Depending on the required depth and the level of rock sample processing, drilling can be extremely expensive, costing tens of millions. This is why actual drilling is always only the last part of the exploration process. The public imagine of petroleum drilling is connected with dozens of petroleum rigs covering the landscape. However, petroleum rigs are no longer used and they are often mistaken for drilling rigs. A drilling rig (Fig. 5.) is a mobile machine which is moved to a particular location and after drilling is finished, it is moved elsewhere. The time needed to drill a borehole depends on its depth and on other factors (such as the technical demands of the drilling process), but is mostly completed in several months. It is true that during the drilling, agricultural land is seized, but once the drilling is finished, the entire “shantytown” along with the drilling rig is dismantled and moved to another location.
Fig. 5. A Drilling Rig Operated by MND, the Largest Petroleum and Gas Producing Company in the Czech Republic
And what will be left after the drilling is over? Even if the borehole does not strike a petroleum trap, it can bring new information relevant to the subsequent exploration of the area. If petroleum is struck, a pumpjack is installed on the borehole. Depending on the petroleum inflow rate which indicates the amount of petroleum the well can produce, additional equipment might be brought in (Fig. 6.). A question which is often discussed is petroleum well density. In the past, petroleum wells were drilled quite close to one another, as horizontally as possible. Today, the preferred approach is different: It is common to drill only one well which splits into several wells underground, with these underground wells branching out in multiple directions, even horizontally. The image of petroleum fields covered with wells is thus no longer present-day reality. If petroleum output is high, meaning that a large petroleum trap was found, processing and storage facilities can be built. A similar facility has recently been built in Uhřice or in
near-by Žarošice in the Hodonín District. In both cases, these are modern facilities which do not cause an aesthetic mismatch with the countryside, they are closely monitored, and the area they occupy is no larger than that of an average-sized agricultural co-operative (Fig. 6.).

3.4 WHAT HAPPENS WHEN HYDROCARBON EXTRACTION IS OVER

Every reservoir will eventually be depleted. When extraction is finished, the drilling and extraction mechanisms are dismantled and they can be used at other locations. The only “scar” left after the drilling is a hole in the ground with a small diameter. Remediation of such openings is absolutely necessary and companies are contractually obliged to do so. Moreover, good public relations are essential for any future drilling operations.

In addition, many depleted reservoirs can have other uses. In the Czech Republic, many of these sites are used as storage facilities of natural gas. The drilling equipment is just modified, people can keep their jobs, and the reservoir can be used for decades to come. Other sites which were found while drilling exploration boreholes can be used to store carbon dioxide (CO$_2$).

3.5 POSSIBLE RISKS AND NEGATIVE IMPACTS

Many people associate the petroleum industry with accidents involving tankers. Petroleum transportation, however, is not the same as petroleum extraction – these are two totally different things. Every human activity carries certain risks and there is always some probability of an accident. While risk is probably higher in third-world countries, events such as the BP petroleum
spill in the Gulf of Mexico attest to the fact that accidents can and do happen. In the Czech Republic, there were 32 accidents between 1949 and 2015: most of them were connected with unexpected leaks of natural gas and altogether, these 32 accidents claimed the lives of four people. The last fatal accident occurred in 1972 at the Rusava II well where one crewmember was killed. To put these numbers into perspective, more than 2000 wells were drilled between 1989 and 2015 in Morava alone.

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An interview with Zdeněk Svoboda of the Czech Oil Company (Česká naftařská společnost)

A training exercise of the emergency services in case of an accident
4. THE GEOLOGY OF THE NUCLEAR FUEL CYCLE

4.1 THE FRONT END: PROSPECTS AND EXPLORATION OF URANIUM DEPOSITS

Prospecting and exploring uranium deposits is very easy due to one specific property of uranium – its radioactivity. This means that the element emits alpha, beta, or gamma radiation which is created when the unstable nuclei of atoms decay. This fact, however, complicates uranium mining and processing, because special measures must be taken to protect workers’ health against radioactivity (these measures are neither common nor necessary when extracting other types of raw materials). On the other hand, radioactivity makes prospecting and exploration relatively easy, because gamma radiation – which is created by the radioactive decay of uranium and some of its daughter isotopes – is relatively easy to detect. Uranium deposits thus “draw attention” to themselves and modern detection instruments (which are both relatively cheap and very accurate) are able to determine uranium concentration in a matter of seconds.

As with other raw materials, the search for and exploration of uranium deposits takes place in several phases. The prospecting phase involves a series of steps which aim to find an anomalously elevated concentration of uranium. The exploration phase
involves a thorough evaluation of the anomaly and aims to determine its extent, the uranium concentration, and a series of other parameters which would indicate whether the deposit is suitable for mining or not.

In terms of prospecting, uranium deposits can be divided into two types – those which reach the surface and those which do not. Looking for the first type of deposits is much easier and airborne gamma-ray spectrometry is often applied. When this method is used, a gamma-ray spectrometer (GRS) – a device for measuring the intensity of gamma radiation – is mounted onto a plane or a helicopter. The plane then flies at a certain altitude (determined by the specific requirements of the measurements, but usually under 200 meters), following a regular grid with pre-determined distances between individual flight trajectories. While the plane follows these trajectories, the gamma-ray spectrometer continually measures and analyzes gamma radiation and the measurements are then used to create a map which depicts uranium anomalies. This method can also be used to create maps depicting anomalously high concentrations of thorium and potassium (these two elements are also naturally radioactive) and maps which depict the overall radioactivity of a given area. The entire territory of the Czech Republic has been mapped in this manner on a scale of 1:500 000 (Fig. 7.). For more detailed prospections, a different scale with a higher profile density can be used. This method puts no strain on the region being surveyed, apart from the short-term increase in noise caused by the passing plane. However, the method has several limitations. The results can be influenced by land relief, vegetation cover, humidity, and many other factors. Other methods offer more accurate results – gamma-ray spectrometry can be carried out manually or using a vehicle, but these methods are more time-consuming. As the names suggest, the gamma-ray spectrometer is either transported in a vehicle or carried by a surveyor (Fig. 8.). Both methods can employ continuous
measurements on given profiles. When surveying manually, the surveyors can also utilize point analyses in a pre-set grid or in an irregular grid which takes into consideration the specific geological situation. Both methods use GPS navigation which makes the subsequent data processing and visualization much easier. To determine the composition of a rock sample more accurately, laboratory gamma-ray spectrometry is used. This is a much more accurate method and it can detect the amount of uranium (U), thorium (Th), potassium (K), or cesium (Cs). Gamma-ray spectrometry has virtually no impact on the region being explored.

However, gamma radiation is often strongly shielded by various barriers, such as soil cover. To eliminate the influence of
in this shielding, gamma-ray measurements can be taken in shallow pits (for example 0.5 meters deep) which are dug into the ground. It is also possible to analyze the composition of soil gases using emanometry, a method which allows scientists to measure the amount of radon in soil gases. A special device extracts a sample of soil gases directly from a soil profile and measures the amount of radon. Radon is a gas created when uranium decomposes and, like uranium, it is also radioactive. Increased radon concentration in soil gases can then indicate elevated uranium levels in the underlying rock layers. This phase also involves detailed geological mapping or collecting of rock samples for further laboratory analysis. During this first phase, people might notice that strangers are moving in the woods. However, they will not be very different from a hiker or a mushroom hunter, in some cases the only difference being the special equipment carried (see Fig. 9.).

If an anomaly is found which is suitable for further exploration, the exploratory phase begins. This phase further employs both gamma-ray spectrometry and emanometry much more thoroughly and it also coincides with first stages of preliminary engineering activities. The near-surface parts of the anomaly are explored in detail using vertical shafts which can be up to 30 meters deep and horizontal trenches dozens of meters long. These activities are very similar to activities which normally take place during a construction of a water pipeline, for example, and they
are accompanied by additional geophysical exploration, involving such approaches as gravimetry (which measures the changes in the local gravitational field) or magnetometry (which measures the changes in the local magnetic field). Both these methods are non-destructive and non-invasive. Geoelectrical exploration, which is also often used, requires a short-term installation of electric cables and sensors on the surface of the surveyed location. There is also a modern and mobile device used for geoelectrical exploration called ground-penetrating radar (GPR). The GPR allows researcher to “see” the structure of solid materials beneath the spot which is being explored. If this phase of near-surface exploration is successful (meaning that the uranium anomaly was confirmed and its characteristics more accurately specified), shallow boreholes are drilled; they are at most a few hundred meters deep. These boreholes are drilled using mobile drilling rigs which are mounted on trucks (Fig. 10.); when it is necessary to drill deeper boreholes, stationary drilling rigs are used. The drilling usually lasts for several weeks and requires a lot of power which is provided by electric generators with internal combustion engines. Water supply is often required and it is also necessary to provide the basic infrastructure for the drilling crews, such as an access road which leads to the drill site. Deep drilling is carried out if needed. These boreholes can be more than one kilometer deep and they require an extensive supply base which can cover dozens or hundreds of square meters. In addition, deep drilling is extremely expensive and a single borehole which exceeds the depth of one kilometer can cost millions. If the deposit appears to be promising, additional exploration follows using underground mining works (exploration galleries and shafts). This phase then requires an extensive infrastructure to be built: facilities for the workers, an access road, or machinery for pumping mine water (and potentially additional equipment for purifying it). Many other activities have to be carried out which do significantly im-
pact the surrounding areas. This phase is also very expensive and time-consuming because exploration using underground mining works can even take several years. If this exploration phase is successful, the uranium deposit can subsequently be mined. This, however, requires the building of a mining facility, including all the related infrastructure which has to be operational during the entire time the mining will go on, which usually means decades. (This video shows an aerial footage of the mining facility in Rožná, a village in the Vysočina Region.)

Searching for underground deposits which might be dozens or hundreds of meters deep is significantly more difficult and this process uses different sources of information. Researches often compare the selected site with other known deposits, they interpret the geological structure, they use information gained through drilling which was carried out for different reasons, they look for
radon anomalies in groundwater, and they use an array of other methods. Exploring underground uranium deposits basically always involves expensive drilling and later exploring using underground mining works. The impact on the surrounding landscape is the same as in the case of deposits which reach the surface.

4.1.1 URANIUM IN THE CZECH REPUBLIC

The Czech Republic is rich in uranium (see Fig. 11.) and uranium, along with gold and lithium, still has a lot of potential. In the past, several uranium deposits were mined in the Czech Republic. The oldest one is in Jáchymov in the Ore Mountains. Since the middle ages, this deposit was mined for silver and uranium was not used at first. Later it was used to color glass (this technique produces
a special type of glass called uranium glass) and uranium ore was used to obtain radium. Jáchymov started to be used as a source of uranium in 1945. Another important deposits of uranium were located around Příbram and uranium was also mined in Horní Slavkov (western Bohemia) and in Okrouhlá Radouň (southern Bohemia). The largest uranium deposits were located in norther Bohemia (Hamr, Stráž pod Ralskem) and important deposits are also located in western Moravia in the Rožná-Olší ore field; the only uranium mine currently in operation is located here, in Rožná. In 2013, 232 tons of uranium were mined at this site (Starý et al. 2014). In terms of world production, the Czech Republic ranked 14th in 2013, having produced around 0.4 percent or the uranium mined that year.

Uranium mining in Czechoslovakia peaked in 1960 at 3,000 tons. So far, 2.45 million tons of uranium were extracted worldwide; the Czech Republic has so far produced 111,000 tons, ranking 10th worldwide. One kilogram of uranium costs between 80 and 85 Euros. The overall uranium reserves in the Czech Republic are estimated at 135,000 tons. Most of these reserves are located in northern Bohemia and are in the form of sandstone-hosted uranium which makes extraction problematic since it involves chemical leaching. Therefore, these reserves are now classified as inviable, meaning that current conditions (such as uranium prices and available mining methods) do not make them economically profitable. Smaller uranium deposits are located in the Bohemian-Moravian Highlands near Brzkov.

**4.1.2 MINING URANIUM**

In the Czech Republic, uranium is mostly extracted in two ways – by underground mining and chemical leaching, depending on the type of deposit. Leaching was used in northern Bohemia where
the uranium deposits are bound in sedimentary rocks of the Bohemian Cretaceous Basin, other deposits were extracted using underground mining. Most underground uranium deposits resemble huge slab-like structures which can be several kilometers long and reach depths over one kilometer. Their thickness varies from dozens of centimeters to a few dozen meters. However, uranium is not distributed equally throughout these slabs; on the contrary, it is concentrated in several locations which are mostly only dozens of meters in size. Using different methods, these concentrations are then selectively mined so as to extract as much uranium as possible and to keep gangue extraction to a minimum. In the Rožná mines, uranium is extracted using underhand bench mining. Using this method, miners break the individual orebodies into blocks around 50 meters long and work on these blocks moving from the top downwards. Even though the mining itself takes place underground, the impact on the landscape is significant. The most visible feature is the mining tower which can be dozens of meters high (Fig. 12.). Surrounding the area of the mine, gangue heaps are a prominent feature. Other facilities (a machine room, for example) also cover a large area and it is necessary to provide facilities for several hundred employees, access roads, or electric power. All in all, the entire compound then covers several hectares. Mine water presents a special problem: it must be brought to the surface and then purified and draining mine water can lower groundwater levels around the mine and this might create the need to build a water pipeline. Huge areas are also covered by gangue heaps.

