

REPUBLIC OF TURKEY
YILDIZ TECHNICAL UNIVERSITY
GRADUATE SCHOOL OF SCIENCE AND ENGINEERING

AN ANALYSIS FOR FINANCING SELECTION CRITERIA FOR
HYDROELECTRIC POWER PLANT CONSTRUCTION

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MASTER OF SCIENCE THESIS

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Supervisor

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A thesis submitted by Selin İPİN in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE is approved by the committee on 09.03.2022 in Department of Architecture, Housing Production and Construction Management Program.

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Selin İPİN

Dedicated to my family



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LIST OF ABBREVIATIONS

AHP	Analytical Hierarchy Process
BOO	Build-own-operate
BOT	Build-operate-transfer
ECA	Export Credit Agency
EIA	U.S. Energy Information Administration
EP	Equator Principles
EPC	Engineering- Procurement- Construction
E&S	Environmental and Social
EXIM	Export-Import
FiT	Feed-in-Tariff
HEP	Hydroelectric Power
HEPP	Hydroelectric Power Plant
HSW	Hydraulic State Works
IBRD	International Bank for Reconstruction and Development
IDA	International Development Association
IFC	International Finance Corporation
MIGA	Multilateral Investment Guarantee Agency
OECD	Organisation for Economic Co-operation and Development
O&M	Operation and Maintenance
PF	Project Finance
PPA	Power Purchase Agreement
PPP	Public Private Partnership
ROR	Run-of-river
RPS	Renewable Portfolio Standard
SPV	Special Purpose Vehicle
TEA	Turkish Electricity Authority

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A Financial Model Proposal for Financing Selection Criteria for Hydroelectric Power Plant Construction

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Department of Architecture

Master of Science Thesis

Supervisor: Assoc. Prof. Dr. Tuğçe ERCAN

Hydroelectric power plants have been used for electricity generation all over the world for over a century. The financing processes of hydroelectric power plants, which are both energy and large-scale construction projects, are quite complex, as are the construction processes. Projects financed entirely by the public in the past have turned into investment projects after the liberalization of the electricity market, and with this process, financing channels have also diversified. Today, there are various financial institutions and different products of them provide financing to hydroelectric power plants. The characteristic features of hydroelectric power plants similar to construction projects create various problems in the financing of these projects. With this study, it is investigated both to identify these problems and which of the financing channels can better respond to the needs of hydroelectric power plant projects. Within the scope of the thesis, the features of hydroelectric power plants that make financing difficult were compiled in the light of the data obtained from the literature, and then the most important of these features were selected with the participation of a large group

such as financial institutions, investors, insurance companies and power plant operators. Afterwards, these features were matched with the financing channels, and they were weighted in the presence of a group composed of sector representatives, and which factors came to the fore were determined. The study is a first in hydroelectric power plant financing and will fill an important gap in the literature. In addition, it is aimed that the thesis study will be an important source of information for further studies.

Keywords: Hydroelectric power plant, finance, project finance, analytical hierarchy process, Delphi technique



Hidroelektrik Santral Yapımında Finansman Seçim Kriterleri İçin Bir Analiz

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Hidroelektrik santraller bir yüzyılı aşkın süredir tüm dünyada elektrik üretimi için kullanılmaktadır. Yapısı itibariyle hem enerji hem de büyük ölçekli inşaat projeleri olan hidroelektrik santrallerin yapım süreçleri gibi finansman süreçleri de oldukça karmaşıktır. Geçmişte tamamen kamu tarafından finanse edilen projeler, elektrik piyasasının liberalleşmesi sonrasında bir yatırım projesi haline dönüşmüş, ve bu süreç ile birlikte finansman kanalları da çeşitlenmiştir. Günümüzde hidroelektrik santrallere finansman sağlayan çok çeşitli finans kuruluşları ve bu kuruluşların farklı ürünleri bulunmaktadır. Hidroelektrik santrallerin inşaat projelerine benzer karakteristik özellikleri, bu projelerin finansmanında çeşitli sorunlar oluşturmaktadır. Çalışma ile hem bu sorunların tespit edilmesi, hem de finansman kanallarından hangilerinin hidroelektrik santral projelerinin ihtiyaçlarına daha iyi yanıt verebildiği araştırılmaktadır. Tez çalışması kapsamında hidroelektrik santrallerin finansmanı zorlaştıran özellikleri literatürden elde edilen veriler ışığında derlenmiş, sonrasında finans kuruluşları, yatırımcılar, sigorta kuruluşları, santral işletmecileri gibi geniş bir grubun katılımıyla bu özelliklerden en önemlileri seçilmiştir. Sonrasında bu özellikler finansman kanalları ile eşleştirilerek yine

sektör temsilcilerinden oluşturulan bir grup eşliğinde ağırlıklandırılmış ve hangi faktörlerin öne çıktığının tespiti gerçekleştirilmiştir. Çalışma, hidroelektrik santral finansmanı konusunda bir ilk niteliği taşımakta olup, literatürdeki önemli bir boşluğu dolduracaktır. Ayrıca tez çalışmasının daha sonraki çalışmalar için önemli bir bilgi kaynağı olması amaçlanmaktadır.

Anahtar Kelimeler: Hidroelektrik santral, finans, proje finansmanı, analitik hiyerarşi yöntemi, Delphi tekniği



1.1 Literature Review

Since the Industrial Revolution and the latter part of the 19th century, electricity has become one of the most important needs of modern societies and is still increasing with the diversification and expansion of economic activities. Hydroelectric power (HEP) is the most important renewable resource used in electricity generation worldwide. The relatively small environmental impact, the sustainability and long life of hydroelectric power plants (HEPPs), and additional functions such as flood control and irrigation are the main reasons for their prevalence. HEP accounts for 17.5% of all electricity generated in the world and its share is expected to increase in the coming decades [1].

The changes in the structure of the electricity generation market since its liberalization and privatization in the mid-1990s has directly affected HEPPs in many ways from construction to financing. The switch to liberalization for the construction of HEPPs meant that public resources were no longer needed. Through public-private sector cooperation and the establishment of partnerships, the development of new HEPPs was completely transferred to the private sector. This change in ownership triggered another transformation in financing models of HEPPs. Previously funded by governments and /or development banks, HEPPs have become fully or partially financed by the private sector and commercial banks and have begun to carry investment value. The new HEPPs are not only electricity generating facilities, but also vehicles for profit to investors [2], because the abolition of monopolies has enabled many more investors to enter the energy market. As the market evolved from monopoly to oligopoly, the financial viability of HEPPs was emphasized, resulting in new financing packages, models and sourcing, and a focus on risk-taking mechanisms.

Since establishing a proper financing model depends primarily on the choice of funding sources, their suitability for offsetting the certain weaknesses of the HEPPs has become crucial.

Since HEPPs are described as construction intensive infrastructure projects, the main items to be financed are construction works. The life cycle of HEPP projects can be classified as pre-construction, construction, and operation. The pre-construction phase is the phase where the necessary measurements are taken to determine whether the project is feasible, and the project is placed on legal ground. The pre-construction phase can be financed by the investor and less capital intensive than the construction phase. The most critical phase of the project is determined as the construction phase because long-term and continuous funding is needed to complete the project. Financing is vital for the construction work to last for a few years. Financiers come into play because of the reasons such that the budgets of the large HEPP projects are too high for the investor to fund alone, and using equity only makes project financially inefficient. As most of the cost of HEPP projects come from construction works, it is very critical to fund the construction phase of the project. The operation period is the phase when the debts will be repaid, and dividends will be distributed. The timely repayment of the loans and the ability of investors to profit from the project are the most important indicators of the success of the project.

All financial institutions that provide funding for HEPP projects are called “financing channels” and the tools provided from these channels are called “financial products”. The characteristics of financial products are shaped according to the channel from which type of financing is provided, because each financing channel finds funds from different markets and/or under different conditions. Using financial products that can meet the needs of the project positively affects the financial performance of the project. Doing this depends on selecting the right financing channels. A well-prepared financing package is created by these channels providing loans at specific rates for each project.

The financing channels mentioned in the literature are under the heading of renewable energy, not for hydroelectric power plant projects. In addition, only

financing channels were mentioned in the literature and detailed information about financial products was not given. Since financial products must be combined in order to make financial arrangements, information about them has been obtained from textbooks. Accordingly, the data obtained from the literature will be summarized below.

When the studies in the literature are examined, it has been determined that there is no literature specifically related to HEPP financing. Since the main features affecting financing can be examined under the same title, the scan has been expanded to renewable energy financing. The studies obtained as a result of the literature review can be examined in 3 main groups such as renewable energy incentives, traditional tools used in project finance, innovative financial tools such as bonds, sukuk, citizen participation and crowdfunding, and local sectoral evaluations.

Firstly, renewable energy incentives are generally examined in the literature under feed-in-tariff (FiT), renewable portfolio standard (RPS) and tax incentives. In the most studies, FiT and RPS have been described as mechanisms that positively affect renewable energy development [3, 4, 6, 2013]. After the mentioned mechanisms started to be implemented, their effects could be evaluated, and there were opinions that it would be more appropriate to apply these incentives according to the market's development level [7]. Although it was previously stated that the incentives had no effect on the development of the renewable energy market [8], as the years progressed, questions arose as to whether the incentive mechanisms were effective. At this stage, Bobinaite and Tarvydas [9] revealed that the use of incentives with other financial instruments yields more effective results. In the next stages, Antoniou and Strausz [5] brought to the agenda that incentives do not have an impact on important problems such as market entry costs and externalities in renewable energy.

Secondly, studies those have the main topic as traditional and innovative financing tools are common in the selected literature and mostly innovative tools were studied. The earliest study about the topic is Brunschweiler's (2010), that arguing the importance of financial intermediary development for renewable energy sector

development and Kulikova [11] also support this argument. However, Steffen and Schmidt [12] proved that multilaterals play the most important role for the renewable energy development. In addition to that, there are many studies that have showed that innovative financing products have a positive effect on renewable energy financing. Of these, Mathews and Kidney [13] green bonds, O'Kane [14] and Ming et.al. [15] carbon finance, Morea and Poggi [16] sukuk, Yildiz [17] and Prislán et.al. [18] mentions that more innovative tools such as cooperative, financial citizen participation and crowdfunding have significant effects on enhancing financing conditions of renewable energy financing. In the literature, there are also studies focusing on the relationship between risk and financing, which examines renewable energy projects with both positive and negative aspects. Of these, Matekanya [19] indicated the importance of innovative tools such as derivatives, put options and swaps in the risk management of renewable energy projects, while Verma and Jagtap [20] dealt with the classification of risks. On the other hand, Xue and Sun [21] focused only on the environmental risks of large HEPP projects. On the other hand, the studies of Thierie and De Moor [22, 23] focus on the analysis of the factors that determining the cost of debt and maturity in project finance loans. As a result, the studies in this group selected from the literature do not show a historical plot and contain very different subjects and approaches.

The last group of the studies in the literature can be defined as local sectoral evaluations because all of them were criticised Turkish renewable energy market. In this context, Komurcu and Akpınar [24] reveal the importance of hydroelectric power plants in the development of Turkey. Kaygusuz and Sari [25], on the other hand, examined the existing policies and offered solutions in order to ensure the development of renewable energy in Turkey. In addition, Kaygusuz [26] and Yuksel and Arman [27] stated that hydroelectric and bioenergy dominate the renewable energy sector in Turkey and what needs to be done for the development of wind and solar energy. Considering the renewable energy boom in Turkey after 2015, it can be said that all these studies reflect the situation at the time they were published. Later studies [28, 29] discuss the role of renewable energy in Turkey's sustainable development with the effect of the Paris Agreement signed in 2016.

As a result, it is seen that there are many different focuses and approaches in studies on renewable energy financing in the literature. Since there is no specific study directly on the financing of HEPP projects among all these studies, this study will make an important contribution to fill this gap in the literature.

1.2 Objective of the Thesis

Within the scope of the traditional financing approach, which was transformed into renewable energy, the project financing method came to the fore. Project finance that forms the roof of this thesis is under-represented in research, therefore project finance research are mostly the textbooks. Although project financing has been used in practice for a long time, it has not received enough attention in the academy, so there is not enough academic work in the field of project financing [30]. In addition, there is no literature review to date that focuses project finance approach in HEPP projects.

Since the project financing method is a method that is often used in financing HEPP projects, which are actually large construction projects, it is a suitable study subject for the construction management field. Project finance is advantageous both clarity and complexity benefits for empirical research and provides insights on construction management.

Given all this, the main purpose of this thesis is:

- Developing a model proposal for selection of financing type by determining selection criteria and weights of financing channels and products,

Secondary aims are:

- Contributing to limited academic knowledge in the field of project finance
- Identification of financing channels with a holistic approach,
- Determination of factors that make HEPP projects financing complicated and determination of their impact levels.

Within the scope of the thesis, in the first part, the literature review, the purpose and scope of the study are specified. In the second part, the life cycle of HEPP projects is examined according to their construction processes and the process from the beginning to the end of these projects is explained. In the third part, the

project financing structure will be discussed by considering its use in HEPP projects. In the fourth section, the methodology of the thesis study will be explained and in the fifth section, the results will be explained.

1.3 Hypothesis

With the model to be proposed, it is aimed to facilitate the selection of financing channels in the financing processes of hydroelectric power plants and to determine which financing channel is more suitable for HEPP projects. The proposed model is aimed to be a guide for both HEPP investors and finance sector professionals.

The following advantages are expected from the proposed model in HEPP financing processes:

- Determining the selection criteria and weights in project financing will enable more accurate investment decisions for HEPPs.
- Systematic evaluation of financing channels will positively affect investment decisions.
- The value of the important factors in the literature in practical application will be determined.
- The factors considered in the practice of HEPP projects financing will be revealed.
- The place and importance of different financing channels in the HEPP projects financing will be determined.
- In addition, the condition that the development of financial intermediaries for deployment of renewable energy financing put forward by Brunnschweiler [10] and Kulikova [11] will be evaluated.

HYDROELECTRIC POWER PLANTS FROM THE PERSPECTIVE OF CONSTRUCTION MANAGEMENT

2.1 Overview of Hydroelectric Power Plants

HEPP is one of the most widely used renewable energy type in the world, and in 2021, the world-wide hydroelectric capacity reached 1,330 GW, this number constitutes %17,5 of all electricity produced in the world [1].