The extracted ore contains only very low concentrations of uranium. To get pure uranium, the extracted material must be processed at a processing center. Due to the physical and chemical properties of uranium, its ores are not processed through smelting like iron, but by different chemical processes whereby uranium is transferred into a chemical solution in which it subsequently condenses. There are two types of leaching: alkaline leaching uses
sodium carbonate ($\text{Na}_2\text{CO}_3$) and acid leaching uses sulfuric acid ($\text{H}_2\text{SO}_4$). Because of the low concentration of uranium in uranium ores, more than 99 percent of the leached rocks is stored in special sites known as sludge lagoons. Storing this material is very
different from gangue storage, because leached rocks were processed differently: they were ground up into particles only several dozen micrometers big and because this powder was mixed with water, the resulting substance is liquid in state. This sludge is stored moist in large sludge lagoons and is often covered by water because when dry, the powder could be blown around by wind. All lagoons which are currently in use are constantly monitored. (This video show an aerial footage of the sludge lagoon in Rožná.)

Underground mining of uranium does not take long because the deposits are usually depleted within a few decades. Because the mining facilities and the gangue heaps are small when compared with coal mining, for example, landscape remediation is relatively easy and involves several steps. The surface of gangue heaps is re-cultivated and planted with trees, the boreholes are filled, structures are removed, and landscape reclamation takes place. Because uranium oxidizes during extraction – changing from tetravalent to hexavalent form which is easily soluble in water –, mine water contains relatively high amounts of dissolved uranium and concentrations can be as high as ten milligrams per liter or even higher. Therefore, this water must be treated for several decades until uranium concentrations reach their original background levels. At the same time, it is also necessary to eliminate the radium which has accumulated in mine water. Radium is a by-product created by radioactive decays of uranium and is commonly present in low quantities alongside uranium. Uranium is eliminated using ion-exchange polymers which trap uranium particles and radium condenses with barium sulfate.

Different uranium minerals are easily soluble in sulfuric acid (see the acid leaching method mentioned above) or alkaline solutions and leached uranium is easily soluble. This is why uranium extraction can utilize another method called in situ leaching. This method provides 45 percent of uranium worldwide and its use is on the rise. Its basic principle is simple: Using a system of
pumps, a sulfuric acid solution is pumped into a borehole, the acid dissolves the uranium minerals, and uranium enters into the solution. This solution is then brought back to the surface and into a processing plant where pure uranium is obtained. Using this method, it is possible to extract uranium even from deposits with uranium concentration not high enough to make underground mining feasible. In situ leaching is also cheaper, but it can only be used in certain places where uranium deposits have high porosity. Sandstone-hosted uranium is typically obtained using this method. In the Czech Republic, this method was used when extracting uranium from the mine in Stráž pod Ralskem. This method runs the high risk of contaminating ground water and this risk is even more serious if there are sources of drinking water nearby. This method is therefore suitable for areas where this risk is low. On the surface, in situ leaching leaves much less impact than underground mining.

4.2 THE REAR END: RADIOACTIVE WASTE AND GEOLOGICAL REPOSITORY

This chapter briefly describes where radioactive waste comes from and why the authorities are looking for a place to build a repository.

4.2.1 RADIOACTIVE WASTE: ORIGIN AND TYPES

Radioactive waste can be defined as any substance, material, or object with a concentration of radionuclides higher than the allowed limits of radionuclide concentration. This substance, material, or object must also be unusable and the owner must declare it as waste. According to its radioactivity, radioactive waste
is divided into low-level, intermediate-level, and high-level waste; according to the time it remains radioactive, radioactive waste is divided into short-lived, medium-lived, and long-lived waste. In terms of safety, it is necessary to isolate radioactive waste until the radioactive substances naturally and spontaneously change into non-radioactive substances which are stable (they no longer emit ionizing radiation) and therefore harmless.

<table>
<thead>
<tr>
<th>Type of Radioactive Waste</th>
<th>Required Isolation Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very-low level waste</td>
<td>Little over a decade</td>
</tr>
<tr>
<td>Low- and intermediate-level short-lived waste (soil, detritus, radioactive waste from hospitals or industrial plants)</td>
<td>Hundreds of years</td>
</tr>
<tr>
<td>Intermediate-level medium-lived waste (long active radionuclides used in research nuclear radiators)</td>
<td>From tens to hundreds of thousands of years</td>
</tr>
<tr>
<td>High-level waste and spent nuclear fuel</td>
<td>From tens to hundreds of thousands of years</td>
</tr>
</tbody>
</table>

At present, there are more than 100 organizations in the Czech Republic which produce radioactive waste. Hospitals use ionizing radiation when establishing diagnoses (using CT scans or X-rays) or for long-term treatments (radiotherapy). In industry, ionizing radiation is used in measuring instruments (such as smoke detectors) or in nondestructive testing which determines the quality and properties of materials (inspecting for defects in welds, for example). In food processing, some foodstuffs (for example spices) are irradiated to kill embryos or parasites or pests. Radiation is also used to sterilize many facilities and instruments and not only medical ones.
4.2.2 REPOSITORY

Countries which operate nuclear facilities must face the problem of what to do with radioactive waste. Experts from all over the world consider deep geological repositories the safest way to isolate radioactive waste from the biosphere. This way of storage is based on a system of technological (artificial) and geological (natural) barriers. The most important barrier is created by at least 500 meters of a stable rock formation which will shield all radioactivity for hundreds of thousands of years. Stable geological formations can remain unchanged for millions or even tens of millions of years.

Countries which produce radioactive waste have adopted different approaches towards handling it. According to their approach, they can be divided into three groups:

1) Countries which are tackling the problem and are planning to open a repository in the next 20 years; this group includes countries such as Sweden, Finland, USA, France, Germany, Switzerland, and Japan.

2) Countries which are considering a repository but have not yet started planning or building it; this group includes the Czech Republic, Slovakia, Hungary, Belgium, or Spain.

3) Countries which have dismissed a repository or have no policies on handling spent nuclear fuel and high-level waste; this group includes countries such as Great Britain, the Netherlands, eastern European countries, and others.

European countries which have made the greatest progress towards building a repository are Sweden and Finland. The Fins are constructing a tunnel at Onkalo which will house an underground laboratory and will be located directly under the Olkiluoto nuclear power plant. At present, the tunnel is four kilometers long and more than 400 meters deep. In southern Sweden, the Äspö laboratory near Oskarshamn (Fig. 13.) is already in operation and in
2009, the village of Forsmark (which currently has a nuclear power plant) was selected as the site for a deep geological repository. In 2007, the Josef Underground Research Centre (URC) was open in the abandoned exploration shafts fifty kilometers south
of Prague and some of the research done in this center is related to radioactive waste storage and deep geological repositories (Fig. 14.). No radioactive waste is being stored there, but some artificial and natural barriers which are proposed for the repository are being tested at this facility.

Fig. 14. URC Josef – Underground Research Centre (Czech Republic)
Researchers all over the world investigate several types of rocks with the desired properties under given geological conditions. These rocks include layers of clay rocks, rock salt seams, or stable crystalline rocks. Research in the Czech Republic focuses primarily on crystalline rocks, specifically on stable granite massifs. Additional artificial barriers include double-shelled metal containers, isolation substance made from special absorbent (a clay mixture called bentonite), and concrete constructions. The containers will consist of an inner casing and an outer shell and the best material for the containers will be selected according the test results which examine properties of different metals. Individual containers will be hermetically sealed in bentonite. This material is waterproof, it binds radioactive substances, and is a good conductor of heat.

Although there already is a project for the Czech Republic, the concept will be further developed based on the geological and technological aspects of the selected location as well as on the economic and social requirements.

The repository itself will be composed of two parts – surface facilities and underground storage areas. The repository will be preceded by an underground laboratory which will verify the properties of the geological environment directly in situ. RAWRA assumes that the repository might start operating in 2065.

4.2.2.1 EXPLORATION: METHODS, PHASES, AND ESTABLISHING WHETHER A LOCATION IS SUITABLE FOR A DEEP GEOLOGICAL REPOSITORY

This chapter describes the methods and the phases of the exploration process which are used to determine whether a given locality is suitable for a repository.

The exploration process can be divided into three phases. The first phase is similar for all pre-selected localities and involves surface geological works. This phase aims to verify the compatibility
and integrity of the pre-selected localities, to compare these localities among themselves, and to identify those which are most suitable for further exploration. The localities are compared not only from a geological perspective, but also using other criteria which include four key concepts: safety; technical feasibility; environmental impacts; and socioeconomic impacts. The first two factors are primarily connected with the geological features of the locality. Studying the environmental impacts shows how to minimize the negative effects and looking at socioeconomic impacts documents the potential implications (both positive and negative) which the project might have on the people living in the area. The study will also suggest how to mitigate the negative impacts or how to eliminate them entirely.

The second phase of the exploration process uses deep boreholes to ascertain geological conditions up to the depth of one kilometer. Based on the results of these two phases, the experts will suggest at least two locations which will be explored further. The third phase of the exploration process involves more detailed geological and engineering works.

### 4.2.2.1.1 EXPLORATION: FIRST PHASE

The first phase begins by preliminary activities which do not disrupt the land; these are followed by fieldwork. Preliminary activities involve studying aerial and satellite footage, archival maps, and previous surveys. Fieldwork involves geological mapping using the methods of surface geophysics, structural geology, and hydrogeological and geochemical surveys. During fieldwork, experts mostly carry out instrumental measurements and collect rock and water samples for further laboratory analysis; all these methods are non-invasive and are carried out in a very considerate manner. During all these activities, researchers cooperate extensively and their results are closely interconnected.
Before they begin the mapping, researchers must obtain a permission from the landowners to enter their property; this is in accordance with Czech law as stipulated by Act No. 62/1988 Coll., on Geological Works and the Czech Geological Authority.

4.2.2.1.1.1 GEOLOGICAL MAPPING

Geological mapping results in a geological map which is one of the basic sources when evaluating whether a locality is suitable for a repository. Using a given scale, a geological map interprets the extent of individual rock bodies and the boundaries which run between them. Geological mapping aims to collect data which allow researchers to record this situation as accurately as possible and petrographic, mineralogical, and geochemical analyses are an integral part of geological mapping. These analyses are carried out in specialized laboratories and based on their results, scientists are able to classify the rocks into different groups. Fieldwork during geological mapping is closely coordinated with hydrogeological and geochemical mapping and with surface geophysics.

Geological mapping is a specific activity and fieldwork can only be carried out when there is no snow. The ideal time for collecting samples is spring and autumn, because there is less vegetation and geologists can also enter agricultural land without any restrictions. The geological map is created in stages which take part simultaneously with all the other activities taking place during the first phase of exploration and it takes between 12 and 14 months to create a geological map.

4.2.2.1.1.2 STRUCTURAL GEOLOGY

Structural geology is one of the basic fields of geological research. Sometimes referred to as tectonics, structural geology explores the sub-surface structures of rock massifs. It also allows researchers
to examine rock deformation grade and to study fracture and fault systems, their origins, and their relationships. Structural geology describes, analyses, and interprets the inner structure of rock bodies. Structural analysis is a critical part of geological research and is used to determine mechanical stability, permeability, and other parameters which are needed when constructing the underground part of the repository.

Structural geology along with geological mapping are the two basic methods used to create a conceptual 3D model of a locality. Apart from describing the inner structure of the geological environment, the contacts between geological bodies, and their 3D geometry, structural geology also provides a detail description of fracture structures which can influence rock behavior when digging tunnels or other underground openings.

Fieldwork involves documenting macroscopic structures and sample collection is carried out in parallel with geological mapping. This is followed by data analysis and laboratory work. Structural data are presented using detailed structural maps.

As with geological mapping, fieldwork in structural geology can only be carried out when there is no snow. Before it starts, archival materials are studied and measurement databases are prepared, along with a geographic information system (GIS) which allows researchers to save, process, and analyze the data obtained in the field. The GIS makes it possible to log location information but also the data related to the properties of an object or of a phenomena. The GIS output is a series of clearly arranged maps which depict many different phenomena. After field data are collected, they are analyzed and statistically processed, and maps are created. An area of 25 square kilometers can be structurally analyzed in 8 months.
4.2.2.1.3 SURFACE GEOPHYSICS

Geophysical methods are primarily used to locate and observe fault lines (also known as tectonic lines), be they located on the surface or deep underground. This allows researchers to assess the integrity and intactness of the geological environment. Using geophysical measurements, it is possible to distinguish different types of rocks, to observe hidden rock boundaries, or to determine the thickness of a weathered or sedimentary overburden. The outcome is a 2D or a 3D model of the surveyed area.

The basic method used in surface geophysics is gravimetry which shows the changes in rock density in a geological structure of the surveyed location. This method is used when studying geological structures which are deep underground; it is able to delimit geological bodies and sedimentary formations, to map tectonic structures (fault lines or tectonic disturbances), and other features. It takes around one year to create an output.

4.2.2.1.4 AREAL GEOCHEMISTRY

The main aim of areal geochemistry is to characterize the surveyed area from a geochemical perspective and – based on the distribution of chemical elements and the relationships between them – to delimit zones containing anomalies or other non-homogeneities which can be the subject of further research. Areal geochemistry can detect rock disturbances which are located hundreds of meters underground and are therefore undetectable using geological mapping. Geochemical results are thus one of the important data sets when looking for a suitable repository location. In addition, geochemical surveys allow researchers to identify the intensity of chemical changes and rock weathering in a given location; these facts are important when evaluating stability of rock formations. The results are processed and published as maps which are a key
dataset when searching for a suitable repository location. The most time-consuming part of a geochemical survey is sample collection which takes between 4 and 8 months.

4.2.2.1.5 SURFACE HYDROGEOLOGY AND HYDROCHEMISTRY

Hydrogeological and hydrochemical surveys aim to locate and describe ground and surface water systems, to characterize the rocks which influence the movement of groundwater, and to determine groundwater chemical composition. To achieve this goal, hydrogeology uses archival sources, field surveys, and laboratory analyses.

Using a GPS, the goal of field surveys is to document and localize all accessible objects and phenomena which are significant from a hydrogeological and hydrochemical perspective. These include springs, wells, hydrogeological boreholes, wetlands, infiltration zones (these are areas where water enters underground), groundwater drainage locations, sources of contamination, hydrometric profiles, weather stations, etc. During fieldwork, ground and surface water samples are collected for basic chemical analysis and measurements of physical and chemical parameters. The acquired data are outputted as a hydrogeological map.

One of the most important advantages of hydrogeological surveys is that they can map permeable tectonic features (such as faults or fractures). These tectonic features might serve as pathways through which contamination might spread from a repository into the biosphere or through which substances could enter a repository from the outside; none of these situations is desirable. The actual nature of the identified tectonic features which might act as pathways is subsequently verified by engineering works.

Fieldwork, laboratory analyses, and results evaluation take between 8 and 12 months. Field surveys can only take place when
there is no snow and they are mostly carried out between March and November.

Exploration methods are designed to have a minimal impact on the environment and on the everyday life in the affected localities.

The methods used in the first phase of the exploration do not have negative impact on the environment. They mostly involve measurements using hand-help instruments, collecting rock and water samples, and simple field tests (Fig. 15.).

To make the geological, geochemical, and hydrogeological maps more accurate, more detailed surveys are carried out using earthworks and exploration boreholes.

Earthworks include exploration probes and trenches which can be defined as excavations below level of the terrain. A probe is primarily vertical (with a maximum depth of 6 meters) while
a trench is primarily horizontal. Earthworks can be done manually or using machinery, either an excavator or a mini-excavator. When the exploration is finished, the underground spaces are backfilled and the area is returned to its original state.

To drill shallow exploration boreholes, drilling rigs are used. They are usually transported to the site using off-road vehicles, but they can also be carried manually. An alternative solution is to use handheld borers. While these activities are carried out, strict regulations and technological procedures are closely followed to minimize environmental impact.

4.2.2.1.2 EXPLORATION: SECOND PHASE

The second phase of the exploration process involves exploration boreholes which are between 500 and 1000 meters. Because these activities are very expensive, they are only carried out once the number of potential locations has been narrowed down.

The aim of exploration drilling is to verify the geological conditions up to the depth of one kilometer. A borehole around 1000 meters deep allows experts to ascertain the key geological information about the structure of the rock massif in the entire geological profile up to the depth which is below the level of the proposed repository. This information includes the hydrological conditions which could have a profound negative impact on the repository, both during its construction and operation. Deep boreholes ascertain the physical and chemical properties of rocks and how these properties change with depth; determine the structural-tectonic conditions in the lower parts of the rock massif; and provide detailed hydrogeological characteristics of the geological environment.

Preparing the drill site involves building an access road and evening out the terrain. Several temporary structures are built, including the office of the drill site manager, trailers, a warehouse, a building for handling diamond core drills samples, etc.
During the drilling, the entire drill site is no bigger than 30x20 meters. The ground under the drill site is reinforced using ferroconcrete panels placed atop an insulation foil which prevents any potential contamination of the area. The drill site and related facilities are temporary and once the exploration process is finished, the borehole will be used as an observation borehole. The opening of the borehole is fitted with a lockable cover and the rest of the drill site is returned to its original state. The entire drilling operation takes between 3 and 4 months.

### 4.2.2.1.2.1 CORE SAMPLE ANALYSIS

Drilling boreholes presumes diamond core drilling. When this method is used, researchers can obtain core samples which they can subsequently analyze. Core sample analysis is used to describe the conditions of the geological environment at the depth where a repository is to be built. This primarily includes the description of petrographic, mineralogical, and geochemical properties of the rocks. Core sample analysis can also determine the geostuctural, petrophysical, and geomechanical properties of the rocks. Petrophysical properties reveal the homogeneity of the analyzed massif and geomechanical properties determine rock deformation grade.

### 4.2.2.1.2.2 BOREHOLE TESTS

Tests carried out in boreholes are the key component of the exploration process. They provide critical information which is essential when characterizing the selected location and when analyzing its potential to house a repository. The basic tests include borehole logging, geotechnical tests, hydrodynamic tests, and groundwater sample collection.

Borehole logging provides tectonic (rock disruption, presence of fractures) and physical information about the properties of
rocks and water. For researchers, it is very important to have information about the hydrological conditions in the borehole (such as water flow speed) and about the geomechanical parameters of the rocks.

Geotechnical tests are used to ascertain resilience of rock.

Borehole logging and geotechnical tests are carried out using special equipment which is housed and transported in trucks.

Hydrodynamic tests provide detailed information about rock permeability and groundwater flow. During these tests, groundwater is pumped out and researchers then observe as the water reaches its original level. Hydrodynamic tests are carried out using a submersible pump and measuring probes. The pump can also be used to collect groundwater samples for detailed analysis.

Collecting groundwater from deep boreholes allows researchers to determine its chemical composition and to ascertain the different physical and chemical parameters at different depths of the rock massif. Chemical composition of groundwater changes with depth and in terms of safety, it is very important to know the composition of water in great depth – this can inform researchers about the potentially aggressive nature of the chemical reactions which might take place between the water and the proposed geotechnical barriers of a repository.

When done correctly, the use of an exploration borehole – which is preceded by a detailed exploration of the area – poses no risks to people or the environment. Despite this fact, unexpected incidents can occur. During the drilling, the drilling rig can malfunction, the walls of the borehole can collapse, or industrial liquids can leak. It can also happen that underground utility infrastructure (such as power cables or water pipelines) is damaged during the drilling or that the drill strikes a rock layer which contains pressurized groundwater and this groundwater might then leak out of the borehole. If these problems occur, they can be promptly and successfully solved without posing any complications.
4.2.2.1.3 LONG-TERM SEISMIC MONITORING OF SITES PRE-SELECTED FOR A DEEP GEOLOGICAL REPOSITORY

When selecting a site for a deep geological repository, one of the most important criteria related in terms of long-term safety is that the site is situated in a geologically stable region, far from geological faults which could cause earthquakes.

In general, earthquakes pose less danger to subterranean installation than to structures located on the surface. Nevertheless, if an earthquake occurred, it could damage not only the artificial barriers built around the repository, but also the natural geological barriers. It is therefore necessary that the probability of a strong earthquake occurring near the installation is as low as possible. And this must remain so during the entire period the repository is in use. At present, the time period for considering seismic risks ranges from ten thousand years to several hundreds of thousands.

Active geological faults manifest themselves in earthquakes and humans have had to face these threats since time immemorial. However, historical sources only mention devastating earthquakes which impacted the lives of people; in addition, chronicles and other historical documents only go a few thousand years back. Earthquakes which occurred further back in time can be detected using paleoseismology, an approach used for detecting huge pre-historic earthquakes which took place millions of years ago. When looking for these earthquakes, geologists examine faults which were subsequently crosscut by ditches and in these ditches, geologists look for structures which are created by earthquakes. Using special dating techniques, they then try to estimate the age of these structures and the magnitude of the earthquake.

Since the beginning of the 20th century, earthquakes have been recorded using specialized instruments. This means that it is possible to evaluate earthquakes more accurately and it is also possible to record even weak earthquakes which go unnoticed by
people. Thanks to very precise measuring instruments which have appeared in the last 20–30 years, it is now possible to detect even extremely small microearthquakes which were previously undetectable. Studying microearthquakes is important, since their increased prevalence can indicate a higher probability of stronger seismic events in the future.

Generally, the Czech Republic is seismically safe and stable. Perceivable earthquakes occur only in western Bohemia (specifically around Cheb) and around the town of Hronov and they are not particularly devastating. Perceivable earthquakes are sporadically also recorded in northern Moravia, southern Bohemia, and very exceptionally in southern Moravia. Regional seismicity in the Czech Republic is currently being monitored by a network of approximately 20 seismic stations which are operated by different institutions. These stations, however, are not distributed equally and in some regions they might not reliably detect all potential perceivable earthquakes. In many parts of the Czech Republic, the knowledge of local microseismic activity is therefore relatively sketchy.

Earthquakes have been measured by accurate instruments only for a relatively short time. When this time is compared with the expected time scales a repository is to be in use and with the time scales on which major earthquakes can potentially occur, it is not possible – without further research – to automatically claim that a given locality is absolutely safe from major earthquakes. The International Atomic Energy Agency (IAEA) demands evaluation of seismic risks and provides specific guidelines on how these very sophisticated and complex evaluations are to be carried out.

One of the important data inputs for these evaluations is the results of detailed seismic monitoring carried out by a network of seismic stations in a given locality. It is best to start collecting data as soon as possible, preferably during the exploration phase because this allows researchers to gather a long series of
continuous measurements. Data collection should continue during the construction phase and during the time when the facility is in operation. This is even more important in regions of low or unknown seismic activity where monitoring should be carried out for as long as possible. These long-term and detailed measurements carried out by local seismic stations enable the researchers to evaluate even the weakest earthquakes which would not have been picked up by more distant stations and this detailed evaluation in turn allows researchers to thoroughly understand the seismic regime of the given region. Monitoring stations can repeatedly register very weak earthquakes occurring in a small area or along a line and this can indicate the existence of a previously unknown fault. On the other hand, local monitoring can confirm that there are no earthquakes in the region, not even very weak ones. The database of recorded earthquakes is one of the primary sources used for calculating seismic risk which is calculated using observations from the entire world. Based on these observations, it is possible to estimate the strength of an earthquake in a given location, its probability, and its frequency (considering timescales which range from a century to ten thousand years and more).

Another important tasks for the seismic station begins during the construction of the repository. During this phase, it is important to monitor whether the construction – which often disrupts the geological environment – does not radically change geological tension and whether these changes do not cause more frequent earthquakes to appear.

A local seismic network suitable for monitoring a repository consists of five or more seismic stations (Fig. 16.). These stations are arranged symmetrically around the monitored location, for example in a circle with a radius of between 10 and 20 kilometers; if this is possible, there might be an additional station in the center. Each station is equipped with a seismometer (a sensor which measures ground motion speed), a recording system (which
processes and digitalizes the data from the seismometer), a power supply (the station is either powered by a battery or is connected to a power grid), a device which precisely records time (such as a GPS), and ideally also a communication unit (such as a GSM or radio modem) which allows the station to immediately and permanently send the measured data to the processing center. If possible, the station should be located in a quite location, far away from the sources of seismic noise (such as roads, railways, or factories). If researchers plan to carry out long-term measurements, it is always better to connect the station to a power grid and to transmit data online. In these cases, it is necessary to consider whether it is technically feasible to build electric lines and at the same time maintain a quite location without seismic noise.
A well-tested way to build a seismic station is to place it in a concrete ring or a shaft with a diameter of one meter. The concrete ring is fitted with a cover and sunk a few meters into the ground so that it reaches the bedrock. This enables the station to accurately register seismic waves.

The station does not actively interfere with the surrounding environment in any way and does not create a mismatch with the landscape. Under ideal circumstances, the station is operational throughout the year without any maintenance being required.

The data from a local seismic network are continuously processed at a processing center. A local network is sensitive enough to detect and localize even very weak local microearthquakes. It is also able to detect shocks caused by human activity (such as detonations in mines or at construction sites, ammunition explosions,
or mining-induced shocks) and it also detects regional earthquakes and all large earthquakes anywhere in the world.

Several such local networks exist in the Czech Republic. A pair monitors the two Czech nuclear power plants (Fig. 17.), one monitors the natural gas reservoir in Háje near Příbram, and another network monitors mining-related shocks in the Ostrava Region.

4.2.2.1.3.1 EARTHQUAKE STRENGTH

Even experts find it difficult to accurately estimate the strength of an earthquake and for the general public, the entire process is rather confusing. The strength of an earthquake is expressed by two values: magnitude and intensity. Each describes different characteristics of an earthquake – magnitude corresponds to the amount of energy released at the hypocenter of an earthquake while intensity describes the impact of the earthquake on the people, structures, and landscape in a specific area. One earthquake has different intensities, depending on the place of observation, but magnitude of a single earthquake is always expressed by a single number.

**Magnitude** is determined by the maximum amplitude of the waves recorded by a seismometer. The scale is logarithmic, meaning, for example, that an earthquake with a magnitude 5.0 causes an amplitude ten-times greater than an earthquake with magnitude 4.0. There are several scales used to measure magnitudes, the most common is the Richter Magnitude, which is often but incorrectly called the Richter Scale. Close to the epicenter, it is possible to feel earthquakes with magnitude around 2; sometimes, if the earthquake is shallow (meaning that it originates close to the Earth’s surface) and the conditions are favorable, it is also possible to register earthquakes with magnitude between 1 and 2. Weaker earthquakes can only be detected by measuring instruments. Earthquakes with magnitude 6 and higher can be destruc-
tive even 100 kilometers from the epicenter, but a lot depends on local conditions. The strongest earthquake registered to date had a magnitude of 9.5 and occurred in Chile in 1960. The instruments used today are very precise and can record even very weak shocks, for example earthquakes with magnitudes lower than 0 (an earthquake with magnitude –1 causes an amplitude ten times smaller than a magnitude 0 earthquake and a hundred times smaller than a magnitude 1 earthquake).