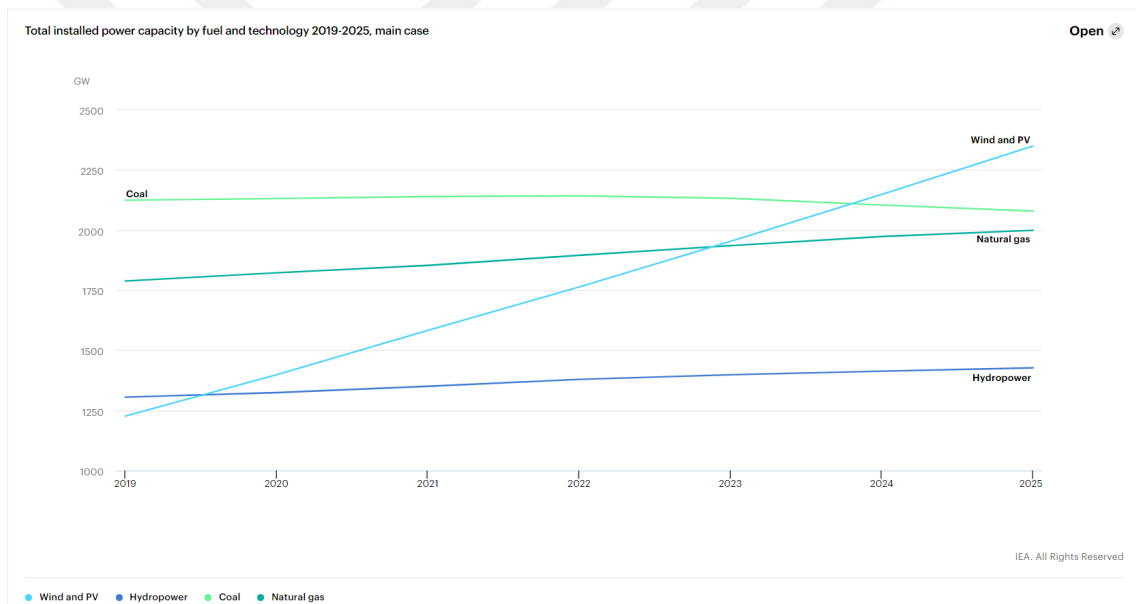


Figure 2.1 Global Renewable Capacity 2019-2025 [31]

Although the history of the use of waterpower dates back to 202 BC in the Chinese Dynasty, its first industrial use was in England in 1771. In 1827, the turbine technology was developed and the world's first HEPP was built. Since then, hydroelectric capacity has been on a continuous upward trend throughout the world. Turkey added 2,48 GW to its hydropower capacity in 2020 [1].

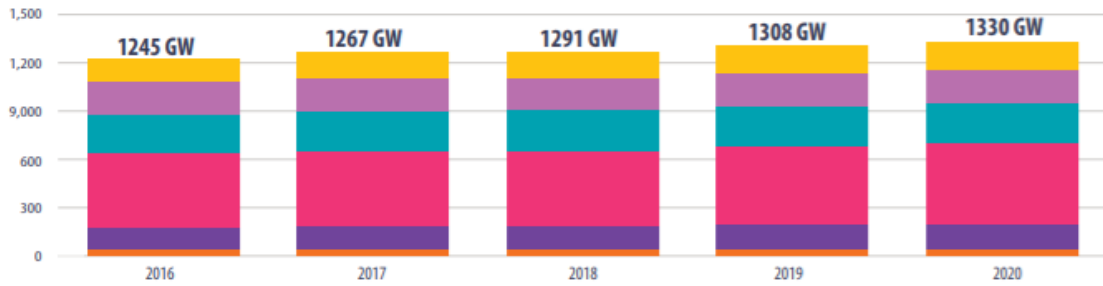


Figure 2.2 Hydropower Installed Capacity Growth 2016-2020 [1]

First micro HEPP of Turkey was built in 1902 in Tarsus while the first large-scale was built in 1913 in Istanbul. With the establishment of the Electrical Power Resources Survey and Development Administration in 1935, hydroelectric potential has been started to be investigated throughout the country (Komurcu & Akpinar, 2010). Although electricity was only available in the city centres in the early days, it was started to be supplied to the villages with the support of Bank of Provinces and Etibank. With the establishment of the State Hydraulic Works (SHW) in 1954, hydroelectric power generation increased. In 1970, Turkey Electricity Authority was established between 1970-1990 and electricity power was provided to all villages in Turkey [24]. Despite HEPPs are known and used in Turkey since nearly a century, the construction of the largest power plants in the Southeastern Anatolia Project (SAP) has been through. Under the SAP, 17 HEPPs were planned and built on the Tigris and Euphrates rivers [27], Turkey's largest HEPPs were among them. Which today has 714 units of HEPP with Turkey, 14% of the hydropower potential of Europe, the world constitutes 1% of the hydropower potential [24].

Hydroelectric power is one of the most important elements of development in terms of being a renewable resource that supports sustainable development and providing cheap energy. In addition, HEPPs are exempt from exchange rate fluctuations and supply problems that cause volatility in electricity prices [33, 34]. Contribution to the development of waterways and infrastructure makes HEPPs important both for Turkey and the world.

HEPPs can be classified according to their size or installed capacity, head size, operation regime and purpose of plant structures [33]. The following describes the classification according to the operation regime which includes run-of-river, storage, pumped storage and offshore schemes.

2.1.1 Run-of-River Scheme

Run-of river (ROR) type HEPPs are power plants that produce electricity by using water flow immediately [34]. ROR type HEPPs operate on the principle of separating the water from the riverbed, storing it in desilting tank and forebay pond and directing the water to the turbines respectively. Water from the turbine can be discharged to the same or a different stream. Because of using instant water flow, they are affected by seasonal flow changes and weather conditions. This causes fluctuations in the production of these type of HEPPs.

Most ROR type HEPPs do not have a storage while some of them have a small one with night-and-day regulation [34, p.33]. ROR type HEPPs are applicable to only rivers those flow is sufficient in dry season [35].



Figure 2.3 Run-of-River Scheme HEPP- Chief Joseph Dam, US [36]

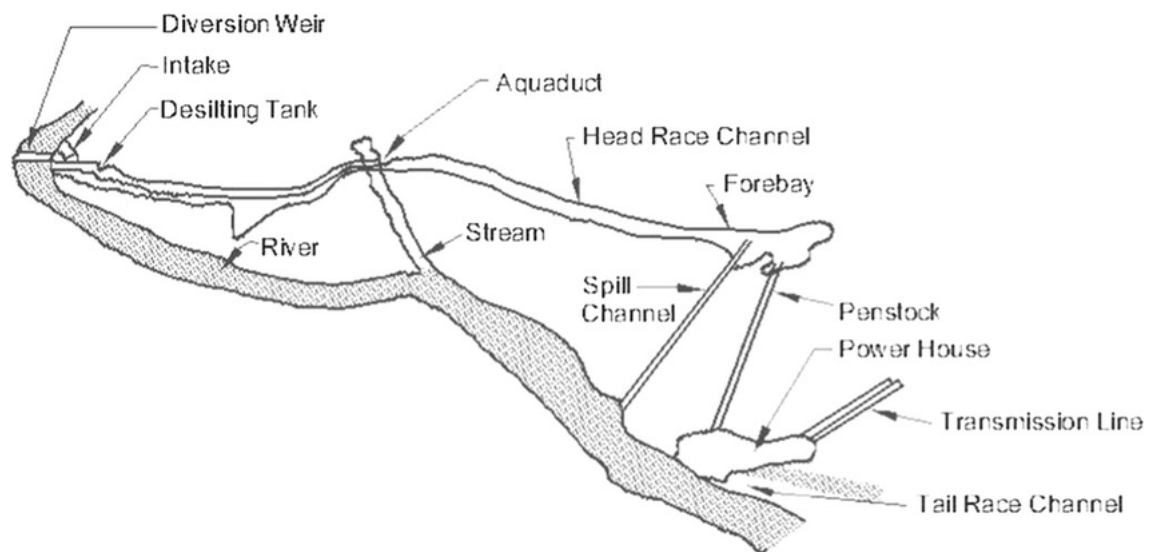


Figure 2.4 General Layout Plan of a Run-of-River HEPP [37]

When RORs are small and well designed, they have the advantages such as low environmental risks due to their low impact on nature and easier financing due to relatively low initial investment cost. However, due to lack of reservoirs, their productions cannot be considered reliable. In addition, large RORs can have a high environmental impact that increases the risks, therefore financing of those projects are difficult.

2.1.2 Storage Scheme

The storage schemes comprise a reservoir for storage of water that feeds the turbine [35]. The reservoir created by a dam structure, allow water to be stored during the seasons with high water flow and used for electricity generation when it is low. Unlike RORs, storage HEPPs have reliable production. In addition, storage systems are not affected by seasonal changes and weather conditions. Size of the reservoir strongly depends on the level of flow regulation and requirement of peak power generation [33].



Figure 2.5 Storage Scheme HEPP- Ataturk Dam, Turkey [38]

Of course, there is always a difference between the demand of electricity both daily and seasonally. Storage schemes help to reach peak demand level production at a required time. In addition, having a storage makes it possible to sell electricity while price is high, allowing investors flexibility in supply that leads more profit.

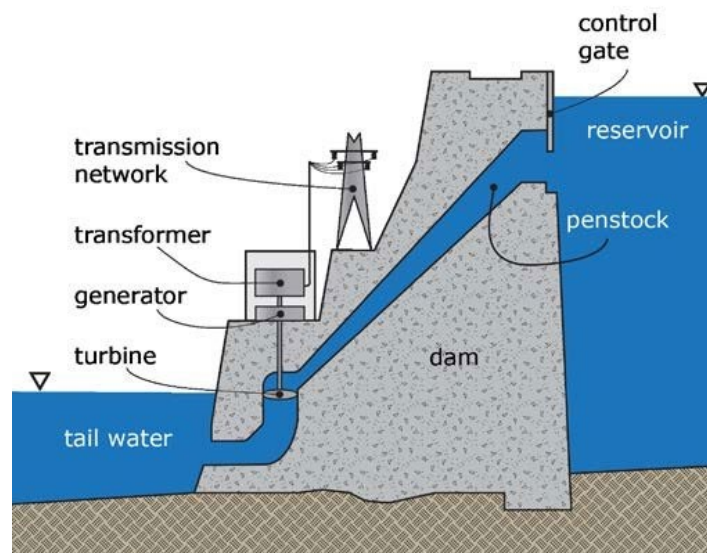


Figure 2.6 Section of Storage Scheme [39]

Storage schemes are preferred due to both electricity generation and other benefits such as drinking and irrigation water reserves, flood control, aquaculture, and recreational facilities. In addition, storage schemes allow the development of solar and wind energy due to the fact that they can be activated at any time in the absence of resources in other renewables. Financing of storage schemes is difficult because these investments are lumpy and sometimes single large dam costs billions of dollars [35]. In addition to high initial cost and environmental concerns, construction period of storage schemes is long and therefore the construction risks are high. With these negative features, financing of those projects is complex and problematic.

2.1.3 Pumped Hydropower Storage Scheme

Pumped hydropower storage (PHS) is a double reservoir system. It operates on the principle of pumping water from the lower reservoir to the upper reservoir at certain times. When the electricity demand and / or the price is low, the water in the lower reservoir is pumped to the upper reservoir and made ready for electricity production. When there is extra demand and the price increases, production is made in the logic of standard storage scheme with water pumped to the upper reservoir. PHSs also provide the storage of excess energy produced in solar and wind power plants and their flexibly use in the absence of these resources [40]. In other words, PHSs contribute energy storage. The efficiency of such systems is one of the highest as 80% - pumps use only 20% of stored energy [33].

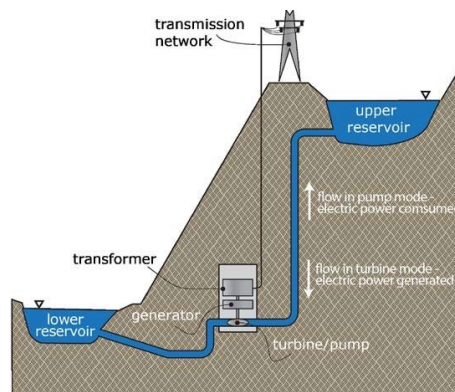


Figure 2.7 Section of Pumped Storage Scheme [39]

The installed capacity of pumped storage HEPPs worldwide reached to 160 GW in 2021 and is in an upward trend [1]. The conversion of existing HEPPs to pumped storage HEPPs means that large reservoirs can be used, and not only daily demand cycles can be met but also seasonal [41].



Figure 2.8 Pumped Storage HEPP [42]

Financing of PHSs should be arranged tailor-made as in other HEPP types. High initial cost and long construction period aggravate financing just like storage schemes and contribute extending payback period. In addition, unclear cash flow makes reimbursement difficult, highlighting the role of financing model optimization. For these reasons, PHSs are generally funded by public sector [37, 33]. All in all, especially HEPPs with large reservoirs are the hardest one to finance. Whether with reservoir or PHS schemes, financing of both is more complicated and difficult than ROR scheme due to factors such as environmental and social impacts, high initial investment costs, excess construction risks and length of the construction period.

Lifecycle of the HEPP projects can be divided into 3 phases, pre-construction, construction, and operation (Figure 2.9). Pre-construction phase can be basically defined as preparation activities for project implementation. Those are listed as

project identification, determination and measurement of site-specific data, preliminary project design, environmental and social assessment, licensing process, financing, and final project design & project management planning. Construction phase includes all construction activities related to plant, such as headworks, waterway, dam body, powerhouse and tailrace, auxiliary structures construction. Operation phase consists of operation, maintenance, and demolition / re-use of the plant.

2.2 Lifecycle of Hydroelectric Power Plants

Life cycle of HEPP projects can be divided into three; pre-construction, construction, and operation (Figure 2.9.). Firstly, pre-construction activities can be called as project development activities. Project development activities are costly phase of the project because HEPP projects are highly site-specific and requires extensive technical, social, and environmental studies [43]. Since this stage is the stage where the project implementation decision is taken, project investors face the risk that the project will never be realized although they do all the feasibility studies. Therefore, some of the feasibility studies are carried out from the public budget. Since project development is the stage where the project stakeholders are also determined, the project structure continues through this setup until the end of the project. The part of the project development activities that are out of public responsibility is funded by the investor. The spent money will form part of the project equity. Financing and loan allocation are carried out in the pre-construction phase. Approval of financing is entirely dependent on the previous phases, for example, the project production estimate values are appropriate, the project is in line with the legal legislation. The financing phase then continues at best, until the end of the project construction phase. The financing phase begins with the emergence of the project idea and continues at almost all stages. While the process up to loan allocation goes with public and equity financing, the next process proceeds with debt financing. After these stages are completed successfully, another important stage, the construction stage, is started. The construction phase is a long-lasting process, such as the pre-