**Intensity** describes the effects of an earthquakes in a given area. In Europe and many other countries, intensity is currently measured using the twelve-point European macroseismic scale (EMS, commonly referred to as EMS-98). Each point on the scale is characterized by a specific set of effects the earthquake has on people, buildings, or landscape, known as macroseismic effects. The data to establish an earthquake’s intensity are collected through macroseismic surveys which are mostly on-line questionnaires where people report and describe their impressions from observing an earthquake. The highest intensity is observed near the earthquake’s epicenter and is called epicentral intensity. This value is used to characterize older earthquakes which took place before the advent of instrumental measurements. It is not easy to convert epicentral intensity to magnitude because many different factors play a role, factors such as the depth of the earthquake’s focus and the local conditions.

### 4.2.2.1.3.2 SEISMIC HAZARD

None of the values used above are suitable to express seismic hazard to structures. It is better to define it using the expected peak ground acceleration (PGA). This value considers both the effects of stronger earthquakes which are more distant and of weaker ones which are closer.
Seismic Hazard Estimates and Their Accuracy

There are many complex and sophisticated methods to determine seismic hazard and it is best to combine them. All of them need a complex data input which includes geological information about the given region, information about tectonic faults, and the best available list of all the earthquakes which have been observed in the area.

The output is not one specific number but a series of probability curves. These estimate the peak ground acceleration which can be expected in the given region, its probability, and its frequency.

Based on these estimates, region-wide maps are published which show, for example, that there is a 90 percent chance that a given peak ground acceleration will not be exceeded in the next 50 years. This information is used for ordinary structures.

The requirements for strategic structures (such as nuclear facilities) are much more rigorous. The responsible authorities must determine the time-scales (ranging from tens of thousands to millions of years) and the probabilities which must be taken into consideration. Based on this information, the authorities will decide whether a given location is suitable and will also determine the required seismic resistance of the specific structure.

Seismic hazard estimates can never be absolutely accurate, but the more accurate the input data, the more accurate the results. The input data include primarily the results of geological and geophysical surveys, knowledge of all the faults which can generate earthquakes, and a complex catalogue of all the earthquakes observed in the area for the longest recorded time possible.

4.2.2.1.4 GLOSSARY

Geochemical analyses are chemical analyses of geological material and water. These methods can determine the chemical composition of rocks, soils, minerals, groundwater, and many other substances.
– **Geochemistry** studies chemical elements in the Earth’s crust and their behavior in nature.

– **Geomechanical properties of rocks** are properties which express how rocks behave when subjected to the effects of outside forces (strain, stress), how strong the rocks are (their ability to resist damage), and how prone they are to deformations (changes in shape and volume).

– **Geophysics** studies physical processes and properties of the Earth, such as gravitational or magnetic fields, heat flow, or background radiation. When exploring an area, geophysical methods can be used to define different types of rocks, differentiate between geological structures, or to discover fractures.

– **Gravimetry** is the measuring of Earth’s gravity which changes due to sub-surface rock density. Using gravimetry, researchers can identify different types of rocks according to their density or they can detect areas with significant disruptions of the rock massif. This information is then used to ascertain the geological structure of the explored area.

– **Hydrogeology** studies water under the Earth’s surface.

– **Hydrological conditions** describe the behavior of water in geological environment and rock permeability, primarily monitoring groundwater levels and the speed and direction of groundwater flow.

– **Macroscopic rock structures** are a set of rock features which can be observed by the naked eye.

– **Mineralogical analyses** are used to determine the type of mineral using different methods. These methods might include: analyzing thin sections and polished sections using a polarization or reflected-light microscopes; infrared spectroscopy; X-ray; thermography; and many other methods.

– **Mineralogy** studies minerals, primarily their properties and creation.
– **Petrographic analyses** use different methods to determine rock types. Rock type is determined according to the rock’s chemical and mineral composition and structural and technological properties. The methods used most often include X-ray diffraction analysis silicate analysis (which expresses the rock chemical composition using oxides).

– **Petrography (petrology)** studies rocks, describes their properties and creation, and classifies them into a system.

– **Rock body** is a rock structure which is usually composed of a single type of rock and has boundaries which delimit it in respect to the surrounding rocks.

– **Rock permeability** is the ability of rocks to let water through.
5. LOCAL ACCEPTANCE AND OPPOSITION

5.1 INTRODUCTION

Local opposition\(^1\) can be generally characterized as the interaction between the project investor (typically the state or a private investor) and the representatives of the local community (typically the local government officials, non-governmental organizations, or civic organizations) who demand, *vis-à-vis* the investor, the right to reject the project. Despite the fact that local opposition is by definition connected with a specific, geographically limited, region, its activities can have consequences which extend beyond the local level. This typically happens when the project is connected with the public interest, as in the case of highways, large production facilities, or energy infrastructure (for example power lines).

The local opposition phenomenon has been significantly influencing the shape of the energy sector since at least the early 1960s when the anti-nuclear movement formed in the United States. The movement reached its peak in the mid-1970s when – also as a result of its activities – the use of nuclear power declined (Daubert and Moran 1985: v). Local oppositions, however, are not limited to nuclear power and their activities can be seen in connection

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\(^1\) Local acceptance can be understood in the same way. The only difference is that what is being demanded is not the right to reject a project but the right to accept it.
with any power source (see Ansolabehere and Konisky 2009). The current shift to a low-carbon economy (LCE) based on renewable energy sources also faces similar issues (see Devine-Wright 2011: xxi-xiii). In 2005, for example, the German Energy Agency (Deutsche Energie-Agentur, DENA) announced that the Energie-wende (the German “energy transition”)² will require 850 km of high voltage power lines to be built by 2015. In 2011, however, only 100 kilometers were built and the construction projects still have to face local opposition. In Lower Saxony alone, 137 civic organizations voiced their objections to the project (Fröhlingsdorf 2011). Windfarm construction faces local opposition of similar proportions (see Wolsink 2000). It is therefore clear that local opposition also affects those energy sources which are generally seen as “safe and clean” and this is the case even in strongly pro-environmentally oriented countries.

5.2 THEORY

Local oppositions are essentially social movements. Snow et al. (2004: 6) define them as collective, noninstitutionalized, partly organized forms of action which aim to change a specific feature of local development. The term “noninstitutionalized” means that actions of such an oppositional group take place (also) outside the official channels which are usually used to create and represent interests (for example via public debates, through lobbying, or putting the decision makers under certain social pressure for example

² This transition involves a general change in Germany’s energy systems which includes a broader transformation of German economy as well. The overall aim is to create a low-carbon society. In particular, this involves decreasing the amount of electricity produced from nuclear and fossil fuels and transferring investments into decentralized and renewable energy sources.
via highly medialized events or happenings. When attempting to promote their interests, oppositional movements thus do not usually follow the standard logic of representative democracy according to which they would establish political groups and subsequently take part in regular elections. Instead, oppositional movements typically create pressure on the existing decision-making structures, usually the mayors and the local governments. The reasons are understandable: opposing a specific (construction) project is in most cases a relatively specific issue which cannot serve as the basis for a party’s candidacy in elections. In addition, the deadlines connected with granting permissions to such projects rarely leave enough time to establish a political group and wait for regular elections.

The current debate about local oppositions is divided into the NIMBY (Not-In-My-Back-Yard) and post-NIMBY approaches which differ in how they explain local opposition (for more details see Burningham et al. 2006; Devine-Wright 2007). While the NIMBY approach is based on rational choice theory\(^3\), the post-NIMBY approach is a heterogeneous assortment of various arguments which are united by their critique of the NIMBY approach.

The NIMBY explanation of local opposition is based on a certain paradox when a project which is generally accepted by the

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\(^3\) At the center of the rational choice theory is an actor, defined as an entity which makes choices. Kydd (2008: 425–426) list six additional features which differentiate rational choice theory from other approaches. The actor (a goal-seeking agent) is characterized: 1) by rational decision-making (rationality); 2) by fixed identity; and 3) by having a fixed set of preferences which are attributed to the different outcomes of given decisions. The actor also: 4) rationally derives beliefs about the world and about other actors from new information; 5) downplays normative considerations (although these can be expressed as preferences, if this is needed); and 6) faces a fixed and known set of options (outcomes) of his/her decisions. These factors are given and are not subject to rational calculations (cf. Simon 1955: 100). A basic introduction to this theory is available [here](#).
entire population (or state) is rejected at the local level (van der Horst 2007: 2705). In accordance with rational choice theory, this situation is explained the fact that the local community perceives the project’s costs and benefits in a very specific way: while the benefits are represented by the public interest and thus are equally distributed among the entire population (a more stable electrical grid, for example), some costs of the given project are borne only by the local community – everything connected with the construction of the project, decreased property value due to transmission towers, or a changed landscape (Bell et al. 2005: 465). Local opposition is formed when these costs are not compensated for by additional benefits, be they financial or non-financial, such as fees paid to the municipalities for geological surveys, new roads, playgrounds, water treatment facilities, or preferential selection of local companies for the construction of the project. The NIMBY approach assumes that local opposition – a collective phenomenon – is essentially a sum-total of actions of specific individuals who make their decisions after having rationally considered the costs and benefits connected with the project.

The post-NIMBY explanations rejects the NIMBY concept as too simplistic and straightforward. Instead of accepting the simple cost-and-benefit calculations proposed by the NIMBY approach, the post-NIMBY explanations emphasize many additional factors which go beyond the rational choice theory. Devine-Wright (2007: 5–10) divides these factors into three groups: 1) personal factors (the standard socio-demographic characteristics such as age, gender, or social class); 2) socio-psychological factors (political and environmental views, opinions, and beliefs, general knowledge, place attachment, or trust in the public institutions); and 3) contextual factors which are connected with the specific project (such as the technologies used and the project’s environmental impact), but also the prevailing opinions about the project or technology; therefore, nuclear facilities will be seen differently
in the Czech Republic and differently in Austria (cf. Burningham et al. 2006). The post-NIMBY approaches explain local oppositions as resulting from the interplay of many context-dependent factors (Wolsink 2000; Devine-Wright 2007), emphasizing those which are beyond the perception and control of individuals (Futrell 2003; Burningham et al. 2006).

### 5.2.1 THE NIMBY APPROACHES

The NIMBY concept was introduced as a standard explanation of opposition movements during the 1980s (Schively 2007: 255; Burningham et al. 2006: 3). One of the most influential definitions of NIMBY was provided by Michael Dear (1992: 288) who described it as “protectionist attitudes and the oppositional tactics adopted by community groups facing an unwelcome development in their neighborhood”. Dear describes NIMBY as a phenomenon reacting to locally unwanted land use (LULU). The NIMBY opposition was surveyed in the context of many different projects – industrial, transport, and energy infrastructure; storage facilities of nuclear and toxic waste; prisons; drug rehab centers; affordable (low-income) housing; homeless shelters; shopping malls; or parks (see Johnson and Sicchitano 2012: 411; Schively 2007: 256). As the concept spread, however, its meaning became less specific (Luloff et al. 1998).

Based on different land use patterns, Schively (2007: 256) differentiates between two basic types on NIMBY. The first type is defined by how it impacts the standard of living or property value (facilities mentioned above, such as parks or shopping malls); the second type is defined by the potential health and environmental impacts (for example storage facilities of toxic or nuclear waste). Schively also states that local opposition mostly includes local residents; if people who do not live in the specific area also
get involved, these are mostly members of various groups and organization which are interested in broader economic, social, environmental, or political issues. Members of these groups can then provide the specific local opposition group with organizational, financial, or other support (Schively 2007: 257). With time, many other variants of NIMBY appeared, such as NIABY (Not-In-Anybody’s-Back-Yard), NIMTOO (Not-In-My-Term-Of-Office), BANANA (Build-Absolutely-Nothing-Anywhere-Near-Anyone), NOPE (Not-On-Planet-Earth), and CAVE (Citizens-Against-Virtually-Everything). Acronyms such as YIMBY (Yes-In-My-Back-Yard) or PIMBY (Please-In-My-Back-Yard), which express support for a given project, are also used. As already mentioned, the basic premise of the NIMBY concept is the paradox when a given project is accepted by the public as a whole, but opposition emerges in the specific location where the given project is to be realized (Schively 2007: 255; van der Horst 2007: 2705; Bell, Gray and Haggett 2005: 460; Burningham et al. 2006: 5).

Wolsink (2000: 53) defines NIMBY as a combination of “a positive attitude [towards the general idea] and resistance [towards the project] motivated by calculated personal costs and benefits”. The NIMBY opposition is further characterized by: 1) mistrust of the project investors; 2) limited amount of information; 3) high aversion to risk; or 4) highly emotional response to conflict situations (Smith and Marquez 2000: 273). Kraft and Clary (qtd. Coppens 2007: 2) provide a similar list of concerns, but add that opponents often have local and parochial attitudes towards the project, even if the project has broader implications. Concerns connected with NIMBY opposition also include: 1) decreased property value; 2) the inability of the community to stop subsequent projects once the first one is finished; 3) decreased standard of living due to noise, higher strain on the transportation networks, or unpleasant odors; 4) stigmatization of the community (“bad image”); 5) increased strain on local infrastructure (primarily roads), services,
and budgets; and 6) esthetic issues connected with the project, mostly a mismatch between local architecture or landscape and the project (Sandman 1986: 453). As will be seen, these motives can be grouped into two main models of NIMBY. The first stresses that opponents have little information or are misinformed, the second presupposes a rational-egoistic motivation of the opponents.

Before moving on, it is important to mention another concept of NIMBY. Bell et al. (2005: 461) differentiate between a social and an individual level of NIMBY. A “social gap” corresponds to the aforementioned situation (“the paradox”) when there is a discrepancy between a generally positive attitude towards a project or technology and its rejection at the local level. An “individual gap” then corresponds to a situation when an individual has a positive attitude towards a certain type of project or technology, but is actively opposed to a specific project in their vicinity. Bell et al. (ibid.) also stress that individual gap can only be one of the possible explanations for the social gap. Burningham et al. (2006: 6) state, for example, that an individual explanation of NIMBY is often connected with the fact that the public has too little or information about the project or that this information is incorrect (see Freudenberg and Pastor qtd. Burningham et al. 2006: 6). The perceived risk on the part of the opponents is then significantly higher than the “real” risks. Insufficient or incorrect information then means that potential risks and benefits are evaluated incorrectly. If the public is provided with sufficient and/or correct information, the opposition should weaken significantly (Bell et al. 2005: 465). In principle, this explanation of NIMBY is not different from those which presuppose a selfish reaction.

The second situation occurs when the production of public goods (such as a power plant or a nuclear waste repository) is rational from the collective standpoint (it is good for society to have power plants), however individuals are motivated by specific conditions to freeride (for an individual, it is rational not to have
a power plant directly in their neighborhood). Therefore, from an individual perspective, it is rational not to take part in the production of these public goods. This outcome results from a specific distribution of costs and benefits: individual costs related to the production of public goods (having to tolerate a power plant in one’s neighborhood) are far higher than individual benefits (the specific location of the power plant will not affect the local region, i.e. the local region will not lose electricity even if the power plant is built somewhere else). The NIMBY approach therefore socializes the benefits (the entire society benefits from a power plant) and privatizes the costs (only some have to tolerate the power plant in their neighborhood) of a given project. If all individuals accept this individually rational strategy, it is no longer possible to produce public goods. NIMBY is therefore conceptually connected with freeriding (Bell et al. 2005: 465; Coppens 2007: 1–2).

However, empirical studies of both of these NIMBY models highlight the fact that the significance of these phenomena is fairly limited (for a summary see Bell et al. 2005: 465; Burningham et al. 2006: 6; Devine-Wright 2007: 3; Gibson 2005: 382).

According to Bell et al. (2005: 461–465), the concepts of “democratic deficit” and “qualified support” are different variants of the NIMBY explanation which is based on individual rationality of opponents. The democratic deficit explanation presupposes that while the majority of the public supports a given project, the decision-making process is influenced by the minority of opponents. According to Bell et al. (2005: 462) this explanation is also based on the fact that both opponents and proponents calculate the costs and benefits of the given project. The second explanation (“qualified support”) is based on the assumption that most people will not support a project without objections. Bell et al. (2005: 463) summarize that these objections typically include the project’s impact on the environmental, on the landscape, on the ecosystem (fauna and flora), and on the community. The “qualified support”
model can therefore explain the existence of the social gap which has been mentioned earlier. Bell et al. (2005: 464) further stress that qualified support can be used as a tactical maneuver to disguise selfish motivations of the opponents (see the explanation based on rational egoism mentioned above).

Another controversial aspect of the NIMBY concept is the attached value judgment. Many authors (Burningham et al. 2006; Gibson 2005; Johnson and Sicchitano 2012; Schively 2007) point out that using the NIMBY model as a conceptual-theoretical framework is usually connected with depicting the opponents as individuals who act emotionally or selfishly and thus harm public interests. The NIMBY model is also criticized due to its low representativeness and because it intentionally influences local politicians. This in turn subverts the democratic decision-making process (Johnson and Sicchitano 2012: 411). The NIMBY concept can also be used as a negative label which diminishes the legitimacy of the oppositional stance (Devine-Wright 2007: 10). On the other hand, when framed in a positive way, NIMBY is seen as an important complement to or manifestation of the democratic system (Schively 2007: 257). It facilitates direct participation of citizens, local communities, and disadvantaged groups, allowing them to defend their interests against politically or economically stronger parties (Gibson 2005: 383). In this context, the presupposed discrepancy between the public interest and the narrowly defined selfish interests of the opponents is also criticized. As argued by Gibson (2005: 387), this concept assumes that project investors (be they state institutions or private companies⁴) are represented as players who rationally promote the public interest, without pursuing their own agenda. On the other hand, the

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⁴ This is not connected with the form of ownership – it is assumed that even private investors who invest in infrastructure (and energy) projects promote the public interest (such as electricity production).
possibility that the arguments of local opposition, even if they are presented in an emotional manner, represent in some cases the public interest, cannot be discounted.

5.2.2 THE POST-NIMBY APPROACHES

The unconvincing results of empirical studies and the usually negative framing of local oppositions led to extensive criticism of the NIMBY approach. This subchapter outlines an explanation of local opposition which is not based on the aforementioned assumption of a selfish, rational actor. Patrick Devine-Wright (2007: 5–10) coherently and clearly introduces three groups of factors which might provide an alternative explanation as to why local opposition emerges. These factors are socio-demographic, psychological, and contextual. Burningham et al. (2006: 7) present similar arguments, mentioning the other issues such as trust, concerns about potential health consequences, and ideological and demographic factors. Nevertheless, Devine-Wright (2005, 2007) does not offer a general theory (for example that higher socioeconomic status – connected with a higher level of environmental awareness – increases the probability of local opposition), but he summarizes the conclusions of many empirical studies which found that the levels of local opposition or acceptance are influenced by some of the factors mentioned above.

According to Devine-Wright, the first group comprises socio-demographic factors which include population characteristics such as age, gender, or socioeconomic status. The influence of these individual variables, however, differs significantly according to the context. Among psychological factors Devine-Wright (2007: 6–7) includes: 1) degree of awareness and understanding; 2) political beliefs; 3) environmental beliefs and concerns; 4) place attachment; and 5) perceived fairness and levels of trust. While
Devine-Wright (2007: 6) states that there is only limited evidence for a connection (correlation) between the degree of awareness and understanding and acceptance, he maintains that political beliefs are, in the British context at least, relevant for the acceptance of low-carbon technologies. The same is true in the case of environmental beliefs and concerns where support for renewable energy sources is connected (correlated) with concerns about the impact of climate change. Devine-Wright (2007: 7) emphasizes, however, that the connection between environmental beliefs and acceptance/opposition is more complex and to a certain extent depends on how general the given problem is. While general support for renewable energy sources is connected with global risk perception, opposition to a specific windfarm project can result from the negatively perceived impact such a project might have on a given region. Place attachment can also lead both to support for and opposition to a given project (ibid.) and the evaluation of the project’s impact on the specific location is crucial here. The last psychological factor is perceived fairness and levels of trust. Devine-Wright (ibid.) states that perceived unfairness (connected with the selection of the locality or with the construction of the project) and lack of trust towards the key actors connected with the project was connected with negative (oppositional) attitudes towards the project.

The last group of factors includes contextual factors which encompass: 1) technological factors which define the scale and type of the technology; 2) institutional factors which determine the ownership structures, the distribution of costs and benefits, and the nature of public participation; and 3) spatial factors which include the distance of a given project from inhabited areas as well as its regional and local contexts (Devine-Wright 2007: 7–10). Devine-Wright (2007: 8) stresses that in the case of technological factors, different technologies bring different problems, such as emissions, increased traffic, or other environmental impacts. It
is also important to consider the scale of a given project and its impact. Devine-Wright differentiates the following levels: micro (single building or household level), meso (local, community or town level), and macro (large scale, for example the impact of building a power plant or a dam). Within the context of institutional factors, project legitimacy and trust towards the investors are crucial. Devine-Wright (2007: 9) therefore argues that the levels of compensations per se are not a sufficient condition for accepting a project; perceived fairness of the decision-making process and the distribution of costs and benefits is decisive.

Deliberation is seen as a suitable model to get the local public involved. This is a thorough, rational debate where the main factor is valid arguments and not the position and/or power of the participants. Devine-Wright (ibid.) emphasizes, however, that the deliberation mechanism can also create conditions under which opponents can exchange information and coordinate their views and activities, thus being more effective. Similar arguments are presented by Kemp (qtd. Burningham et al. 2006: 9) who claims that structural, institutional, and contextual factors support certain ways of thinking about a given problem. Kemp (ibid.) emphasizes that negative (oppositional) attitudes are primarily created when the process lacks transparency, fairness, and comprehensibility. In the case of spatial factors, a positive relationship (correlation) between the proximity of a project and oppositional attitudes was not empirically proven, since studies offer both negative and positive conclusions. This means that individuals who live close to a project can have more positive attitudes than those who live further away (Devine-Wright 2007: 9).

Robert Futrell (2003: 360) opposes the mechanistic notions about the origins of local opposition where individuals possess fixed ideological preferences tied to individual though schemata which are activated due to a change in external circumstances, that is by the announcement of a project. Instead he inverts the
traditional relation between problems and solutions (ibid.). Solutions do not have to be formulated only after a problem was identified; instead, they can provide frames within which the problem can be thematized (Spector and Kitsuse 1977 qtd. in Burningham et al. 2006: 10). The assumption that the perception of a given project is influenced by interaction with the investors and other important stakeholders is also significant (Futrell 2003: 360). Burningham et al. (2006: 10) add that local opposition cannot therefore be seen only as an aggregate outcome of individuals acting rationally, but rather as a product of socially constructed (and therefore) context-dependent demands.

5.2.3 THREE IDEOLOGICAL DISTINCTIONS OF LOCAL OPPOSITION

The discussion between the NIMBY and the post-NIMBY approaches will now be structured along three lines of ideological distinction which separate the specific arguments into ideologically homogenous groups.

The first distinction is based on a different conception of actor’s rationality and this is one of the significant differences between the NIMBY and the post-NIMBY approaches. While the NIMBY approaches are based on rational choice theory, the post-NIMBY approaches usually criticize the concept of instrumental rationality and stress the value systems of actors or their value rationality. The second distinction is based on different concepts of justice. While the NIMBY approaches stress distributive justice connected with fair distribution of costs and benefits (this type of justice is outcome-oriented), the post-NIMBY approaches focus primarily on procedural justice related to the process of

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5 A fair solution divides the costs and benefits equally among the participants.
distribution\(^6\) (this type of justice is \textit{process-oriented}). The issue of (environmental) justice is commonly addressed in the literature on local opposition (Cotton 2005; Cotton and Motta 2011). The third distinction arises due to different forms of democratic governance. The NIMBY approaches clearly distinguish between the public interest and the private interests of the opponents, implicitly delegitimizing the latter (see above). Here, the NIMBY approaches come close to the “elite democracy” model in which decision-making is entrusted to the elected representatives of the people. The post-NIMBY approaches stress equal participation of the local community and is therefore closer to the “participatory democracy” model which presupposes that citizens significantly and directly participate in the decision-making process. The concept of (democratic) governance and specifically the issue of local community involvement is also often addressed in the current literature on local opposition (Cotton 2010; Churchman 2012).

5.2.3.1 RATIONALITY

Rationality is one of the basic philosophical categories. In humanities and social sciences, the distinction between instrumental and value rationality, introduced by Max Weber, is particularly widespread and influential (Hollis and Smith 1990).\(^7\)

Instrumental rationality, which is the central concept of rational choice theory (see Kydd 2008; Quackenbush 2004), is usually defined as the ability to choose an action which results in the most preferred outcome (Vanberg 2002: 10) or the ability to effectively achieve given goals (Russell 1954: 8 qtd. Thacher

\(^6\) A fair solution offers fair amount of participation for everyone involved.

\(^7\) This distinction is based on Weber’s typology of social actions which can have emotional, traditional, value-rational, and instrumentally-rational characteristics (Kalberg 1980: 1148).
Instrumental rationality, however, does not evaluate the goals themselves, because in many cases, they can have emotional or other “non-rational” motivations. The instrumental rationality mechanism is connected with utilitarian calculations and it determines and justifies the desired goal which is to maximize benefits. According to the tenets of classical utilitarianism, ethical behavior is defined as behavior which results in the greatest happiness of the greatest number of people and therefore in the greatest level of overall gains (see Bentham 1789/1996: 11–12). Actions which increase the benefits of the entire society, even if they disadvantage a specific minority, are also acceptable. Actions which provide the most benefits to a given society are therefore both rational and ethical. The utilitarian perspective – unlike that based on value rationality – does not recognize an intrinsic value of things or actions.

Not only personal attitudes but also public policies can be based on these ideas. When instrumental rationality is applied in combination with economic utilitarianism (which is an important strand of utilitarianism), it is permissible to undertake any project (regardless of its environmental impact, for example) as long as the (economic) benefits (including externalities) are greater than the costs (including externalities).