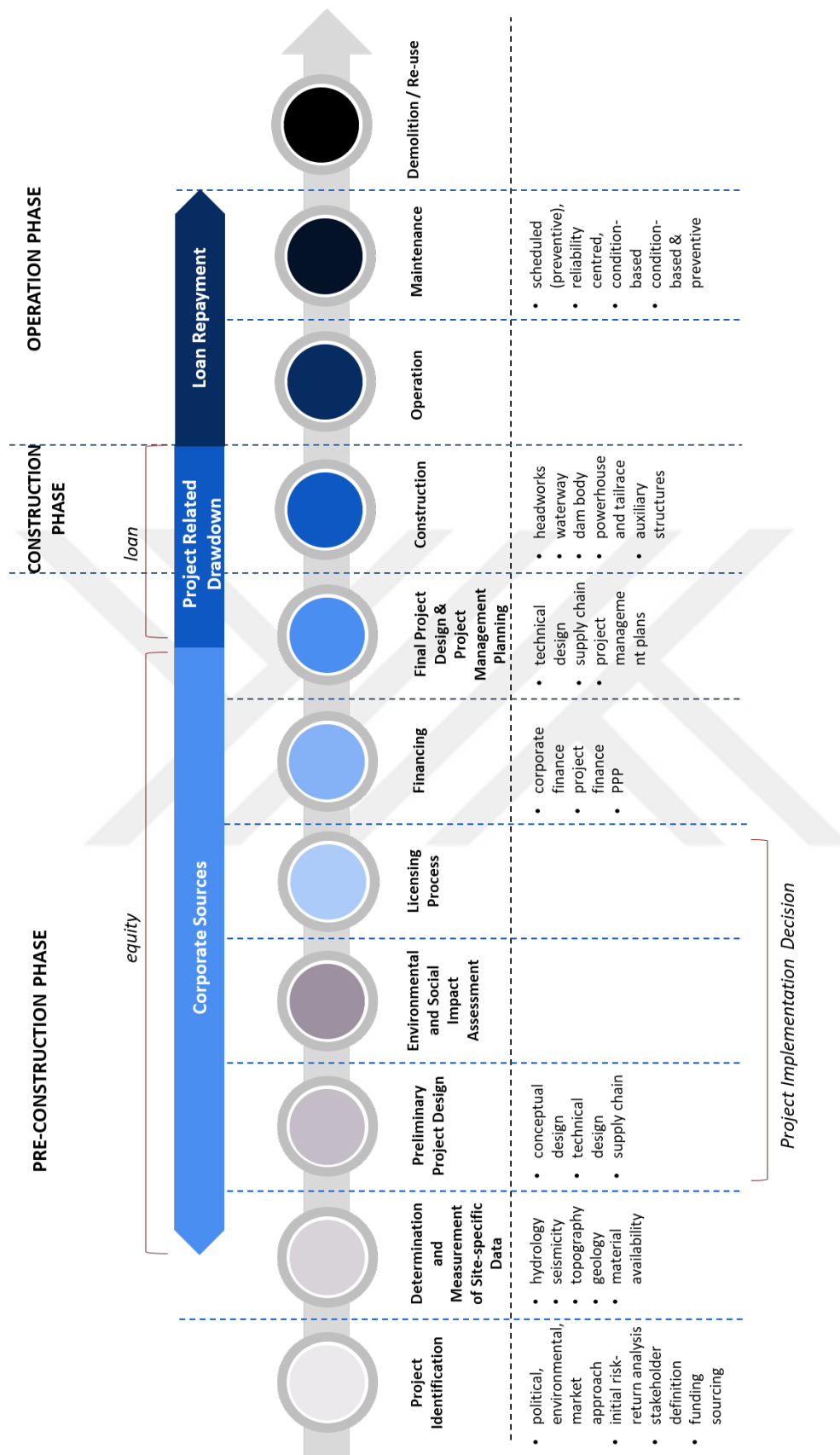


Figure 2.9 HEPP projects' lifecycle

construction phase, and it is the most risk-bearing part of the project, as the project performance mostly depends on the performance of the construction works. Engineering- procurement- construction (EPC) contracts are signed, and risks are transferred to the contractor so that this responsibility can be gathered at one point.

2.2.1 Pre-Construction Phase

The pre-construction process of HEPP projects begins with the identification of the project. At this point, the investor must have made a preliminary decision for the realization of the project. Then, measurement and analysis of site-specific data is carried out to determine whether the project is feasible. If the project is evaluated as positive at this stage, a preliminary design is prepared. With the preliminary design, the technical features of the project are determined. Afterwards, environmental and social impact assessment, which is one of the most important steps for the project to be feasible, is made. If the environmental and social risks are too high, the project decision will be negative as the financial expenses will increase. If the project decision is positive, the license and permit process is carried out and the financing phase is started. The financing phase begins during field measurements but applying to financial institutions usually takes place after licenses and permits are obtained. The costs of the transactions until they are financed (measurement and analysis of site-specific data, permissions, etc.) are realized by using the corporate resources of the companies and they are called as equity financing. While final project design and project management planning is being made, it is decided by the financial institutions to allocation and drawdown until the end of the construction phase. Financing transactions in this period are called debt financing. Most of the construction process, the costliest phase of HEPP projects, is financed by loans. With the commissioning of the project, the loan will expire after the loan period and the loan will be reimbursed. In some cases, lending continues in the first months of the operation, making it easier to cover operational expenses. The pre-construction period of HEPP projects is a multi-step process and progresses linearly. However, the general financing process has spread to almost all pre-construction and construction phases of the project and

can be both retrospective and forward-looking. Pre-construction steps are clarified in sections below.

2.2.1.1 Project Identification

Project identification phase is used for developing approaches in terms of political, environmental and market. The political approach of the project includes defining the legal basis on which the project is located, the incentives it will benefit from and the state policies. Environmental approach is the process of determining the environmental and social approach of the project. It includes actions to identify and define the potential environmental and social impacts of the project on the preliminary scale and which practices and procedures it will be subject to. Determination of the market approach includes the issues that form the basic cornerstones of financing such as production and sales strategies, whether the project will be profitable, profitability analysis, amount of return.

In addition, determining the project stakeholders and the relationship between them is also a step in the project identification, the structuring of the project is done accordingly.

2.2.1.2 Determination and Measurement of Site-specific Data

Field measurements are of great importance because of the characteristics of HEPP projects such as using renewable sources and being large construction projects. Since hydropower projects generate electricity with the help of water, hydrology measurements are the most important field measurements. Within the scope of hydrological measurements, flow rate and flow rate changes according to seasons are measured for long periods. Hydrological measurements are made for at least 10 years for large HEPP projects, and these measurements are interpreted and estimated production data of the plant with a certain deviation rate are generated. Whether the project is bankable and credit repayment plans are determined according to these data. Measurement of the topography data starts with determination of the type of the valley so that dam body can be designed. The material and basic properties of the dam body are determined according to the geological characteristics of the site and the materials that are easily found in the

region are taken into consideration. Seismicity affects the positioning of the project relative to the fault lines and again design considerations.

2.2.1.3 Preliminary Project Design

In the preliminary design process, the basic decisions of the project design are made. This stage, in which decisions are made regarding the location of the project and the natural measurement data, constitute the input of the licensing process, environmental and social impacts, and most importantly financing decisions.

HEPP design is affected by civil works and natural conditions such as geological, topographical, hydrological conditions. In addition, project location, distance from national network and environmental & social considerations are crucial for design. These conditions affect design considerations that have effect on performance and cost of the plant. Geological conditions determine foundation type and are especially important for large HEPPs. Identification of seismic condition of the site is crucial because if dam structure is damaged due to earthquake and completely or partially collapsed, it will cause great damage to its environment [44]. Topographical conditions determine layout and preference of the civil elements below. Effects of natural conditions on design criteria of HEPPs can be seen in Table 2.1:

Table 2.1 Design Criteria of Dam Types According to Natural Conditions [33]

Factor	Condition	Dam Type
<i>Topography</i>	Narrow U-shaped valley Concrete overflow dams	Narrow U-shaped valley Concrete overflow dams
	Narrow V-shaped valley Arch dams	Narrow V-shaped valley Arch dams
	Low plain country Earth fill dams	Low plain country Earth fill dams

Table 2.2 Design Criteria of Dam Types According to Natural Conditions [33]
(continued)

<i>Geology</i>	Solid rock Almost every kind of dams	Solid rock Almost every kind of dams
	Gravel foundation Earthen and rockfill dams	Gravel foundation Earthen and rockfill dams
	Silt and fine sand Earth dams	Silt and fine sand Earth dams
	Clay foundation Earth fill dams	Clay foundation Earth fill dams
<i>Availability of Materials</i>	The materials required for the construction of a specific dam type must be available locally or at short distances from the construction site.	
<i>Seismicity</i>	Seismicity Earthquake zone	Preferably earthen and concrete gravity dams

2.2.1.4 Environmental and Social Impacts Assessment

The magnitude of the environmental and social (E&S) impacts of HEPPs varies according to project size, type and site-specific conditions. Since the aim of the HEPP investments is to optimize the benefit of the project, the negative impacts of the project should be minimized. Like any construction project, each HEPP project is unique and distinctive, each project presents a complex (E&S) risk chart that is independent. Since (E&S) risks vary depending on the type and size of the project, these risks vary separately for storage and ROR schemes.

Among all HEPP schemes, large storage types are the most discussed in terms of (E&S) impacts. HEPPs with large reservoir have low electricity generation costs

and contribution to energy security while contain (E&S) risks due to the destruction of biodiversity, and the necessity of resettlement [44]. Site selection is therefore critical to reducing (E&S) risks and balancing the cost / benefit ratio in any HEPP type. Generally, dam-type HEPP projects with a smaller reservoir surface area have less (E&S) risk as they reduce natural habitat losses and resettlement requirements to a relatively low level. Environmentally best designed HEPPs are located on the upper tributaries of the rivers, while the most problematic ones are located on the large main stems. The most important titles of (E&S) impacts are, alternations in flow regime in downstream river, structure and condition of downstream bed, banks and riparian zone, sediment dynamics, physio-chemical conditions in downstream water bodies and/ or reservoirs, water structure of reservoir shore zone habitats, water level fluctuation in the reservoir, possibility of fish entrainment in turbine intakes, and structural barrier to the movement of aquatic fauna [35].

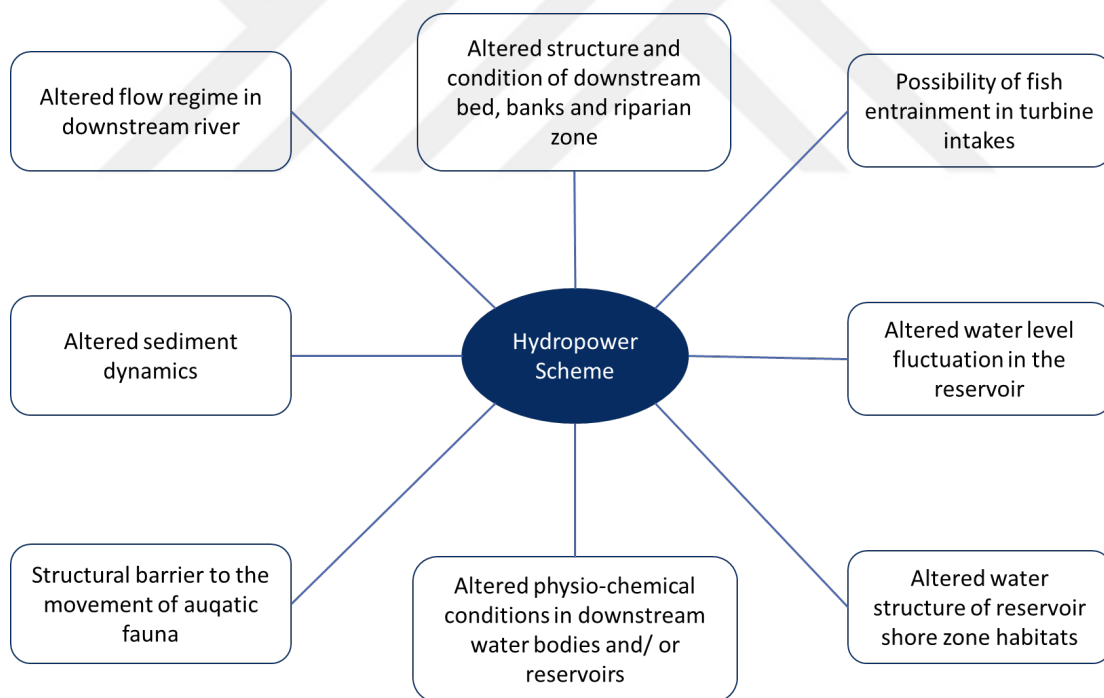


Figure 2.10 Environmental Impacts of HEPPs [35]

Small HEPPs have less environmental impacts than large dams because small HEPPs continue to operate with smaller flows directed through smaller branches, not the whole river flow. HEPPs are a very popular electricity generation method in rural and remote locations because they are more viable than other types of

energy. For small HEPPs, project development and permitting processes are shorter as construction times are short and construction risks are low; this results in lower costs and increased compliance with local requirements.

Smaller HEPPs can contribute to electricity generation with low E&S effects. In general, small HEPPs are suitable for the ROR type, which does not require a reservoir. They do not lead to large-scale and complex resettlement. In addition, the construction and commissioning times of small scale HEPPs are short; and they are easy to manage because of the size. It should be kept in mind that there is no connection between the installed capacity and potential project impacts in the small scale HEPP. A small scale and/or ROR type of HEPP does not mean zero or low impact [33]. HEPP projects may be important and desirable locally, but project development and site selection issues should be meticulously conducted.

E&S impacts also have significant effects on financing. A project with high E&S risks will always be financed more expensive due to the risks involved. In addition, within the scope of sustainable finance concept, it is required to meet certain criteria for financing HEPP projects. In order to measure the E&S impacts of the project, banks have developed self-assessment tools. Projects do not meet bank's criteria, cannot be financed, and these projects face unfavourable financing conditions. The most important criteria used for the identification and evaluation of E&S risks in finance are the Equator Principles set by the World Bank [45, 33].

Equator Principles: The Equator Principles (EP) is a financial industry agreement established to identify, assess and manage environmental and social risks in project finance and corporate loans. A financial institution that accepts the EP is committed to lending only projects that comply or are willing to comply with environmental and socially responsible [46]. EP emphasizes and encourages meeting around common environmental and social standards in project finance deals. Organizations such as the European Parliament, the European Bank for Reconstruction and Development (EBRD) and the Organisation for Economic Co-operation and Development (OECD) adopt the EP and agreed on the same standards. For bankers and investors, EP is the reference for minimum E&S risk management practices. As EP provide a forward due diligence framework to guide

risk decisions but are not intended to address site-specific and local E&S concerns [46], consultants should provide a local E&S risk framework specific to each project.

HEPP developers, who will provide financing from banks that have signed the EP, must comply with EP and IFC performance standards. In EP transactions, borrowers undertake to act to manage and mitigate E&S risks, otherwise banks may exercise their right to request cancellation and repayment of the loan. Although EP is not often applied for small HEPP projects, this is not the case for IFC performance standards. In addition, it is necessary to make applications for E&S risks in all kinds of HEPP projects.

2.2.1.5 Licensing Process

Licensing process starts tight after E&S impact assessment. If there are excess amount of E&S risk, project implementation decision possibly will be negative. If the risks are tolerable, project implementation decision will be positive and licensing stage begins. Licensing process changes country to country and depends regulations set by related ministry.

2.2.1.6 Final Project Design

Final project design is the most developed and ready to implement version of preliminary project design.

2.2.1.7 Financing

The most important factor that complicates HEPP project financing is that production depends on natural conditions. Particularly in ROR type HEPPs, dependence on hydrology causes uncertainty of production income due to uncertain water flow and climatic conditions. Financing structure needs to be arranged in order to reduce these risks. The project financing program should consider cost overruns, delays and resettlement risks. In addition, another important issue in HEPP project financing is the high initial cost. This can be compensated to some extent with long operating life and low operating cost.

Properties of the HEPP projects such as being totally site-specific having long construction period, and excess of construction risks, in reality being a

construction project, requiring high capital cost, having very long plant lifespan, depending on hydrology, serious E&S considerations, and externalities have significant effects on financing.

There are two financing option for financing HEPP projects:

- **Corporate Finance-** The borrower is liable for borrowing by taking responsibility for the debt service (interest and capital repayments). The focus of lenders is on the institution's ability to serve interest and the ability to repay or refinance the debt.
- **Project Finance-** The focus is on the reliability of the HEPP project since the provision of debt service is based on the cash flow generated by the project. In the project financing scheme, the project assets can serve as collateral of the loan.