As the name suggests, value rationality is defined by values and beliefs (for example religious beliefs) which limit the actors in what can be considered acceptable or ethical behavior. At the same time, these values and beliefs are independent of the results of one’s behavior. From the viewpoint of value rationality, considering and comparing alternative consequences of one’s actions is therefore irrelevant (Oakes 2003: 39). While instrumental rationality is conceptually connected with consequentialist views of ethics (which hold that behavior is justified by its end-goal which is to maximize benefits), value rationality is consistent with deontological ethics (where behavior is justified by being in accord
with a specific system of rules); for more, see the three formulations of Kant’s moral imperative or Rawls’s Liberty Principle. Here, ethical behavior is defined by being in accord with a set of accepted values and with the rules which are derived from these values. Production of public goods (for example construction of highways) therefore cannot be justifiable by the fact that it benefits society, but only if rules are obeyed; these rules can include protection of private ownership or of the environment.

Environmental ethics further elaborates on these distinctions using the concepts of instrumental and intrinsic values. While instrumental value of a specific entity is given by how the entity helps to protect or to maximize a specific intrinsic value, such as the prosperity of the human race, intrinsic value of a specific entity is given by its nature per se, such as by the uniqueness of a landscape (McShane 2009: 408–409). The anthropocentric approach assumes that only human beings and their interests have intrinsic value; the value of all other entities is determined by how beneficial these entities are to humans and to their interests. On the other hand, the non-anthropocentric approach ascribes intrinsic value at least to some parts of the natural world (McShane 2009: 407–408). In the first case, if a piece of land serves as a source of food, its value will be instrumental. In the second case, a piece of land will have intrinsic value, because it is a unique environmental entity. An intrinsic value of a specific entity then creates a moral obligation to protect it. Environmental protection and landscape preservation is therefore connected not only with instrumental value but also with intrinsic value.

8 “Each person is to have an equal right to the most extensive basic liberty compatible with a similar liberty for others.” (Rawls 1999: 53)
5.2.3.2 JUSTICE

Justice is another key philosophical concept. Apart from its many other roles, it co-determines how people think about social organization and about the management of public goods. Concepts of justice are always situated in a “complex system of ideas which provide the basis for explaining and critiquing politics” (Dufek 2010: 56). Each concept of justice is therefore closely tied with broader notions of normative political theory which provides the framework for interpreting additional key concepts such as freedom, equality, legitimate political authority, and many others (ibid.). Within the context of this book, the key concept is democratic governance which is introduced below. Here, one of the most important distinctions is between distributive and procedural justice.

Distributive justice defines how goods and burdens (costs and benefits) should be distributed in society. A typical example is Rawls’s Difference Principle which states that “social and economic inequalities should be arranged in such a way as to provide the most benefit to the most disadvantaged members of society” (Rawls 1999:53). Rawls is convinced that from an ethical point of view, it is irrelevant how this state of affairs is achieved, as long as the Liberty Principle and the Fair Equality of Opportunity Principle are observed. If, for example, a ban on mining in a given area improves the (environmental) position of the most disadvantaged group of (local) inhabitants, then – if the process abides by the above-mentioned rules – it is not relevant whether the ban is the result of a central/local government decision or a central/local referendum (or whether it is the outcome of any other measure).

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9 Rawls states that “positions and offices should be open to all on condition that the Fair Equality of Opportunity Principle is observed” (Rawls 1999: 53).
On the other hand, procedural justice defines the rules and processes which should determine how resources are to be distributed in society. Rawls’s Original Position\(^{10}\) serves as a useful example because it can be used to arrive at the principles of distributive justice. The Original Position does not presupposes any specific outcome. For example, if the guiding principle is to be the consent of the local community, a decision is fair as long as it was reached this way, even if the decision itself has negative consequences in the future (for example, a decision to build a mine which will cause serious environmental damage, including related negative externalities). One variant of procedural justice is the participation model of procedural justice (see Solum 2004: 259–273). This model is based on the assumption that everyone who is to be affected by a decision-making process should have a “fair share” in terms of participation in that process. Therefore, if a decision-making process is to be fair, it must be ensured that all those concerned have the right to participate. This version of procedural justice is typically connected with environmental issues, but also with other questions (see Pretty and Pimbert 1995; Schlosberg 2004).

The Environmental Protection Agency (EPA) recognizes both dimensions of justice (distributive and procedural) when it defines environmental justice as “equitable distribution of environmental harms and benefits and a fair inclusion in the decision-making process, regardless of race, income or ethnicity” (EPA 2015).

\(^{10}\) The Original Position is a default neutral state which serves as the basis for creating the principles of fairness. The neutrality of the basic assumptions is guaranteed by a “veil of ignorance” which “hides” personal predispositions and characteristics of the individuals, as well as the historical, social, economic, and other circumstances into which they are born (Rawls 1999: 15–19).
5.2.3.3 GOVERNANCE

Governance is the third central politico-philosophical concept employed in this book. Governance theory deals with the political organization of society, focusing on questions such as: What constitutes a legitimate political authority? How should private interests be promoted? What constitutes a public interest and how should it be promoted? Representative democracy can currently be seen as the dominant form of government in the Western world. The third ideological distinction is then based on the extent to which components of direct democracy are strengthened or weakened in representative democracies. At the one end of the spectrum is the “elite democracy” model and at the other is the “participatory democracy” model.

Representative democracy is based on the fact that voters delegate their political will to their representatives who are chosen via free elections\(^\text{11}\) or other mediatory mechanisms\(^\text{12}\) (Ankersmit 2007: 21). The elected representatives should then represent the interests of their voters, ensuring that all citizens participate in the governance process while the costs are kept to a reasonable level. Representative democracy is therefore based on the principle of political representation. According to an influential definition provided by Hanna Pitkin, political representation is an activity through which the voices, views, and opinions of the voters are “presented again” (that is “re-presented”) in the process of creating public policies. Political representation therefore includes situations when “political actors speak, advocate, symbolize, and act on the behalf of others in the political arena” (ibid.). The legitimacy of political representation then rests upon the collective judgment of the electorate which – while respecting the rules of
democracy – prefers one candidate to another. This preferred candidate will act as a representative for a specific social group and will fulfil a specific function.

In simplified terms, elite democracy can be seen as a kind of minimal definition of representative democracy which is based on free elections (see above), on the separation of powers, and on the majority principle of decision-making. The people who compete for political offices in free elections are mostly members of the social elite\(^\text{13}\); the moment they are elected, they enjoy a significant amount of autonomy *vis-à-vis* their voters and their political actions are therefore restricted mostly institutionally, particularly by the separation of powers and by the majority principle (see Posner 2003: 130, 164). The elite democracy model is most closely connected with Joseph Schumpeter who claims that “democracy does not mean and cannot mean that the people actually rule in any obvious sense of terms ‘people’ and ‘rule’. Democracy means only that the people have the opportunity of accepting or refusing the men who are to rule them” (Schumpeter 1942/2010: 284–285). Because of the interaction between the expert knowledge (possessed by the elites) and the bureaucratic apparatus (possessed by the state), it is then possible to tackle the complex problems faced by modern society. In this context, then, the representative principle is transformed and the only way for the (unelected) citizens to influence the decision-making process is to use the elections to remove the ruling elites from office. Elite democracy also focuses on the stability of the social system rather than on issues such as voter education, self-improvement, or protection of marginalized groups (Sturm 1998: 135).

\(^{13}\) Elite democracy is connected with a pessimistic view as to the ability of voters to keep track of the political situation, to understand it, and to influence it (Pestoff 2009: 201). On the other hand, the elites are “endowed” with expert knowledge and experience which allow them to govern better.
Participatory democracy is then described as a “process of collective decision-making that combines elements from both direct and representative democracy” (Aragonés and Pagés 2008: 1). In this approach to democracy, citizens have the right to directly decide about certain issues. One example is participative budgeting where citizens decide how to spend a portion of the town’s budget (ibid.). This approach interconnects the concepts of participatory democracy and procedural justice (see above) which is sometimes listed as a desired component of participatory governance (see Churchman 2012; Wipf et al. 2009). One component of participatory democracy is the deliberation process. The aim of this process is to use reciprocal rational argumentation to reach a consensus, to find a better solution, or to identify the cause of a conflict (Floridia 2013: 3). In this way, participatory democracy combines the institutions of elected representatives with public gatherings; the aim of these gatherings is to increase the legitimacy of the decision-making process by strengthening procedural justice and the accountability of elected representatives. This system, in contrast with representative democracy, brings policy-making closer to the citizens. It is also important to notice the normative shift relating to the notion of citizenship which reflects a more positive anthropology of this approach. In contrast to seeing “the man in the street” as incompetent and shortsighted, participatory democracy emphasizes the capacity of people for self-improvement. The same holds true for the ideals of individual self-determination, autonomy, and independence; these ideas, however, are not usually 

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14 This relationship is, however, not unambiguous since both representative and elite models of democracy rest on some shared procedures, most notably the election procedure.

15 Participation and deliberation (or participatory and deliberative democracies) cannot be equated, despite the fact that they share some important characteristics, namely the attempt to strengthen the role citizens play in policy creation and political decision-making (see Floridia 2013).
connected with typically liberal notions which see the individual as a rational, atomized egoist\textsuperscript{16} (The Port Huron Statement qtd. Floridia 2013: 4).

5.3 METHODOLOGY

To analyze local oppositions, it is possible to use a set of methods grounded in relational sociology. Relational sociology stresses that social identities, meanings, and opinions are constructed via transactions between individual actors, for example through a public discussion at a town meeting or during a casual conversation people have in a store or in a pub. This perspective is intertwined with social network analysis (SNA).\textsuperscript{17} The theoretical foundations of SNA emphasize that actors are anchored within their social environments (social surrounding) and that this is crucial for the development of their identities, preferences, and opinions; in addition, SNA offers a robust methodological framework to study all these phenomena. One area of research focuses on knowledge networks. These include discursive networks which represent an interconnection between actor networks (individuals and institutions) and ideational networks (primacy of the public interest over the interests of a local community, mistrust towards the state, participatory governance, environmental protection). A discursive network thus includes actors who are connected both by direct ties (for example when mayors cooperate on an issues which affect their villages or when different state institutions col-

\textsuperscript{16} This is the extreme form of liberalism as described by proponents of participatory forms of governance and maybe by some libertarians. The individual distinctions are, however, constructed as ideal types; emphasizing definitional characteristics is therefore understood in this context.

\textsuperscript{17} The phrase “social network” is used here in its most general sense, not referring to specific social networks such as Facebook.
laborate) and by ties which include shared ideas and values (for example international collaboration of non-governmental organizations which have the same interests). This means that the analysis of local oppositions can be based on the analysis of discursive networks. This analysis interconnects two specific methods: social network analysis (which studies contacts and ties between individual actors) and frame analysis (which studies the way actors thematize a given problem). In specific cases, the results of frame and network analyses can be used as source of data for simulating the future developments in a given local community or to model different situational changes such as the appearance of new actors (a non-governmental organization which did not exist or was not active in a given community; a new platform for negotiating between the investor and the local residents) or changes in other aspects (more attractive incentives, such as compensations, or the fact that the local community finds a new way to participate in the project).

5.3.1 SELECTED METHODS FOR THE STUDY OF LOCAL OPPOSITIONS

5.3.1.1 NETWORK ANALYSIS

The term “network” is usually understood as an entity composed of two types of features, nodes (vertices) and ties (edges). Networks are further divided into real, observed, and hypothetical. Real networks are understood as unobservable structures which (jointly) form a specific observed phenomenon (such as a social network constituted by friendship bonds). Observable networks are manifestations of real networks (such as a social network of Facebook friends) – these are networks which can be measured and used to estimate the parameters of the real underlying
network. Hypothetical networks represent ideal network arrangements (such as a random or a regular network) which can then be compared to observed networks and indirectly to real networks as well. Social networks can then be regarded as networks which are either created by social actors and processes (for example family, friendship, professional, commercial, semantic, or discursive networks) or which involve social processes and actors (such as individuals, groups, organizations, or states).

Social network analysis (SNA) therefore explores how social actors are connected through social relationships or interactions. Emphasis is placed on exploring regular relationship patterns (structures) in which actors are anchored. The goal of SNA is to measure and represent these structure as well as explain their origins and consequences (Knoke and Yang 2008: 4). In the case of SNA, distinction is usually made between relational and positional network analysis. Relational analysis explains social behavior through direct and indirect relationships which exist between actors. It therefore focuses on the topology (shape) of the network, actors’ centrality, as well as sub-group cohesion (see below). Positional analysis, rather than studying relationships, aims to identify actors which have a similar position within the network (the “structural equivalence” concept; see 2.3). The basic assumption is that a given position is usually connected with a specific social role or with a set of social roles. Actors who occupy similar positions will therefore have a tendency to manifest similar behavior (Everton 2012: 402).