The advantage of the project financing method is that the risk of the investor is reduced, and the other assets are secured. This is also the case; the project company is not affected in case of bankruptcy of project investors. Estimating the cash flow of the project is not an easy process, but many HEPP projects are financed through project finance.

The number and diversity of players varies according to the complexity of the HEPP project, but the main players are usually included as sponsors/ SPV shareholders, lenders, international commercial banks, local banks, developmental agencies, multilateral institutions, off-taker, contractors, operating company, and insurance company. Sponsors, bank requirements and managerial discretions play a decisive role in risk mitigation actions.

Risks are the most important factors affecting HEPP project financing. Lenders want to keep their exposure low and aim to keep repayments safe; however, equity investors may be willing to expose more risks to obtain higher returns. In short, risks can increase the attractiveness of the project for some lenders while decrease for others. Since the risk profile of the project directly affects the financing, the financial analysis should include a detailed risk analysis. Project development is affected by risk profile of the project indicated in Figure 2.11. The financing cost of HEPP projects depends on risks; that is, the higher the risks, the higher the cost

of financing. If the risks are reduced, the cost of financing decreases. Financial modelling and sensitivity analysis are essential to reveal the effects of risks.

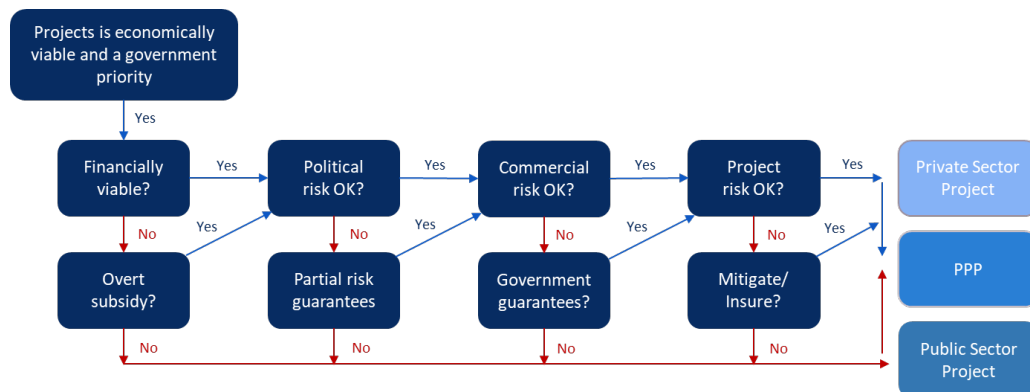


Figure 2.11 Risks and Project Development [33]

The most crucial risks in HEPP projects are listed as hydrology, permitting/licensing, payment default, local currency devaluation, change in the regulatory framework, cost overruns and schedule delays, and market dynamics.

Determining the financing scheme and sources for HEPP projects depends on project size, capital requirements, financial viability of the project and risks [33].

The relationship between the size of the project and the selection of the financing scheme is given in Figure 2.12. Accordingly, some HEPP projects may be too small for project finance and/or too risky for corporate finance.

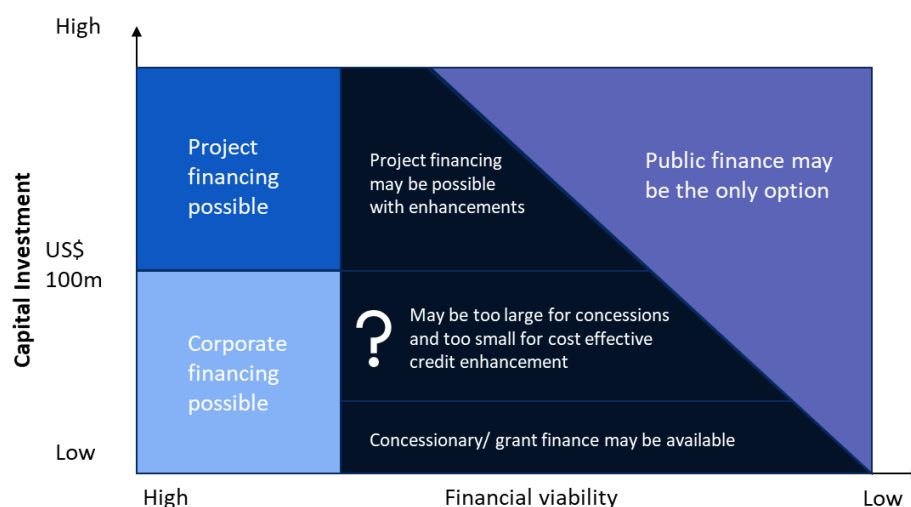


Figure 2.12 Financing Options in Relation to Project Size (Head, 2000)

The private sector financing models are as follows:

- BOT—build-operate-transfer.

In the BOT model, which is frequently preferred for public-private partnership (PPP) small HEPPs, it transfers the tasks of designing a public administration facility, building infrastructure, financing and operating to a private sector entity for a certain period of time. During this period, the private sector is the owner of all income from the project in order to pay the debts obtained from the financial institutions for the realization of the project. At the end of the concession agreement, the facility is transferred to the public administration.

- BOO—build-own-operate.

BOO scheme is used for HEPP projects with high investment cost and long repayment period. In the BOO schemes, the physical life of the project coincides with the duration of the concession agreement.

The financing of HEPP projects is complex due to long operating life, high capital costs, high construction risks, site-specific projects, E&S considerations, externalities, dependence on hydrology, long tenor financing need, and project risks. The overall financing scheme is shaped by the size of the project and its financial viability. Debt and equity sources of the project strictly depends on project risks and development type.

2.2.2 Construction Phase

As previously indicated, besides to be an energy project, HEPPs are mainly construction projects. Because about 60-70% of the total costs are originated from construction works, construction risks are the most important and construction period -especially in large HEPPs- lasts up to 10-12 years. Civil structures form HEPPs may be classified into 5 main groups [33]:

Headworks: Headworks are the structures that are used for elevating water to the desired level. In addition, headworks service to discharge excess water safely.

The dams create a barrier in front of the water and serve for increasing the water level. Reservoirs created by dams and undertook functions such as storing water, increasing the discharge amount, ensuring enough discharge during dry seasons,

developing head, and diverting floodwater. Dams are classified into two according to their construction material these are natural earth and concrete [33]. Natural earth is flexible and erosion resistant material and suitable for seismic areas. Concrete is preferred when there is no natural earth available in the site, but sand and gravel is existing. Besides construction materials, there are different classifications of dams according to function, height, sealing system and static function. Weirs are used for regulating water in HEPPs. Weir allows to divert water, increase water level and divert flood water.

Intake structures transport the water in the reservoir to the waterway. In addition, it provides filtration of sediments and particles carried by water. Intake structures are the components that are most subjected to maintenance.

Waterway: Waterway directs water to the powerhouse. Waterway schemes are composed by sand trap, headrace, forebay, surge tank and penstock. Sand traps are suspended systems generally used in medium and high head HEPPs. Sand traps mainly block sediments and particles from going to steel structures and turbines. In large storage schemes, sand traps can be negligible because of settlement. However, in RORs, existence of sand trap is crucial.

Headraces convey water to surge tanks safely. Structure of headraces can be one or combination of the open channels and tunnels. If topographical conditions are suitable, only open channels are used for construction of headraces. Tunnels are used when topographical conditions are ineligible. Forebays connects headrace with penstock and ensure enough water for starting up. Also prevents air ingress into the penstock causing pressure fluctuations and water column collapse.

Surge tanks helps controlling pressure in the penstock and the headrace. Finally, penstock provides to transfer pressurized water from the forebay or surge tank to the turbine. Penstock should protect the water pressure which is caused by height difference. Penstock schemes can be variable, separate penstocks can be installed for each unit or a penstock can be installed for a branch.

Powerhouse and Tailrace: Turbine, generator and auxiliary equipment are located in powerhouse. Easy installation and easy access are two crucial criteria for powerhouse construction. Powerhouses can be above or below ground. When

powerhouses are locating, the following factors should be considered, spillway location, foundation conditions, valley width, accessibility, location of switchyard and transmission lines. Tailrace is the structure that remove water from the powerhouse and turbine. It should be designed in proper slope and oriented downstream to ensure suitable flow.

Auxiliary Structures: Auxiliary structures composed by protective structures that protect HEPP from turbine abrasion, sediment collection and riverbed erosion.

2.2.3 Operation Phase

2.2.3.1 Operation

The most important feature of the HEPPs is long operating life that causes investors make more profit. The economic operating life of a HEPP should be at least 50 years, in average 70-100 years [33]. In this duration some parts of equipment must be rehabilitated or replaced. Average life expectancies of the parts change according to site-specific conditions. Average life expectancy of the parts is given in Table 2.2.

Table 2.2 Average Life Expectancy of Parts of HEPPs [33]

Plant Part or System	Expected Useful Life (years)
Main generating equipment; turbine equipment	40
Turbine runners	10
Power transformers	40
High voltage switchgear and switchyard equipment	40
Medium voltage switchgear	30
Low voltage switchgear	30

Table 2.2 Average Life Expectancy of Parts of HEPPs [33] *(continued)*

Control and protection system, remote control, SCADA, communication equipment, metering	20
Plant auxiliary mechanical and electrical equipment	30
Transmission lines	70
Penstocks, gates, stoplogs, trash racks	70

2.2.3.2 Maintenance

Maintenance works are classified into four; scheduled (preventive), reliability centered, condition-based and condition-based & preventive maintenances. Maintenance staffing and timing is important for long operating life.

2.2.3.3 Demolition / Re-use

HEPPs are used for the longest time they can be used in electricity generation, as they provide reliable production, and their demolition processes are very difficult. Operation period is extended with capacity increase and technological improvements such as renovation or rehabilitation. The most important factor that determines whether a hydroelectric power plant can be used in electricity generation is the filling of the reservoir completely with sediment. The filling of the reservoir of a power plant with sediment takes a minimum of 50 years, which determines the economic life of the power plant. In addition, HEPPs with an economic life of less than 50 years are neither feasible nor approved by SHW. The reuse of HEPP power plants usually occurs when they are considered as a lake. HEPPs, which have the potential for recreational area both in operation and reuse periods, are used in areas such as fishing and tourism. For example, Bunyan HPP which is the oldest hydroelectric plant operating since 1929, reused as tourism facility in 2009.

FINANCING OF HYDROELECTRIC POWER PLANT PROJECTS

3.1 Project Finance Method

The project finance (PF) method has been used frequently for the financing of capital-intensive projects extensively since the 1980s, although known and applied since the 19th century. In PF deals, the granting and repayment of the loan depends entirely on the project. There are five distinctive characteristics of a PF deal, these are legally independent project company (special purpose vehicle – SPV), limited or non-recourse to the sponsors, allocated risks to parties which can best manage them, necessity of cash flow that is sufficient to cover debt service and operational costs, given collateral as security for cash inflows [47, 48].

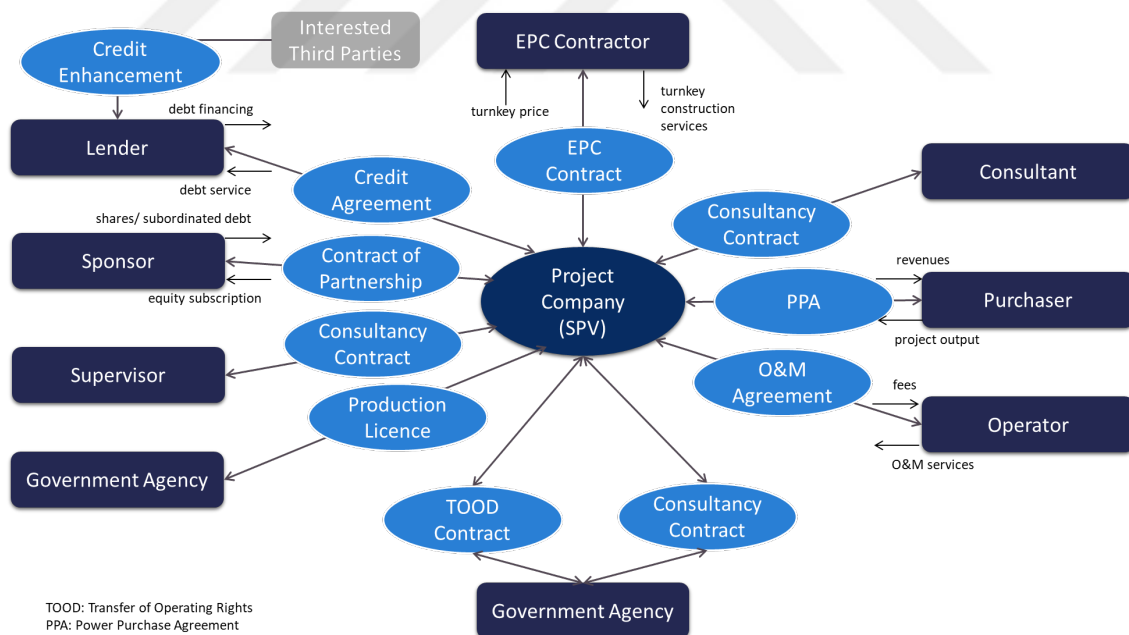


Figure 3.1 Structure of a HEPP Project Finance Deal

Major participants of the PF deals can be classified into two, first one is participants found in all PF deals and participants found in some, but not all deals

[51]. Sponsor(s), project company, construction contractor, lenders and insurance providers are found in any PF deal. The parties involved for a generic PF deal and the agreements between them are shown in Figure 3.1. The government the most role in the project financing of HEPP projects. The "Concession Awarder" and "Regulator" roles are specific to energy projects and therefore HEPP projects [49]. Governments, which are the primary actors in the regulation of industrial, environmental, and economic policies, also undertake legislative roles.

Governments want to ensure that public benefit is achieved by having control over these projects because the unique natural resources are used in operation of HEPPs [50]. Governments can participate in PF transactions as concession awarder, regulator, fiscal incentive provider and sovereign guarantor. As concession awarder, the transfer of rights such as construction and operation of HEPP projects under its own monopoly to the private sector. As regulator, determines the price and quantity in tariffs. With the role of fiscal incentive provider, it opens the way to provide grants and subsidies to HEPP projects. Finally, as a sovereign guarantor, it can provide guarantees to projects through Ministry of Finance or the Treasury.

Special Purpose Vehicle (SPV) is a specific entity that established by the sponsors in PF transactions, without any registered assets or debts, and without a commercial background. Financial transactions related to the project (equity injection, credit allocation etc.) are carried out through this company. The sponsors provide equity financing to SPV. The establishment of a separate company coincides with the principle of project financing being off-balance sheet, thereby isolating the project from other assets and liabilities of the parent companies.

Project sponsors appear as electricity utilities in traditional PF deals. However, due to the private ownership trend after the 80s in HEPP projects, project sponsors were generally private companies. The equity capital provider to SPV is named as sponsor. Roles and expectations of the sponsors strongly depend on in which type they are involved in the deal. There are four types of sponsors: industrial sponsors, public sponsors, contractor/sponsors and purely financial investors [47]. For industrial sponsors, PF is related to their core business. Public sponsors see PF for

a chance to carry out public works. Contractor/ sponsors develop, build and/or run plants and provide equity and/or subordinated debt to SPV. Pure financial sponsors do not interest in project's operation, they see PF as an opportunity to get return on their investments.

Lenders are vital for realizing both public and private sector projects. Lenders are quite diverse and there can be numerous lenders in one project. It is possible to classify lenders as multilateral banks, regional development banks, developmental agencies, national development banks and funds, national-backed funds, export credit agencies, commercial banks, Islamic banks, bond underwrites and institutional investors. The main role of the lenders in the project is to provide loans and get the repayment during the operation period. Main purpose and expectation of lending varies according to the type of lenders above-mentioned. earn as much credit as the operation period of the project and to earn money by getting this money and interest according to a certain payment plan during the operation period.

Purchaser is the buyer of the output of HEPP, mostly electricity however they can be buyer of non-energy services. Purchaser specifically called as off-taker in PF deals. Loan disbursement and operational expenses of the project mostly financed via electricity sales. To sale the generated electricity, a long-term Power Purchase Agreement (PPA) signed between SPV and off-taker. Electricity sale can be made by using merchant basis. In fact, having the PPA agreement significantly facilitates the financing of the project. PPA means that for a long time, the project will sell the electricity it produces at a certain price, and in a sense, it is the guarantee of loan repayment. Another tradable output of the project is non-energy benefits, and these are irrigation regulation, water supply regulation, reduction in saline intrusion, tourism, and leisure facilities.

Construction contractor - generally referred as engineering- procurement-construction (EPC) contractor- undoubtedly has the largest role. The contractor can transfer his work on the project to other parties using the traditional subcontracting method. Generally, works are done with split package contracts. A typical large hydro project is divided into 4 or 5 major contract packages, but in

some cases this number may increase. The division approach to main contract packages is often used in public projects. In the private sector projects that are designed as PF deal, EPC contracts with single focus transfer of responsibility are used. EPC contracts have turnkey features and not preferred in international projects because the merger of the works means the increased risks. In such cases, civil works, turbine supply, electrical and mechanical works and other works separately contracted.

Suppliers can be provider of any additional service and goods to SPV. If the EPC contract has been made for the construction work, the EPC contractor will be assigned as a supplier. In addition, in fossil fuel-powered power plants, the supplier is a very important actor that supplies fuel (coal, natural gas, oil, etc.) to the power plant. However, in HEPP projects, suppliers can be any organization that provides any product.

The operator of the project may be a project owner or a separate operating company. If the project company is the operator of the project, it will also perform operations such as operation and maintenance under the "Operation and Maintenance (O&M) Contract". O&M contract consists, operation, commercial management, maintenance, overhaul, refurbishment, and dispatch.

Insurance providers play an active role in more than one phase of HEPP projects. It can be provided by construction insurance, companies, advisors, brokers, and re-insurers teams and provides various coverages as insurance, bonds and sureties. Construction contractors are required to submit bonds in terms of warranty and performance. Political risk insurances are cost effective element of security packages and provided by various financial institutions and commercial insurers. Credit guarantees are used for securing project revenue stream and improve the credit terms. Partial credit guarantees are provided by multilateral development banks and bilateral agencies. Project owners and operators can insure loss of income due to insurable reasons through operation insurances. Organizations that provide this type of insurance are generally the same as those that provide construction insurance.

In addition to the above participants, advisors, consultants, and community stakeholders are indirectly involved in PF deals. Advisors and consultants take part in almost every stage of HEPP projects. Community stakeholders are people that directly or indirectly affected by the project, either positively or negatively [49, p.14].

As can be seen above, the PF method is slow, complex and leading to some control loss of project and very expensive, due to the large number of participants in PF deals and other factors. Compared to corporate finance, PF costs 2-3 times more. Despite all these disadvantages, PF is the most preferred method especially for large HEPP projects. The first reason for this situation is high leverage. High leverage is a factor that increases investors' profits. Also, borrowing is always cheaper than equity because lenders are willing to take less risk and less returns than equity investors. The second reason is that PF provides tax benefit because interest is tax deductible. The third is that PF is off-balance sheet financing. This ensures that the investor's debt in the PF does not appear in the consolidated balance sheet. Fourth, since PF transactions are non-recourse, the borrowing capacity of the investor increases, and the investor can realize more than one major project at the same time. Fifth, the debt repayment is not guaranteed in PF, so in its default state it is limited to lost equity, which provides risk limitation. Sixth, if the project is too big to be overcome by a single investor, the PF process enables the establishment of joint venture SPV. Risks are also shared with this structure. Seventh, PF loans have longer term than corporate ones because of HEPP projects are capital intensive. The last one is that firms with low capital, but project development capacity can realize their projects with PF, even though they have low capital due to high leverage.

To sum up, the number of participants in PF transactions is high and there is extensive task sharing among the participants. Participants are approximately the same for each PF deal, but the supplier is of little importance in HEPP projects, and its function is different. In addition, the importance of the EPC contractor has increased, and the project cannot be completed if the EPC contractor cannot fulfil its task. Although the PF method has disadvantages, its advantageous aspects

make it attractive. For this reason, project financing has been the most preferred method for HEPP projects since the past.

3.2 Lenders

3.2.1 Multilateral Agencies

Multilateral agencies (MLAs) are a type of development banks and provide HEPP projects with loan, equity, or both. Development financing, which is one of the founding goals of MLAs, is well suited for energy projects, one of the most important requirements of development. Loans from MLAs have the following advantages over market-supplied ones: long maturity, fixed and / or lower interest rates, participation of those institutions attract the other possible lenders, co-financing, or complementary financing opportunities; however, these loans have their advantages as well as their disadvantages. Approval process of MLA loans takes a long time. Also, if the fund provided in currencies (some local currencies) those are difficult to hedge, significant currency risks may be faced with. Nevertheless, the conditions of financial products provided by MLA are more favourable than market conditions, and these products are frequently desired to be included in HEPP projects.

3.2.1.1 The World Bank Group

The best known and most active MLA is the World Bank Group. The World Bank Group has five subsidiaries, International Development Association (IDA), International Bank for Reconstruction and Development (IBRD), International Finance Corporation (IFC), Multilateral Investment Guarantee Agency (MIGA) and International Centre for Settlement of Investment Disputes (ICSID). Since ICSID is not a funding agency, the rest will be examined in detail below.

- **The International Development Association (IDA)**

IDA has 173 member countries to provide loans and concessional lending for the 76 of the world's poorest countries. IDA provides assistance and interest-free loans to eligible countries. In other words, IDA mainly serves for World Bank's poverty-reduction mission. Of course, it provides loans for HEPP projects in those countries however those carry different conditions than other type of loans.

- **The International Bank for Reconstruction and Development (IBRD)**

IBRD has 189 member countries and assist middle income developing and credible poorer countries. IBRD loans are mostly used for financing the infrastructure investments which are lack in developing countries. Those loans generally used by public authorities and can be secured by different methods. A counter-guarantee by member country, an undertaking from privates and assignment of an offshore trust account are three types of securitisation methods [51, p.177].

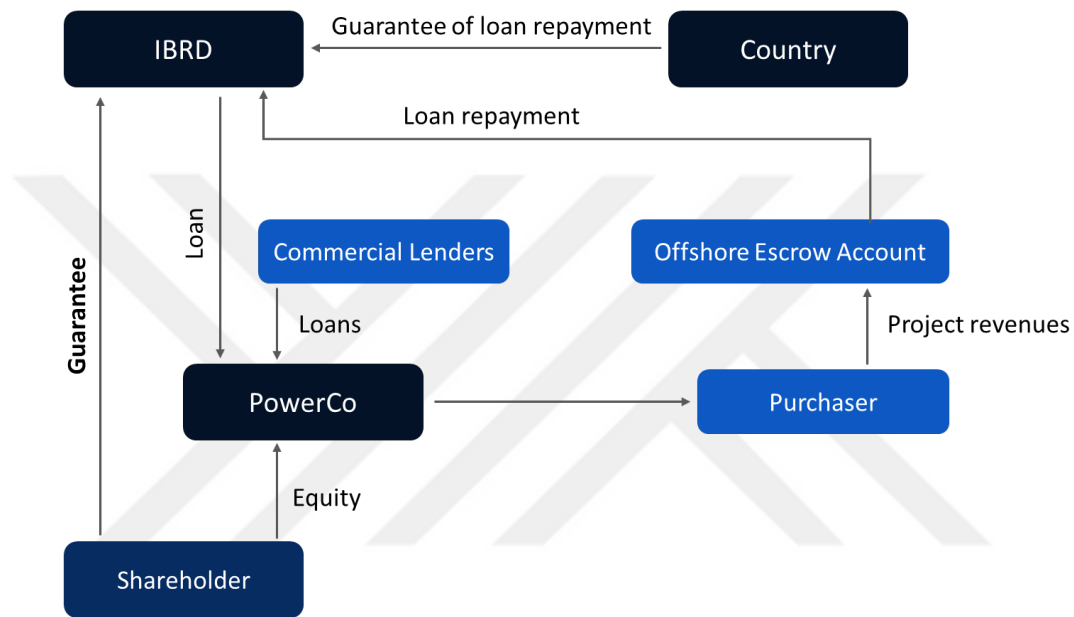


Figure 3.2 IBRD Project Loans for Projects in IDA Countries [52]

- **The International Finance Corporation (IFC)**

The focus of the IFC funding is private sector of the 185 member countries. The most important condition for IFC to fund a project is that the project cannot be financed otherwise. The IFC finances projects in various sectors, and the energy sector is one of the most important of them.

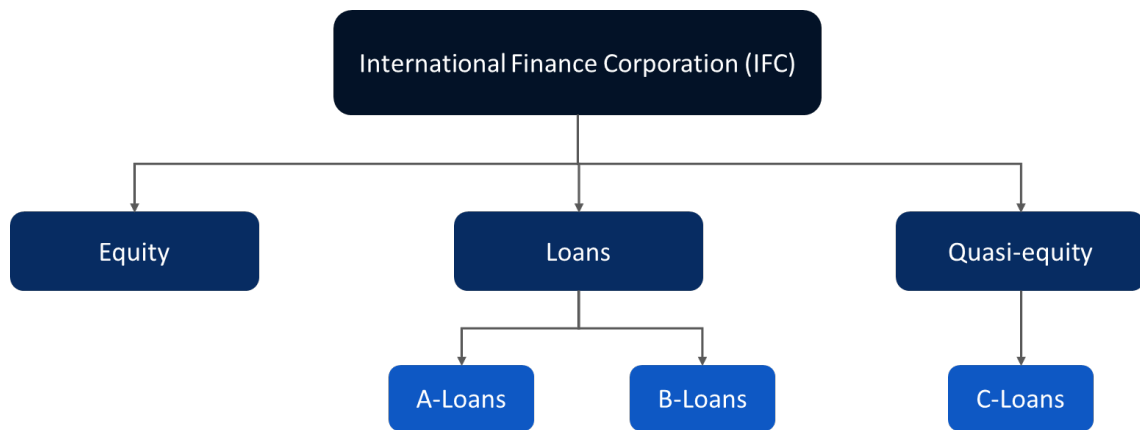


Figure 3.3 IFC Contribution Instruments to HEPP Projects

The IFC can contribute to financing HEPP projects with three different instruments. These are equity, quasi-equity, and loans. When IFC is equity investor for a HEPP project, it becomes the common stock of the project companies or other types of project vehicles. The quasi-equity instrument is rarely used, called C-Loan and can be in the form of convertible debt and subordinated debt. C-Loans positioned between equity and loan and has a fixed repayment schedule. Also, it can also offer preferred stock and income note investments that means a less rigid repayment schedule [53, p.116]. C-Loans provide financing when necessary to be sure that a project is soundly funded. This risk/return profile is again between equity and loan. IFC direct loans provide long-term financing to the project, and these are two types, A-Loans and B-Loans. A-Loans are loans funded by IFC from their own resources and are limited to 25% of the project cost for new projects. This rate can be up to 50% in expansion projects. A-Loans interest rates are determined as fixed + variable margin. B-Loans is arranged or syndicated with participating financial institutions- mostly commercial banks, insurance company lenders and leasing companies. It is desirable to participate IFC B-Loans for private lenders because it protects against a number of risks. The most important aspect of B-Loans is that exposure to country risk can be limited to private financial institutions, but this does not mean that B-Loans are formal guarantees.

Considering the above information, The World Bank Group's body offering the widest range of instruments for HEPP projects is IFC. IFC increases the financing

volume with instruments of different qualities and flexibility that it offers for projects.

- **The Multilateral Investment Guarantee Agency (MIGA)**

MIGA provides a political risk guarantee for private foreign investment debt and equity [51]. The guarantee covers situations such as expropriation, war and civil disturbance, currency transfers and breach of contracts. MIGA's guarantee offerings differ from those of IBRD and IDA. First of all, MIGA guarantees have an upper limit of \$ 200 million for each project. Secondly, these warranties do not require the host country's counter guarantee. Finally, MIGA guarantees include coverage for equity and shareholder loans and commercial loans. Besides those, multilateral status of MIGA means rights of the investors will be respected.

3.2.2 Regional Development Banks

The objectives of the regional development banks and their contribution to the financing of HEPP projects are the same as multilateral agencies. The most important difference between these two groups is that they have limited the activities of regional development banks to certain regions. The most important regional development banks are as follows:

- European Bank for Reconstruction and Development (EBRD)
- Asian Development Bank (ADB)
- African Development Bank (AfDB)
- Inter-American Development Bank (IDB)
- Islamic Development Bank (IsDB)

The rigidity of the territory boundaries varies between banks. For example, although the main region of the EBRD is Europe, it can provide funds for projects in Central Asia. However, some banks operate only in their own region.

The instruments that regional development banks provide for financing HEPP projects are the same as The World Bank Group, but they are divided into three as equity, quasi-equity and loan. There are also grant mechanisms and guarantee facilities for the countries those need assistance.

3.2.3 Development Agencies

Development agencies are bilateral financial institutions established to support investments within countries. Grants and/or subsidized loans can be obtained from development agencies. Development agencies can be additional funding sources for HEPP projects, and they may have different focus sectors from time to time, as well as they may be open for funding to certain industries all the time.

3.2.4 Export Credit Agencies

As bilateral institutions, export credit agencies (ECAs) are important sources in PF deals. Compared to other energy projects they have been less employed in HEPP projects, although they can be useful for supplying electromechanical equipment such as turbines etc. Loans provided by ECAs are more advantageous than market conditions. These loans aim to increase the exports from home country to developing countries. ECA loans can cover up to 85% of the product cost subject to issuance. In addition, since these loans may be medium (7 years) and long-term (+7 years), can be considered as attractive when considering the lengthy construction period of HEPP projects. EXIM buyer credits can be provided in 2 ways as direct and indirect (Figure 3.4). The first is to provide credit directly from the EXIM bank of the country concerned. The second is when the funds provided to local commercial banks at the EXIM bank are made available to customers through the bank. Although EXIM loans were used by the public sector before 2000s, today the private sector has taken the first place.