5.3.1.2 FRAME ANALYSIS

The goal of frame analysis is to discover the shared ideational schemata through which individual actors understand a specific problem or problems and which (jointly) form their behavior vis-à-vis this problem (Benford and Snow 2003; Entman 2003).
Framing itself is then defined as the process of creating and using these interpretive schemata (frames). In other words, it is a thematization of a concrete problem and this thematization represents a specific “version of reality” or a way of looking at the given problem; in the case of such representations, it is common that some of their characteristics are emphasized and others are suppressed. Apart from interpreting and evaluating a problem, framing also involves proposing and promoting a specific solution or a specific problem-related policy (Entman 2003: 417). Framing is therefore essentially not only a form of thematization, but also a form of strategic behavior which aims to dominate or at least to change the public discussion about a given problem. A country where public support for renewable energy is thematized as a distortion of the free market with electricity, which then destabilizes a (working) energy system based on fossil fuels, will have a specific energy policy. On the other hand, a country where the public discussion about renewable energy emphasizes the positive environmental impacts (focuses on the negative externalities of fossil fuels) and stresses energy self-sufficiency of local communities will have a very different energy policy. Framing is a directed activity of an actor (or of a group of actors) which aims to promote their own thematization of a given problem within which society (or at least its part) will perceive the problem and make decisions accordingly. In the Czech context, one of the best examples is the former president Václav Klaus. His framing and thematization of climate change\footnote{Klaus denies anthropogenic climate change and instead emphasizes “the dangers of ideological environmentalism” which threaten economic growth – an activity Klaus sees as the most important goal of human actions.} or of European integration\footnote{Klaus sees the European Union as an over-bureaucratized, over-regulated colossus which lacks democratic control. Comparing EU to the Soviet Union is also part of his framing.} was accepted by a large segment of the Czech population.
and still strongly influences the ways people think about these topics today.

5.3.1.3 AGENT-BASED MODELLING

Agent-based modelling (ABM) is a computational method which allows researchers to create, analyze, and experiment with models which represent given actors interacting in a given environment. In this sense, models can be understood as purposeful simplifications of reality which facilitate its easier understanding (Starfield et al. 1990). Models also allow researchers to carry out experiments which would not be possible in the real world – for example to observe the growth and development of a city (because such an experiment would be too lengthy and difficult) or to study the movement of a crowd in a specific space (a building) during a fire (because such an experiment would be too dangerous). In such cases, models (working only with selected components of reality which are relevant for the research goal) offer an easy way to reduce time demands and financial costs or to avoid ethical issues.

Agent-based models are based on the assumption that even difficult (social) systems can emerge as aggregates of specific actions of individual actors. Therefore, ABM does not focus primarily on the system as such or on different variables which characterize the system (in economics, for example, the market and the interaction between supply and demand) but emphasis is placed on the individual actors who follow certain goals – organisms want to survive, stock brokers want to make money, companies want to generate profit and stay to on the market, state authorities want to enforce the laws. There are differences between these actors – in their size, in their position within the system, in the resources they have available, in their motivations and histories; and their behavior can be seen as adaptive – they change it based on the
available information about themselves, about the other actors, and about the environment which is being created and shaped by their activities.

The classic example of ABM use is Schelling’s segregation model (1971) which assumes that households from two ethnic groups occupy the same area. The model contained a two-dimensional “board” (a map of the area) and actors – households situated on the board in such a way that they were adjacent to three, five, or eight other households. Some of these households were from the same ethnic group and some were from a different ethnic group. The model further assumed that around 30 per cent of the cells on the board were vacant and that agents could relocate to these cells. Another assumption was that each household had specific preferences with regard to the ethnic composition of its surrounding – it demanded that a certain number of the adjacent households be from the same ethnic group as its own. If a household was adjacent to more households from the other ethnic group than it was willing to tolerate, then it moved to a random vacant cell. In this way, Schelling explored what equilibrium state of household distribution will be created on the board depending on the preferences for a neighbor from the same ethnic group. The model showed that even willingness to live in a neighborhood where as much as 70 per cent of the households are from a different ethnic group leads to the creation of ethnically homogenous and segregated areas.

Specificities of agent-based models

**Actor Representation**

In agent-based models, actors can be represented in different ways. There are models where one actor corresponds to one specific real actors (an energy company or a farmer) but also models where actors represent a class or a group of real actors (the gov-
ernment, the unions, or employees; companies can therefore be represented by any one of the model actors).

**Actor Heterogeneity**
In agent-based models, individual characteristics can be assigned to individual actors or to groups of actors. These models can therefore reflect the heterogeneity of actors according to different factors: their possibility to influence the environment in which they interact (the state versus individuals); the different ways actors make decisions (bureaucratic institutions, non-governmental institutions, associations, and individuals all make decisions in different ways); or according to other characteristic features (such as political preferences of individuals, prescribed goals and permitted actions of state institutions, or – in the case of local oppositions – the three lines of ideological distinction related to rationality, justice, and governance which were mentioned above).

**Environment**
In agent-based models, environment is the basic parameter because it directly influences the interactions of the actors by delimiting boundaries. In some cases, these boundaries are delimited very strictly (for example, the model explores how actors interact in a specific area, through a specific form of communication, or through specific legislation which limits certain types of behavior); in other cases, boundaries are defined more loosely, for example through transportation costs (be they expressed in time or money) which limit the possibilities of actors to meet and to influence their opinions.

**Mutual Influences between Actors**
Inter-actor interaction is the key element of agent-based models. For the purposes of the model, it can acquire different forms:
from the simplest ones which simulate only formalized interactions, such as information exchange (for example how information spreads through a specific network of actors) to the relatively complex ones which take into consideration many different factors, such as communication noise (there is only a certain probability that the intended message will reach the recipient) or the fact that – due to interaction with others – actors may change their opinions and behavior.

**Evolution and Learning**

Agent-based models are also able to simulate actors’ learning on both individual and collective levels. Learning can have different forms: 1) individual learning (where actors learn through their own experience); 2) evolutionary learning (which eliminates unsuccessful actors – they “go extinct” and are then replaced by more successful actors); and 3) social learning (where some actors offer knowledge or experience to other actors). For example, models which focus on corporate behavior combine individual and evolutionary learning – companies learn to decrease unit costs (for example by optimizing the manufacturing process and logistics) with the least successful companies going bankrupt and freeing a place on the market for new business models. In the case of local oppositions, the most important aspect is social learning, for example when non-governmental organizations share information about the most effective ways to mobilize the local community. However, forms of individual learning can also be applied when exploring and specifying these methods.
5.3.2 METHODOLOGICAL PRACTICE

5.3.2.1 FRAME ANALYSIS

5.3.2.1.1 PRELIMINARY PHASE

In the experimental part of the research, both types of analysis follow a similar set of steps. The research begins with the preliminary phase which involves familiarization with the given problem. This includes studying the facts (including the details), the theoretical issues, and the actors who influence the problem. When analyzing local opposition to a specific project, this means studying similar projects, specifically their technological and economic characteristics and focusing on how these projects impacted local communities. The entire process also involves theoretical reflections on the issue of local opposition (as sketched above). Finally, it is necessary to identify the actors which influence the authorization and construction of the project; these are typically the investor, local state authorities (the Ministry of the Environment, the local mining administration), mayors of the municipalities which are involved in the project, or non-governmental organization.

5.3.2.1.2 RESEARCH TOOLS AND DATA COLLECTION

The next step involves creating the research tools. Frame analysis usually uses semi-structured interviews: its basic structure is given, yet the questions are intentionally asked in a general way so that the interviewees can express their views on the problem in their own words, including their position as well as the positions of other actors who are involved in the project. When transcribed, these interviews usually constitute the main data source. When examining public figures, however, the data corpus (the collection of texts) can be also made to include their public statements, because it can be assumed that they will be in line with the way these actors frame the problem.
5.3.2.1.3 DATA PROCESSING

The first step is to transcribe the interviews. The transcription should follow a specific transcription manual which provides specific guidelines for specific situations. For example: special characters should be inserted before names of people, geographic locations, and organizations so that these can be later identified; whether to transcribe the interviews into standard language or keep the text unchanged\(^{20}\); or whether to include the questions in the final text or keep the answers only.

The next step is the coding process which involves identifying and labelling concrete meanings in the text. Given the fact that a frame is essentially a set of specific, recurring meanings which – when taken together – create a coherent picture about a given problem, data processing (transcription of the interviews and other texts) is done through coding (which precedes data evaluation). Coding involves looking for and labelling of specific codes which represent the recurring meanings within a text. The entire process is as follows: First, it is necessary to create a coding scheme – a list of all the codes, their detailed characteristics (what they mean), and the coding rules (when the codes are used, when they are not used, and how they differ from other codes). The coding scheme can be created using the induction method whereby individual codes are identified as “recurring meanings within a text”. The researcher therefore repeatedly reads through the text corpus and looks for fixed argumentative patterns. When analyzing local opposition to a deep geological repository of nu-

\(^{20}\) This depends on the text processing method. For quantitative methods which are based on word frequency, it is better to transcribe the text into the standard language because the algorithm counts the word stems which can be changed in a non-standard dialect. However, for some forms of qualitative analysis, it is better to keep the text unchanged, including fillers such as “uh”, “er”, or “um”.
clear waste in the Czech Republic, the code (meaning) “repository fail” can be used:

The repository fail concept is related to the speaker’s concerns that the storage technology will fail (either in a short- or long-term perspective), regardless of the specific factors which cause the speaker to mistrust the technological and geological aspects of the project itself. For example: “Basically, there are two main arguments there, first, the safety of the structure has not been proven, or the safety of the system as such, of course it will be developing further so I stress that it won’t affect our generation, maybe later only in terms of the structure, not technology, but I’m not aware of a repository in the world, I mean a permanent repository, which is already functional, something or other is done everywhere, some kind of laboratory, but a working repository for ten, hundred thousand years, I don’t know of such a thing.” (From an interview MAY 014)

Apart from the codes created through the inductive method, the coding scheme can also contain codes which were created through a deductive process – by isolating the main points of the theoretical reflection about the given problem. In the case of local opposition, this might include a theoretical basis represented by the NIMBY/post-NIMBY divide or by the three lines of ideological distinction (rationality, justice, and governance) which were mentioned earlier. The specific codes will therefore reflect the specific basis of these theories or theoretical concepts. In the case of instrumental rationality, this could mean a code such as “moral obligation/cost acknowledgement”:

The moral obligation concept is related to the explicit recognition of a moral obligation to compensate for production of public goods. If a given community uses public goods, such as electricity, it has a moral obligation to bear some of the costs connected with
production of electricity, for example to tolerate power lines or a deep geological repository in its neighborhood. Failure to recognize such an obligation is connected with individual selfish motivation which decreases the effectiveness with which public interests can be promoted and subsequently also decreases the amount of benefits for the entire society. Such behavior is in conflict with utilitarian ethics and is therefore thematized as morally questionable. This concept is therefore included in the instrumental rationality category. For example: “I always tell it to everyone – that when I eat a yogurt, I get some pleasure out of it. [...] But we have to, that’s clear, that then you have the cup left and somebody has to get rid of it. But people don’t care about it, they just throw it in some garbage can somewhere and someone else must take care of it. (From an interview MAY 016)

The coding process itself involves labelling partial segments in the text corpus. Each segment which contains a specific meaning is labelled with a specific code which represents the meaning. All is done using specialized software such as ATLAS.ti or the RQDA package for R; this process is actually not very different from adding comments in MS Word.

The coding process is the key to successful research. Given the fact that the presence or absence of a specific meaning in a given text segment is not always entirely clear, it is not possible to encode the text corpus based on one reading of the text by one person (coder) only, since this would result in chronic unreliability of the research.21 There are two solutions to this problem: 1) mechanical coding of the text using keywords and fixed ex-

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21 Reliability states to what extent two different researchers would reach the same results using the same data. If different coders see different meanings in the same text, one coder cannot guarantee that the coding was reliable. This in turn does not allow the researchers to draw reliable conclusions about the given topic.
pressions, ideally done by a computer; 2) coding using a detailed text analysis (which includes “reading between the lines”) carried out by multiple coders – they must undergo special training and show agreement in coding, meaning that the same text segment is assigned the same code. By definition, mechanical coding is reliable, time efficient, and cheap, yet it significantly decreases the amount of useful information gained by researchers. For example, it is very difficult to determine whether the speaker asserts that the project will increase employment or whether the speaker questions this assertion. The use of coders allows researchers to examine the meaning of the text much more thoroughly, yet its reliability is problematic and this makes the entire method more demanding in terms of time and money.

While mechanical coding only involves identifying key-words connected with given meanings and subsequently entering them into the software, using coders is much more complex. The entire process begins by selecting (at least two) coders. They are then given detailed information about the research goals, about the theoretical approach to the problem (if this is relevant), and also about the derived categories, concepts, and codes. The coders then read through the coding scheme and are briefed on the meaning of individual codes. The coders should be given the opportunity to talk about how they understand individual concepts and codes and they should also have the opportunity to ask questions about the coding process and other related issues. The next phase involves testing the codes. During this phase, the codes independently encode a randomly selected text segment; subsequently, their reliability is assessed. This is done on two levels: 1) inter-rater reliability assesses the agreement between coders using percentage agreement indices. What percentage of codes is in agreement, i.e. the same text segment is labelled with the same code.
and Krippendorff’s alpha\textsuperscript{23} (see Krippendorff 2004); 2) intra-rater reliability uses correlational analysis\textsuperscript{24} to assess the reliability of the coding scheme when used repeatedly. The last portion of the training involves result evaluation, analysis of incorrectly encoded segments, and proposals to improve the coding scheme (the actual improvements of the coding scheme might also be carried out at this point); codes which were shown to cause chronic problems are usually encoded in a more formalized manner (it is determined which argumentative patterns fall under a given code and which do not; as a last resort, specific keywords and phrases with the desired meanings are defined and other instances are not encoded); codes can also be merged or split. The coding process, evaluation, and modifications to the coding procedure continue until the coders reach a desired level of agreement: both Krippen-

\textsuperscript{23} Krippendorff’s alpha expresses the ratio between the observed disagreement among coders and the expected rate of disagreement, i.e. the amount of disagreement which would be created if coding was done randomly. When interpreting the results, this value is subtracted from 1. The value of $\alpha$ therefore ranges between $-1$ and 1; 1 denotes total agreement while 0 denotes absence of agreement (0 corresponds to a situation in which coding is done absolutely randomly). The coefficient can theoretically also reach negative values if there is systematic disagreement; if the coders were coding “inversely” (i.e. one coder would always encode an opposite value of a binary variable than the other coder), the value of $\alpha$ would be $-1$. Krippendorff’s alpha can be used for any number of values of a variable (i.e. for any number of codes), for any number of coders, for both large and small data sets, for both categorical and metric data, and it can also be used for data which lack some observations (a situation when one coder is coding and the other one is not) (Krippendorff 2004: 222).