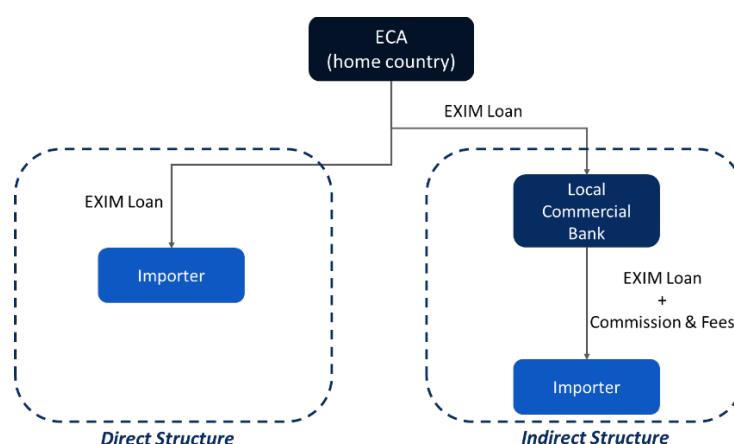


Figure 3.4 ECA Buyer Credit Structure

In addition to buyer credits, there are 3 other products provided by ECAs. In this case, all products of ECAs can be classified as insurance products, loans and guarantees, buyer credit and supplier credit (Figure 3.5). Since insurance products, guarantee and loans and buyer credits are used in HEPP projects, those three will be examined.

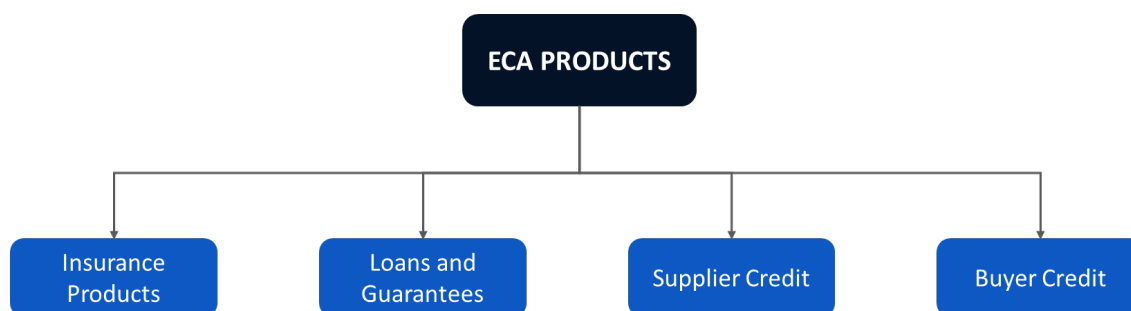


Figure 3.5 Products Provided by ECAs

ECAs, which previously only served as loan providers, started to provide guarantee products for exports to developing countries, and with the increasing use of these products, some ECAs have only become warranty providers. As a result, not every ECA loan provider is today, many provide short-term guarantees. These guarantees increase the credibility of the project and mitigate the risks of the country and reduce the risk exposure of investors. Insurance products cover the insurance of the products that are imported / exported during transportation.

All in all, EXIM loans are preferred in HEPP projects due to their maturity advantage and guarantee options, and the use of these loans increases the project's creditworthiness and reduces investor risks.

3.2.5 Commercial Banks

Commercial banks, which had little role in energy PF deals before the liberalization of the energy market, have become the most important provider of PF loans today. 90% of the PF loans in 2012 were obtained from commercial banks [49, p.62]. Commercial banks often use the syndication method to finance large projects such as large HEPP. In the syndication structure, more than one commercial bank combines and finances the total loan amount jointly, thus sharing the risk.

In many developing countries, local financing of HEPP projects is limited, because the financial market in the country is still immature. As a result of this, financing costs remain quite high (Head, 2000). Offshore funds fill the financing gap in countries whose financial markets are underdeveloped.

3.2.6 Institutional Investors

Institutional investors are corporate bodies such as insurance funds and pension funds [51, p.450]. The main purpose of institutional investors in financing a project is to make a profit. Since institutional investors generally focus on long-term, low-risk and asset backed investments [49], they are interested in infrastructure investments such as HEPP projects. Unlike banks, institutional investors take part in HEPP projects not as a lender, but as an equity investor.

3.3 Factors Complicating Hydroelectric Power Plant Project Finance

As a result of the content analysis study, 12 factors those complicate finance the HEPP projects, were identified. Those can be listed as natural conditions, political conditions, equity return rates, technological costs, initial cost, transaction costs, production costs, construction risks, construction period, externalities, market conditions, and financing period (Table 3.1).

3.3.1 Natural Conditions

Since natural conditions determine the production values of HEPP projects, it is the most important factor affecting project revenues. Natural conditions include hydrological factors, temperature and wind, evaporation, and climate change. It is possible to accurately estimate the production value of the project with proper and long-term measurements, but the effect of individual events on these values may sometimes cause difficulties in repayment therefore financing structure highly depends on natural conditions [3, 21, 19]. Since unexpected volatility in production can be considered a risk, it is important that the financing package includes risk coverage. In addition, low interest rates also help to compensate this effect.

Table 3.1 Factors Found in Literature Those Complicate HEPP Finance

		natural conditions	political conditions	equity return rates	technological costs	initial cost	transaction costs	production costs	construction risks	construction period	externalities	market conditions	financing period
1	[3]	✓	✓		✓	✓							
2	[17]			✓	✓		✓						
3	[20]							✓	✓				
4	[7]				✓			✓			✓		
5	[22]		✓									✓	✓
6	[23]												✓
7	[18]		✓	✓			✓						
8	[11]		✓			✓						✓	
9	[19]	✓			✓				✓			✓	
10	[10]					✓		✓					✓
11	[4]		✓		✓						✓	✓	
12	[8]							✓					
13	[5]					✓					✓		
14	[21]	✓							✓	✓			
15	[24]		✓			✓				✓			
16	[28]					✓		✓					

3.3.2 Political Conditions

The political environment is crucial for investment projects such as HEPPs. Conditions such as fluidity of macroeconomic indicators, government instability

have wide effects on HEPP investments [11, 24, 18, 4]. In addition, the cost of borrowing can increase significantly in countries with risky political conditions [23]. Therefore, it is important that financing packages in HEPP projects contain risk coverages and availability of long maturity loans.

3.3.3 Equity Return Rates

Equity return rate sometimes called as return on equity (ROE), is obtained by dividing net income by equity. Compared to other investment projects, equity return rate is low in renewable energy projects [17, 18] and this may decrease investors' interest in such projects. For equity return rate optimization, the debt / equity ratio should be set well and the debt rate in the project should be increased, if possible, this means high leverage. Low interest rates will also increase project revenues, helping increase ROE.

3.3.4 Technological Cost

Technological costs become important due to the rapid changes in renewable energy technologies [19, 3, 4, 7, 17]. This is partly true since the technology used in HEPP projects is in its mature age. Compared to other renewable energy projects, technological costs are lowest in HEPP projects, but they are higher than conventional energy projects. In order to reduce the impact of technological costs on the project, leverage should be high and long maturity loans should be preferred.

3.3.5 Initial Cost

Until renewable energy projects are implemented, different and costly processes such as permission, expropriation, resettlement, and resource assessment operate [3]. In addition, since the construction costs are high and the construction period is long for HEPPs, cause initial cost is quite high, and those projects are considered as capital intensive. Therefore, the existence of grace period will increase the financial strength of the project while the construction works are going on. The high leverage ratio determined to be high enough to cover the construction costs, low interest rates and long maturity term also contribute to the financial strength of the project.

3.3.6 Transaction Cost

In renewable energy projects, the transaction costs are higher than conventional ones [17, 18]. Most of the transaction costs arise from the preliminary transactions in the project. Performing the essential works for the realization of the project causes certain costs and these items are very diverse in HEPP projects. For example, most roles in the project exist on both the owner and the lender side, resulting in double the costs. Also, the increase in the project size causes the transaction cost to increase, in order to compensate this, interest rates should be low.

3.3.7 Production Cost

Renewable energy production costs are higher than conventional energy. The lack of subsidies and excessive construction costs are among the reasons for this situation [10, 20, 28, 7, 8]. Also, the fact that the resource is not always available increases the production costs. Although the production cost of HEPPs is the lowest among all renewables, long maturity and low interest loans are required to compensation.

3.3.8 Construction Risks

The fact that 60-70% of the total cost of HEPP projects is the construction cost is proof that those projects are large construction projects. These projects contain many construction risks, such as completion risk, cost over-run, performance related risks [19, 21, 20). It is very important that there should be a risk coverage for construction risks in the financing package of HEPP projects. The existence of a grace period and low interest rates can help mitigate construction risks.

3.3.9 Externalities

It is difficult to price the environmental benefits of HEPPs other than reducing carbon emissions. Examples of these benefits include flood prevention, water and energy security, drinking water and agricultural irrigation. In addition, pricing cannot be made for situations such as expropriation caused by HEPPs, damage to flora and fauna. The fact that externalities cannot be priced prevents the accurate calculation of the unit cost of energy [7, 5]. For this reason, it is necessary to

conduct studies in which environmental and social risks are analysed to appropriate standards and the financing package should include risk coverage. In addition, low interest rates help eliminate these effects.

3.3.10 Market Conditions

Market conditions are critical to the financing of all type energy projects. Poorly designed markets cause problems in financing projects [4] due to the uncertainty of electricity sales prices. In order for loan repayment to be established, a long-term fixed price is required, and this can only occur in stable markets [19, 22, 11]. Risk coverages, high leverage, long maturity, and lower interest rate loans mitigate the risk of price uncertainty.

3.3.11 Financing Period

Long construction period and capital-intensive projects like HEPPs need loans those have long maturity [10, 22, 23]. The due date of the debt should be long enough to finance both the whole construction period and the initial phases of operation period. Given that the construction period may take up to 10 years, especially for large HEPPs, the loans should be medium-term at best, and these loans are more difficult to obtain than short-term. In addition, high leverage eases the effect of this situation.

4.1 Methodology of the Study

Various sources can be used to finance HEPP projects with project finance method. In addition, the unique characteristics of HEPP projects may make financing difficult.

The lack of a study on the extent to which the funding channels in project finance respond to the problematic characteristics of HEPP projects has been the starting point of this thesis. The aim of the thesis is to evaluate the financing channels in HEPP projects according to the factors complicating finance and propose a financial model that can compensate for these factors.

In order to achieve these goals, 3-steps method which can be seen in Figure 4.1 is adopted.

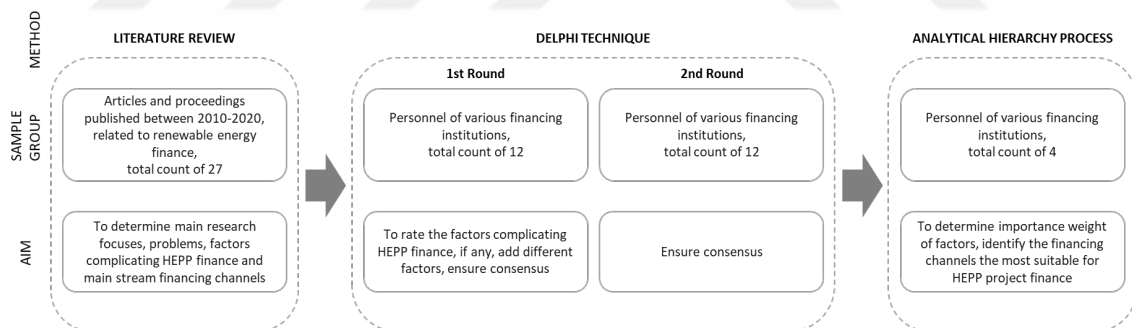


Figure 4.1 Flow Diagram of the Study

As the first step, the study involved a systematic literature review and review of peer-reviewed publications and proceedings between January 2010 and April 2019. The search of the appropriate databases was performed by a method of content analysis, which is a type of qualitative research. In order to synthesize the previous studies and findings, the literature review comprised the beginnings of all academic papers. Qualitative content analysis is the gathering and analysis of

non-numerical data such as papers, interviews, and visual materials [54]. The systematic literature review approach is a method that includes the identification and analysis of data to achieve accurate conclusions on a topic and to recognise gaps in the literature for future research opportunities in this area [55].

In the next stage, factors complicating HEPP financing found in the literature review were evaluated by experts through Delphi surveys. As a result of the evaluation, the importance weights of all factors were found, and the financing channels were evaluated according to these factors. The results of the literature review and Delphi research were compared and the financing model for the selection criteria of the financing channel of the HEPP projects was proposed.

As a final step, Analytical Hierarchy Process (AHP) was employed. At this stage, it is aimed to make pairwise comparisons of financing channels according to the factors complicating finance. The factors that participants agreed on in Delphi surveys will form the inputs of the AHP study. Later, the most suitable financing channels for HEPP financing will be determined.

In section 4.2, aim, classification method, scope and method of content analysis conducted on hydropower financing is defined. Content analysis conclusions will be made over the categories and sub-categories derived from the content analysis.

In the next section, 4.3, conclusions from content analysis are evaluated by experts who are working in banks, multilateral agencies, public sector, and consultancy firms, using Delphi Technique. In addition, Section 4.4 includes the details and results of the AHP study.

Section 4.5 is the last section in methodology part and contains the discussion of the results obtained from all previous sections.

4.2 Content Analysis on Hydropower Financing

In this section, academic studies on hydropower financing, which is a type of renewable energy, will be evaluated with meta-analysis method.

4.2.1 Data Collecting Procedure

Priority was given to articles published between 2010-2019 in international peer-reviewed journals in the above databases in order to reach up-to-date information. As a result of this search, 27 studies have been reached. The searches were carried out primarily with the keyword “hydropower financing”, and the research was continued with the keyword “renewables financing” as there were not enough studies and hydroelectric energy was a type of renewable energy. As a result of searches with these two keywords, 20 articles and 7 proceedings were obtained. In order to expand the research and spread the results to the general, “project finance” determined as primary keyword and, “hydropower” and / or “energy” as secondary keywords. As a result of all searches, 20 articles and 7 proceedings related to financing of HEPPs have been reached.

Literature between 2010- 2019 was searched and related studies were embodied in this study. Data analysis has been conducted for understanding the characteristics of the literature on renewable financing. Content analysis have performed for determining type, date, databases, category, methods, keywords, and content of the studies.

27 studies that collected in this context:

- 20 of them are articles those subjects are “renewable energy financing” and published peer-reviewed journals,
 - 7 of them are proceedings those are taken part in international conferences
- (Figure 4.2)

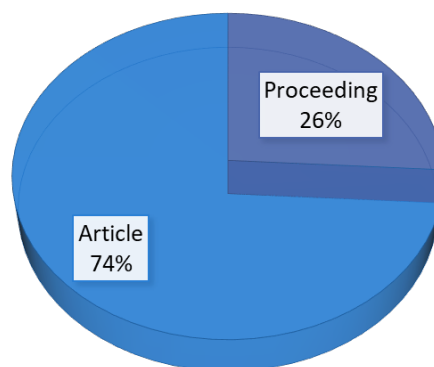


Figure 4.2 Classification According to Types

The number of studies varies by years. The number of studies included in the thesis by years is shown in Figure 4.3. According to the date of publication, 2 in 2010, 3 in 2011, 3 in 2012, 2 in 2013, 5 in 2014, 1 in 2015, 3 in 2016, 3 in 2017, 4 in 2018 and in 2019, one study was included in the study. Similar patterns are observed when the number of studies in the literature is compared with the total amount of renewable energy investments. When the number of studies and investment graph are coincided, it is observed that they show similar trends with an interval of about 1 year.