\textsuperscript{24} Test-retest correlation is used to determine how reliable a coding tool is when used repeatedly and this reliability is expressed using the Pearson Correlation Coefficient ($r$). When this procedure is implemented, the same coder encodes the same text using the same coding tool. This is done twice over a short time period (approximately one week) and the results of the two sessions are then correlated. The higher the value of the correlation coefficient, the higher the agreement between the first and the second coding sessions, and vice versa.
dorff’s alpha and Pearson Correlation Coefficient $r$ must be above 0.7. The entire process of coding reliability testing is depicted on the flowchart below:

![Flowchart](image)

**Fig. 18. Testing of coding reliability**

### 5.3.2.1.4 DATA EVALUATION

The encoded text is evaluated using a software. It can show the distance between individual codes (in the text), which codes are often used together, which codes overlap, and which codes do not occur together. The software can also show whether some actors prefer certain codes or whether they avoid using others; it is also possible to see the emphasis put on certain codes (or code combinations) by certain actors and whether this emphasis is shared by other actors or not. Code combinations used by certain actors (or by groups of actors) then create frames – a comprehensive set of arguments about a problem.

These results can show, for example, that local opposition unanimously rejects a specific project due to mistrust. However, one sub-group rejects it because it mistrusts the technology being used while another sub-group mistrusts the investor or the state authorities – it is unsure that they will supervise the project properly or they mistrust the efficiency of justice if the investor is found
to be at fault. Local opposition will therefore be based on frames which emphasize the risks connected with the given technology or mistrust the ways the process is organized.

5.3.2.2 NETWORK ANALYSIS

5.3.2.2.1 PRELIMINARY PHASE

The preliminary phase of network analysis is to a significant degree similar to the preliminary phase of frame analysis. It also involves familiarization with the problem which includes studying the facts, the theoretical issues, and the actors who influence the problem. Network analysis will emphasize the actors and the relationships between them.

5.3.2.2.2 RESEARCH TOOLS AND DATA COLLECTION

The questionnaire for network analysis data collection is significantly different from the interviews used for frame analysis, because it consists mostly of closed questions. The respondents therefore do not have the possibility to write their own answers, they just decide between several available ones, choosing those which best expresses their views. The questions related to network analysis aim to find out about cooperation and general interaction between the actors who are connected with the given problem in order to identify their (inter)connections within the given problem. The questions can therefore include the following examples: How often do you pass on project-related information to other actors? How often do you receive project-related information from other actors? With which actors do you coordinate your project-related activities? With which actors do you directly collaborate in relation to the project?
5. LOCAL ACCEPTANCE AND OPPOSITION

Each question has a set of answers from which the respondent chooses the most suitable one. In reality, the questionnaire consists of questions and answers which can look like this:

How often do you pass on project information to other actors?

<table>
<thead>
<tr>
<th>Actor 1</th>
<th>More often</th>
<th>Once a week</th>
<th>Once a month</th>
<th>Less often</th>
<th>Never</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actor 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actor 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Data processing is then done exclusively using a software which evaluates mutual relationships between actors based on the questionnaire information.

5.3.2.2.3 DATA EVALUATION

A network arrangement is described by its topology. Networks can have different topologies, depending on the arrangement of their nodes and ties (Freeman 1978: 218). The two main analytical categories are connectivity and centrality. It is also standard procedure to differentiate between local and global scales. While local scales are related to individual nodes, ties, or partial sections of the network (subgraphs), global scales are related to the entire network.

Connectivity

Connectivity describes the interconnectedness of a network. It therefore focuses on the way a graph is connected. Whether a network is connected or disconnected, how many components can
be identified, what are their properties, which ties significantly influence connectivity, etc. Network density is also a fundamental concept: it is the ratio of the observed number of ties to the maximum number of possible ties in the network. Another important concept is robustness which is usually defined by node and tie connectivity; this defines how many network components (ties or nodes) must be removed in order to disconnect the network. By eliminating certain nodes and ties, two separate components (unconnected network sections) can be created: these crucial nodes and edges are called cutpoints and bridges, respectively. Bridges are always weak ties which are crucial for determining diffusion (Granovetter 1973).  

Centrality

Centrality describes the position of individual nodes within the network or within a network section. This concept also assumes that some nodes are more important than others due to their position (Freeman 1978; Wasserman and Faust 1994: 169). Centrality analysis rests upon three commonly used variants of centrality: degree centrality, closeness centrality, and betweenness centrality (see Freeman 1978). Maximum centrality of a node therefore corresponds to a star-shaped configuration where one node is adjacent to all other nodes while all the other nodes are only adjacent to the central node. In a cycle configuration, all nodes have an equivalent position and therefore the same value of centrality (in all its variants).

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Granovetter’s (1973) study is very well known in this context. In his study Granovetter showed that the most important prerequisite for getting a job is not the individual characteristics of the applicant (such as their motivation or qualification), but the number of weak ties through which the applicant can receive information (for example about a vacant position) from otherwise distant social circles.
Degree centrality is defined by number of the links incident to a node. High degree of a given node is usually connected with high importance or influence of given actors. A high degree actor can directly reach a high number of other actors. On the other hand, low degree actors usually occupy a peripheral position. Closeness centrality represents an actor’s proximity to all the other actors within a network. Closeness expresses a given actor’s reachability or peripherality within the entire network. High centrality is usually connected with the ability to quickly spread information or other resources through the network. Betweenness centrality expresses how important a given node is in terms of connecting other nodes in the network. High betweenness of an actor therefore means that the given actor is interconnected with two or more groups of actors who are otherwise connected only by weak ties. A high betweenness actors is thus crucial for the cohesion of the entire network; it acts as a cutpoint (or mediator) between two or more disconnected groups of actors.
Centrality analysis can yield a lot of important information. In the case of (energy) infrastructure placement and the related phenomena of local opposition and acceptance, researchers can learn a lot about the interaction between the investor, the local community, and non-governmental organizations. In the case of a specific project, researchers can, for example, observe which actors are crucial in terms of spreading information. If a working group is created in order to bring together all the stakeholders and to find a compromise solution, yet the central actors are not included, there is reason to doubt the effectiveness and functionality of such a group. High betweenness actors can be asked to undertake the role of mediators. High degree actors are then crucial in terms of
approaching the specific network segments, such as communities in different areas.

5.3.2.3 AGENT-BASED MODELLING

5.3.2.3.1 FORMULATING THE RESEARCH QUESTION

A research question serves as the main guideline for research and for creating models. In principle, it is the entire research goal simplified into a single sentence. Formulating the research question is usually a continuous process and during model creation, the research question is often changed or modified because it has become clear that it is not specific enough, that it is too general, or that it is too simplistic.

5.3.2.3.2 FORMULATING PARTIAL HYPOTHESES

The specificity of agent-based modeling is that the models do not necessarily attempt to create substitute categories for groups of actors (such as leftist voters, employees, or the civic sector), but can present each individual actor involved in the problem under examination. This direct representation of reality requires the researchers to formulate a full range of theses according to which the model then operates. In the case of local oppositions, this can involve a thesis about how the local community perceives the costs associated with accepting a given project. This perception can be framed by analyzing costs and benefits (environmental strains versus compensations), by the attitudes a society or a community has towards the technology or a project (a deep geological repository of nuclear waste versus a supermarket), and also by the relationship the community has with the given area and the attitudes the local community has towards industrial developments in the area. The partial theses can look as follows:
– The bigger the disproportion between environmental costs and benefits, the higher the perceived costs.
– The more the project is seen as dangerous or undesirable, the higher the perceived costs.
– The closer the relationship between the community and the area, the higher the perceived costs.
– The less experience the community has with industrial development, the higher the perceived costs.
– The higher the perceived costs, the greater the opposition to the project.

These theses represent an intermediate stage in model creation which should always proceed from the simplest thesis (in this case, the last one on the list) to the more detailed ones which deal with specific issues (such as the relationship between the community and the area); the more specific theses thus improve the model which can then represent reality more accurately.

5.3.2.3.3 MODEL PROPOSAL AND IMPLEMENTATION

Having set the partial theses and the model assumptions, it is now time to formulate the model in words. This is a proposal which articulates: 1) the basic specificities of the environment in which the actors are situated; 2) the basic information about the actors (typology, motivation, numbers, etc.); and 3) the operational parameters of the model, such as the way in which the actors interact, the duration of the simulation, and the time or condition when the model simulation finishes. This phase is a suitable time for further discussions – with those who are experts in the given field, with modeling experts, with the project contracting party, and with other professionals.

The final proposal is then translated into a computational language. Currently, one software used most often is NetLogo.
(Wilensky). It is sophisticated enough, yet, thanks to an intuitive graphical user interface, it is also accessible to beginner-level researchers.

5.3.2.3.4 TESTING AND REVISING THE MODEL

Model testing has two main goals: 1) to increase the representational validity of the model (that is how much the model corresponds to the reality being simulated); and 2) to increase the analytical value of the model (that is to increase the possibilities the simulation offers to the researchers). The goal of this phase is twofold: First, to modify the model so that the actors’ behavior corresponds as closely as possible to observed reality. Second, the model should allow the researchers to test or simulate the settings which affect both the environment of the model and the behavior of the actors, as far as these settings are analytically relevant.

This is usually the most difficult phase of model creation and it often leads to the reevaluation of previous phases – from totally reformulating the central research question to small corrections of partial hypotheses.
This book aims to provide understanding of selected activities related to energy infrastructure related site evaluation. Reflecting the recent development in the European oil & gas and nuclear industry, namely shale gas controversies and nuclear waste repository siting processes taking place in various EU Member States, the book opts for a novel approach. With recognition of the increasing importance of the local acceptance and opposition towards new (energy) infrastructure projects the book intends to highlight the need for a more comprehensive approach, when evaluating the possible sites or locations.

A combination of solid knowledge of the technical, geological and social aspects of the project seems crucial for its implementation in the way that is acceptable for both the investor and local community. Importantly, these aspects are much closer interrelated than it could appear on the first glance. While geological and technological features are key drivers in the project’s sustainability, the approval by the local communities is nowadays a prerequisite for the project to materialize in the first place. In the modern developed societies the participation of the local communities on the project planning and implementation is likely to be the most efficient means of achieving consensus and getting to that approval. To ensure meaningful participation, in turn, more information on the community, its perceptions, needs and ways of thinking is needed.

The main ambition of this book is therefore to introduce a comprehensive approach towards a site evaluation. Apart from
6. CONCLUSIONS

traditional geological exploration and technological planning we include techniques developed to better understand the local communities and help them voice their expectations, concerns and conditions for approval. The more the local community knows about the particular technology and its interaction with its immediate environment and the more is known about the community’s priorities the more efficient its participation on the project development is. In this sense, the book is intended as a contribution to bringing the communities, authorities and investors closer together.
7. LITERATURE


of space in Israel: The map of settlements and land. Jerusalem: Land Use Research Institute and Keter Books.


Zákon č. 44/1988 Sb., zákon o ochraně a využití nerostného bohatství (horní zákon)

Zákon č. 61/1988 Sb., o hornické činnosti, výbušninách a o státní báňské správě

Zákon č. 62/1988 Sb., o geologických pracích
8. ABSTRACT

This book aims to describe exploration activities, their methods, and the impact they have on their environment. In an accessible manner, it will also try to explain the legislative framework surrounding the issue of exploration areas and to explain how activities connected with building energy infrastructure may influence the public. The book deals with energy infrastructure on two levels: First, it looks at exploration areas when used to look for energy raw materials (natural resources which can be used as sources of energy), focusing on oil, gas and the front end of the nuclear fuel cycle, i.e. uranium prospects and mining, and the geological aspects of the rear end, i.e. localization and prospecting sites suitable for geological repository of the decommissioned nuclear fuel. Second, it focuses on the issue of local acceptance and local oppositions. It introduces the phenomena of local opposition, its most influential reflections in social science theory, and methodological tools to provide deeper understanding of the particular opposition movements.

The main ambition of this book is to introduce a comprehensive approach towards a site evaluation. Apart from traditional geological exploration and technological planning we include techniques developed to better understand the local communities and help them voice their expectations, concerns and conditions for approval. The more the local community knows about the particular technology and its interaction with its immediate environment and the more is known about the community’s pri-
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ENERGY INFRASTRUCTURE AND EXPLORATION AREAS:
CHARACTERISTICS, RELATIONSHIPS, AND LOCAL ACCEPTANCE

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