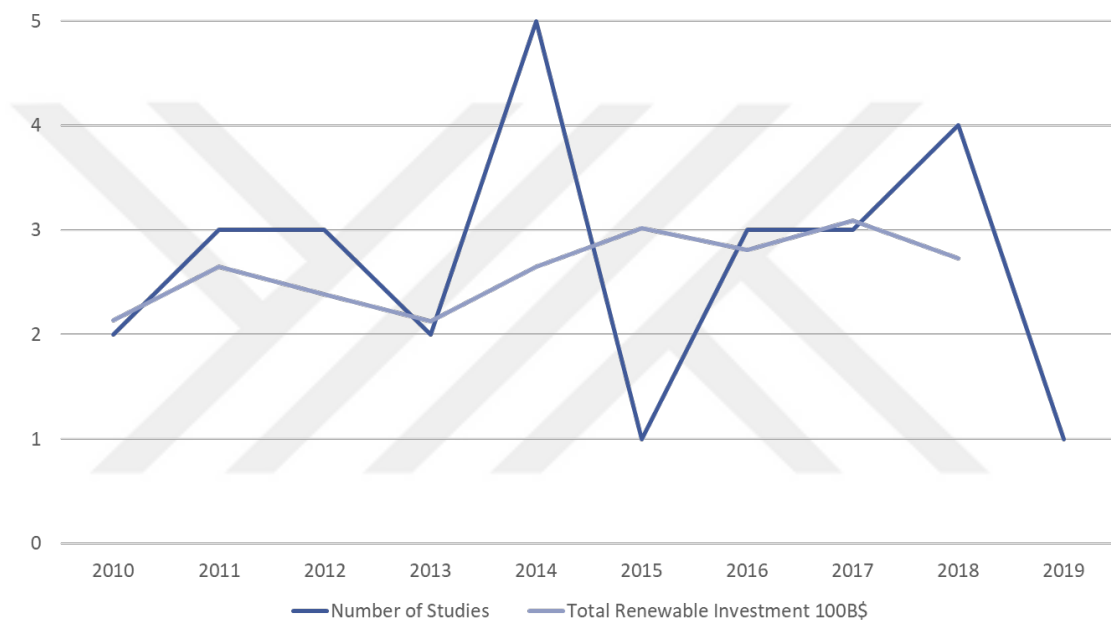


Figure 4.3 Number of Studies vs. Total Renewable Energy Investment

For the content analysis method, EBSCO Academic Publishing, IEEE Xplore Digital Library, Emerald Group Publishing, JSTOR, Springer and Taylor & Francis databases, which can be accessed through Yildiz Technical University network, searched with the keywords “hydropower financing”, “renewables financing” and “project finance”. All proceedings are reached from IEEE while articles from the another five databases. As it shown in Figure 4.4, 7 studies from both Taylor and Francis and EBSCO, 6 from IEEE, 3 from Springer and 2 from both Emerald and JSTOR included the literature review.

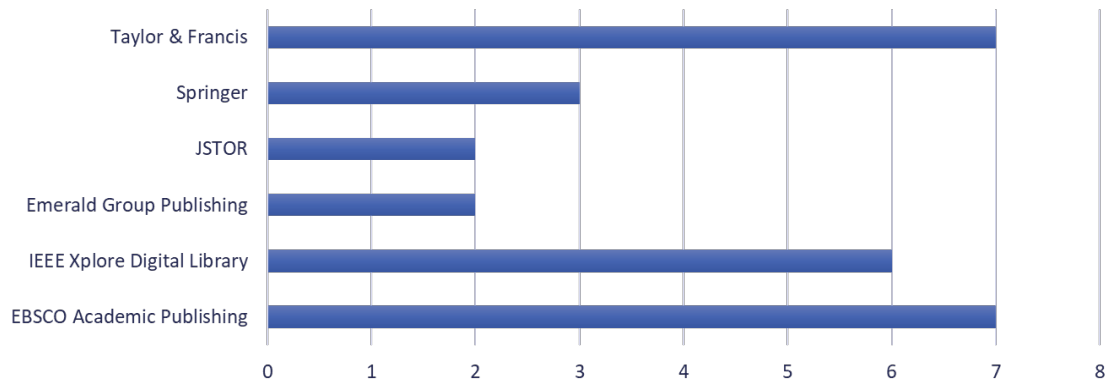


Figure 4.4 Classification According to Databases

All studies processed are listed in Table 4.1. Classifications made according to database, type, aim of the study, method and category.

Table 4.1 Studies Referred in Literature Review

	<i>DATA BASE</i>	<i>REFER ENCE</i>	<i>TYPE</i>	<i>NAME</i>	<i>METHOD</i>	<i>CATEGORY</i>
1	EBSCO	[13]	A	Financing Climate- friendly Energy Development Through Bonds	normative inference	financing channels
2	EBSCO	[3]	A	Financing for Renewable Energy Projects: A Decision Guide by Developmental Stages with Case Studies	case study	financing channels & factors complicatin g finance

Table 4.2 Studies Referred in Literature Review (*continued*)

3	EBSCO	[9]	A	Financing Instruments and Channels for the Increasing Production and Consumption of Renewable Energy: Lithuanian Case	case study	financing channels
4	EBSCO	[17]	A	Financing Renewable Energy Infrastructures via Financial Citizen Participation - The Case of Germany	normative inference	financing channels & factors complicating finance
5	EBSCO	[15]	A	Review of Renewable Energy Investment and Financing in China: Status, Mode, Issues and Countermeasures	case study	financing channels
6	EBSCO	[20]	P	Study of Risks Affecting Renewable Energy Financing	literature review	finance – risk relationship & factors complicating finance

Table 4.3 Studies Referred in Literature Review (*continued*)

7	EBSCO	[7]	A	The Main Support Mechanisms to Finance Renewable Energy Development	normative inference	financing channels & factors complicating finance
8	EMERALD	[22]	A	Determinants of Bank Loan Spread in Project Finance	regression analysis	finance – risk relationship & factors complicating finance
9	EMERALD	[23]	A	Loan Tenor in Project Finance	regression analysis	financing channels & factors complicating finance
10	IEEE	[6]	P	Attracting Foreign Direct Investment	case study	financing channels
11	IEEE	[11]	P	Features of Financing Innovative Renewable Energy Development	normative inference	finance – risk relationship & factors complicating finance
12	IEEE	[18]	P	Financing of Renewable Energy Installations	case study	financing channels

Table 4.4 Studies Referred in Literature Review (*continued*)

13	IEEE	[14]	P	Impact of Carbon Financing on the Development of Small-Scale Run of River Hydropower Plants in Malaysia During the Period 2008-2012	case study	financing channels
14	IEEE	[16]	P	Islamic Finance and Renewable Energy: An Innovative Model for the Sustainability of Investments	case study	financing channels
15	IEEE	[19]	P	Structuring Renewable Energy Projects to Enhance Bankability	normative inference	finance – risk relationship & factors complicating finance
16	JSTOR	[10]	A	Finance for Renewable Energy: An Empirical Analysis of Developing and Transition Economies	regression analysis	financing channels & factors complicating finance

Table 4.5 Studies Referred in Literature Review *(continued)*

17	JSTOR	[4]	A	Support Schemes for Renewable Energy: An Economic Analysis	case study	financing channels & factors complicating finance
18	SPRINGER	[8]	A	Regulatory design and incentives for renewable energy	mathematical model suggestion	financing channels & factors complicating finance
19	SPRINGER	[5]	A	Feed-in Subsidies, Taxation, and Inefficient Entry	mathematical model suggestion	financing channels & factors complicating finance
20	SPRINGER	[12]	A	A Quantitative Analysis of 10 Multilateral Development Banks' Investment in Conventional and Renewable Power-generation Technologies from 2006 to 2015	normative inference	financing channels

Table 4.6 Studies Referred in Literature Review (*continued*)

21	TANDF	[21]	P	Economics of Hydropower Energy: A Critical Assessment	normative inference	finance – risk relationship & factors complicating finance
22	TANDF	[27]	A	Energy and Environmental Policies in Turkey	normative inference	financing channels
23	TANDF	[24]	A	Hydropower Energy Versus Other Energy Sources in Turkey	normative inference	factors complicating finance
24	TANDF	[25]	A	Sustainable Energy Policies in Turkey	normative inference	financing channels
25	TANDF	[26]	A	The Paradigm of Sustainability in Turkey's Energy Sector	case study	finance – risk relationship
26	TANDF	[28]	A	The status of renewable electricity from hydropower in Turkey	case study	factors complicating finance
27	TANDF	[29]	A	Trends on energy policy and sustainable development in Turkey	normative inference	financing channels

4.2.2 Content Analysis Procedure

3 main research focus is determined in content analysis. These are, finance-risk relationship, financing channels and factors complicating HEPP finance. In some cases, factors complicating HEPP finance category may fall within other categories. As can be seen in Figure 4.5, majority of the studies are about financing channels. Total number of the studies including the factors complicating finance is sixteen, however most of them fall within included in other studies have another main topic. Articles on finance-risk relationship constitutes six, while only on factors complicating finance is two.

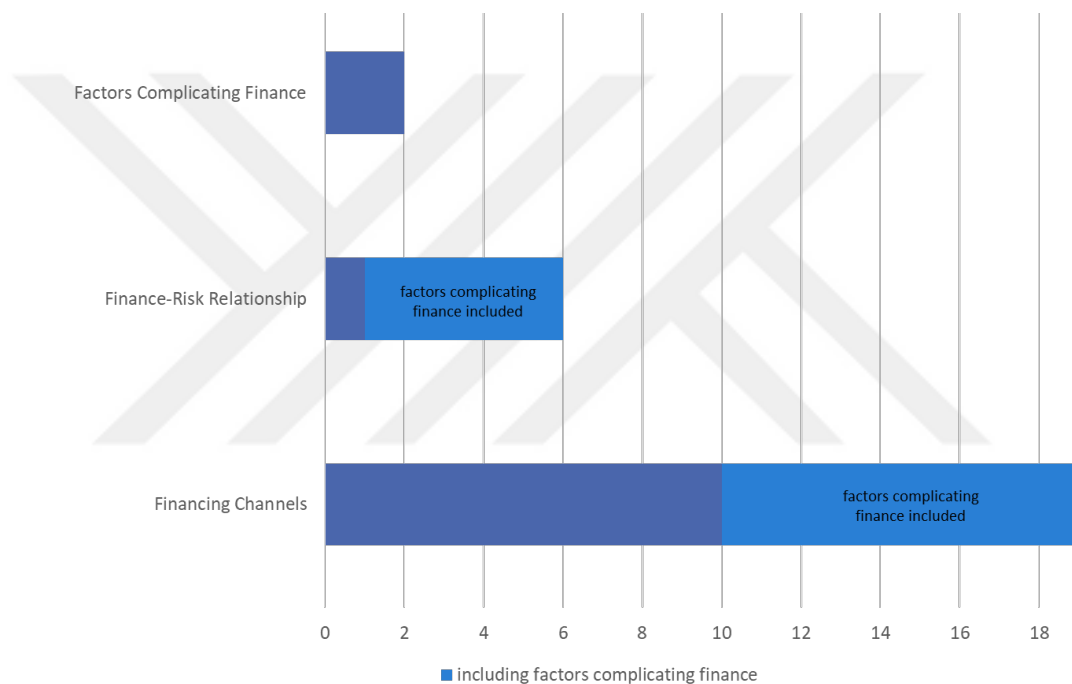


Figure 4.5 Classification According to Categories

The research methods used in the studies utilized in the literature review are determined as mathematical model suggestion, regression analysis, literature review, case study and normative inference. As it shown in Figure 4.6, the most used method is normative inference that constitutes 11 studies. Second most used method is case study. For those 27 studies, qualitative methods are preferred generally.

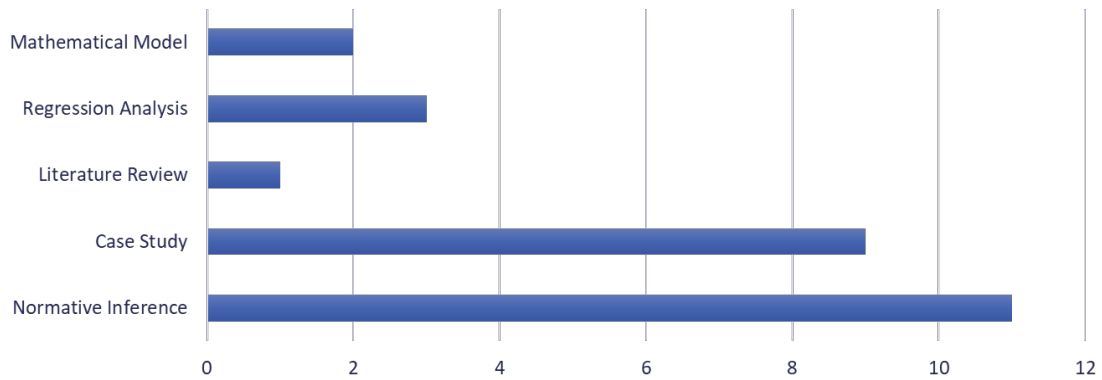


Figure 4.6 Research Methods Used in Studies

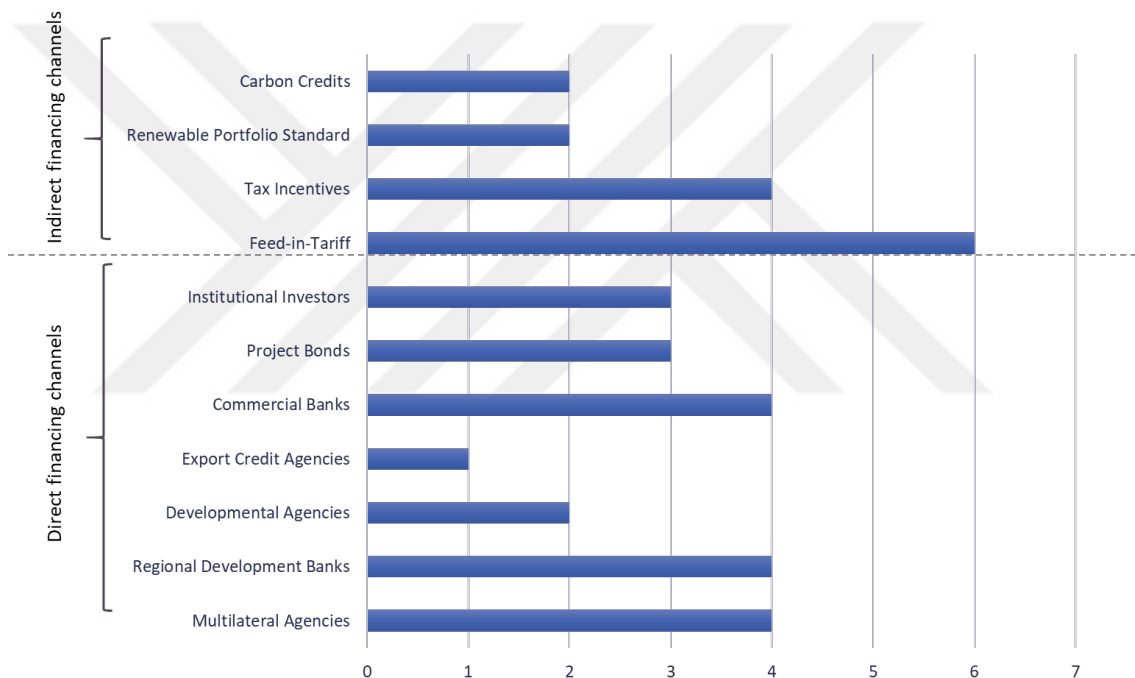


Figure 4.7 Financing Channels Found in Literature Review

11 funding channels were obtained, one of the 3 research focuses identified in the literature review. These can be grouped as direct and indirect financing channels. While indirect funding channels are determined as carbon credits, renewable portfolio standard mechanism, tax incentives and feed-in-tariff mechanism, direct funding channels can be listed as multilateral agencies, regional development banks, developmental agencies, export credit agencies, commercial banks, project bonds and institutional investors. As it seen in Figure 4.7, the most frequently

cited financing channel in the literature is feed-in-tariff. Since the scope of the thesis consists of direct financing channels, only those are considered. Among the direct financing channels, commercial banks, regional development banks and multilateral agencies are the most indicated. Export credit agencies are the least mentioned among all categories.

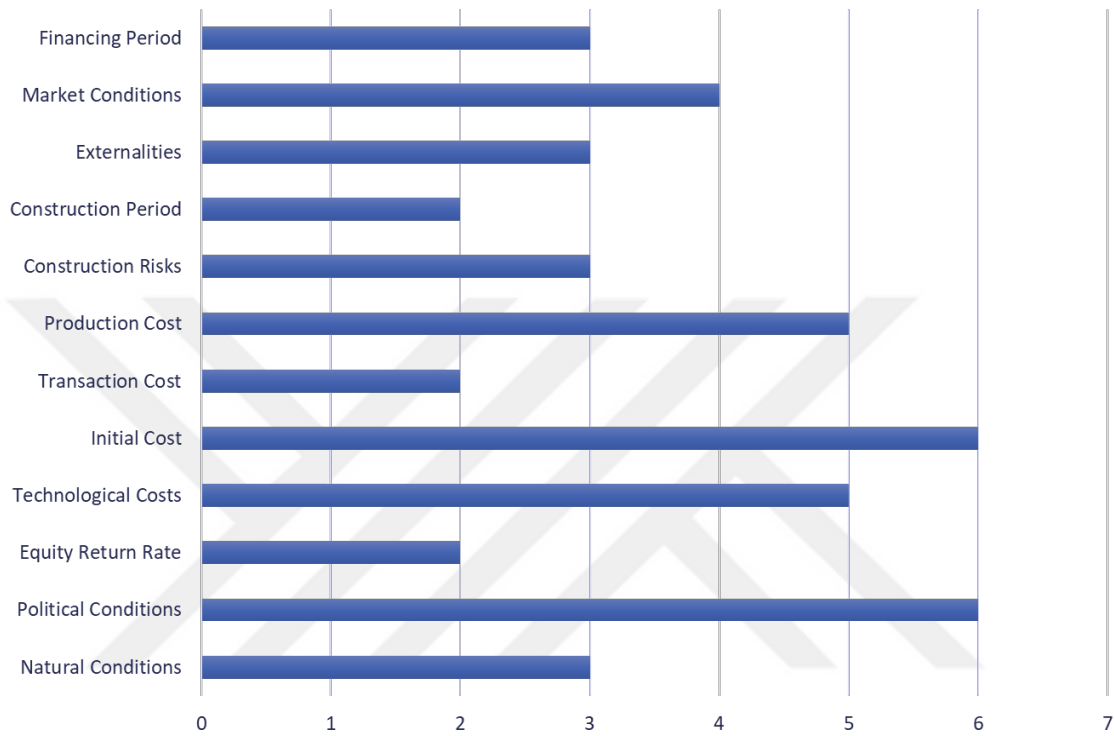


Figure 4.8 Factors Complicating HEPP Finance Found in Literature Review

For factors that complicate HEPP financing, 12 factors were found in the literature (Figure 4.8). In the content analysis, the most mentioned factors are the initial cost and political conditions. Production cost and technological cost items, which are secondary important, are removed from the list since they are not valid for HEPP projects. Although the production cost of HEPPs is still not as low as conventional power plants, it is the lowest among all renewable power plants [56, p.21]. Also, HEPPs' technology cost is lower than other renewables, as their equipment has been known for a long time and is now in a state of maturity. Market conditions come in third, while financing period, externalities, construction risks and natural conditions come fourth. The least mentioned

categories in the literature were determined as construction period, transaction cost and equity return rate.

All in all, after deducting 2 criteria that are not valid for HEPP projects, the list has decreased to 10 factors. The 10 factors mentioned here will create a key indicator list in the next step, Delphi panels. With the Delphi study, it is aimed to determine the real importance order of the factors based on expert opinions.

4.3 Delphi Technique

Delphi method was developed in 1959 by Olaf Helmer, Norman Dalkey, and Nicholas Rescher as a Research and Development Corporation (RAND) project. The technique is based on panels, which provides expert opinions. Dalkey [57] defined Delphi method as “Delphi is the name of a set of procedures for eliciting and refining the opinions of a group of people. In practice, the procedures would be used with a group of experts or especially knowledgeable individuals.” In the same report, distinctive characteristics of the Delphi defined as, anonymity, controlled feedback and statistical ‘group response’. Anonymity serves to reduce the impact of social dominance through private answers. Controlled feedback inhibits irrelevant answers and other unnecessary information. Lastly in order to represent group opinion, statistical measurements are used.

Delphi has a wide range of uses [58]. The method is adapted according to each usage area. Using Delphi for key indicator selection is a preferred approach. For the study, adopted Delphi approach is shown in the Table 4.2.

Table 4.2 Delphi Approach Adopted in the Study [58]

Perspective	1 st Questionnaire	2 nd Questionnaire
Objectives (top-down)	List key indicators	Expand key indicators, perform initial rating

4.3.1 1st Round

4.3.1.1 Questionnaire Form

In the 1st questionnaire, that was performed between 11-26 March 2020, participants are asked to rate the existing indicators via e-mail, and to add the indicators they thought were missing. Since the sample group formed both local and foreigners, the questionnaire forms are organized in both Turkish and English language, can be seen in the Appendix section. Content of the 1st questionnaire consists of 4 sections and indicated below:

- *Instructions*: Participants were informed about the purpose, subject and method of the study. Information was also given about the duration of the study and how many rounds it will last.

- *Personal information*: Participants were informed that their personal information would be kept confidential and used as anonymous data, and contact address was shared if they wanted to contact with the researchers. Participants were asked about their names, institutions, positions, total experience and experience in the field of HEPP projects financing.

- *Key indicators list*: In the 1st round of Delphi panels, a form consisting of factors that complicate financing of the HEPP projects determined from the literature was gathered. All 12 factors in the form are taken from the literature (Table 4.3). Although technological cost and production cost factors are found in the literature, they are not included in the form. Because these factors are problematic in other type renewable energy projects, they are not valid for HEPP projects. Therefore, the total number of factors has decreased to 10 (Table 4.4). The 10-item key indicators list in the literature was shared with the participants and asked to rate them. In addition, the participants were provided with 2 fields to add the indicators they saw missing.

Table 4.3 Initial Key Indicators List

Number	Factors
1	financing period

Table 4.3 Initial Key Indicators List (*continued*)

2	market conditions
3	externalities
4	construction period
5	construction risks
6	production cost
7	transaction cost
8	initial cost
9	technological cost
10	equity return rate
11	political conditions
12	natural conditions

Table 4.4 Key Indicators List Sent to Participants

Number	Factors
1	financing period
2	market conditions
3	externalities
4	construction period
5	construction risks

Table 4.4 Key Indicators List Sent to Participants (*continued*)

6	transaction cost
7	initial cost
8	equity return rate
9	political conditions
10	natural conditions

- *Rating scale:* Participants were asked to score according to the importance of each key indicator. Scoring is realised on the 6-point Likert scale. The scores and the degree of importance they represent determined as Table 4.5.

Table 4.5 Scales and Definitions of the 1st Questionnaire

Scale	Definition	Scale	Definition
1	not at all important	4	important
2	less important	5	very important
3	slightly important	6	vital

4.3.1.2 Sample Group

A 12-person sample group was created for Delphi panels. Direct financing channels determined from the literature and the consultants and sponsors categories added to them were taken as basis in forming the sample group. In the 1st round of Delphi panels, a form consisting of factors that complicate financing the HEPP projects determined from the literature was sent to the participants via e-mail.

The percentile of the organizations that the participants are employed is as in Figure 4.9. 3 people from commercial banks, consultants, and sponsors groups, 2 people from developmental agencies and 1 person from regional development bank group attended the 1st round of Delphi panels. Accordingly, a heterogeneous sample group was created for Delphi panels. According to Figure 4.10, consultants, sponsors and commercial banks are equal and each account for 25% of the number of participants. Regional development banks employees make up 8% of the sample group, while developmental agencies make up 17%.

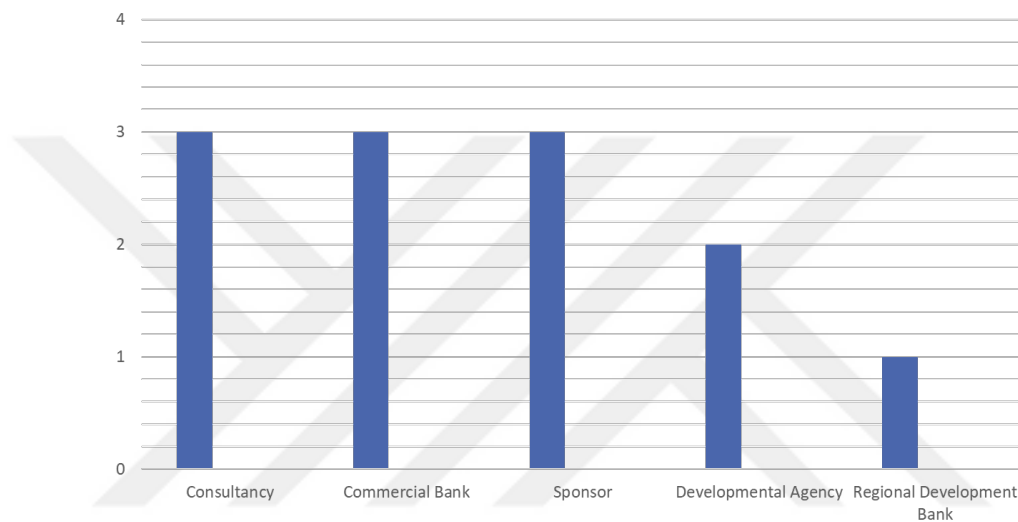


Figure 4.9 Number of Participants According to Institution

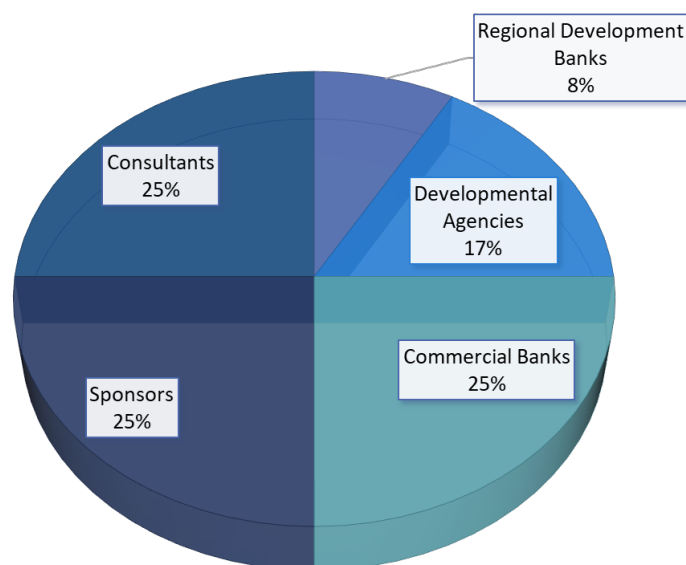


Figure 4.10 Institutions of Participants

The total experience of the participants in their field of study can be seen in Figure 4.11. Accordingly, the least experienced participant has 3 years, and the most experienced participant has 25 years of experience. The total experience average of the participants is 14.41 years / participant.

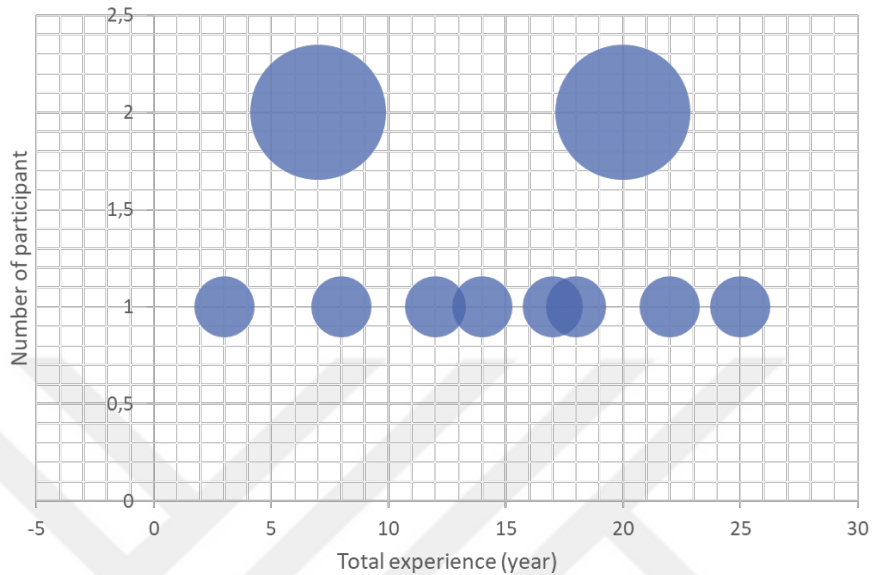


Figure 4.11 Total Experience of the Sample Group

According to Figure 4.12, %50 of the participants has experience more than 15 years. While % 25 of the participants have 5 to 10 years' experience, %17 have 10 to 15 and %8 have 1 to 5 years. Totally %67 of the participants has 10 or more years' experience.

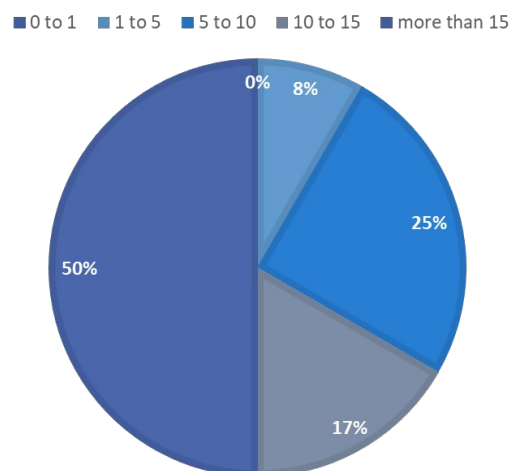


Figure 4.12 Total Experience Percentages of Sample Group

Participants' experience in financing HEPP projects is as in Figure 4.13. In the field of HEPP project financing, the lowest experience period is 0 years, and the highest experience is 20 years. The average experience of the participants in the field of HEPP financing is found to be 8.16 years / participant.

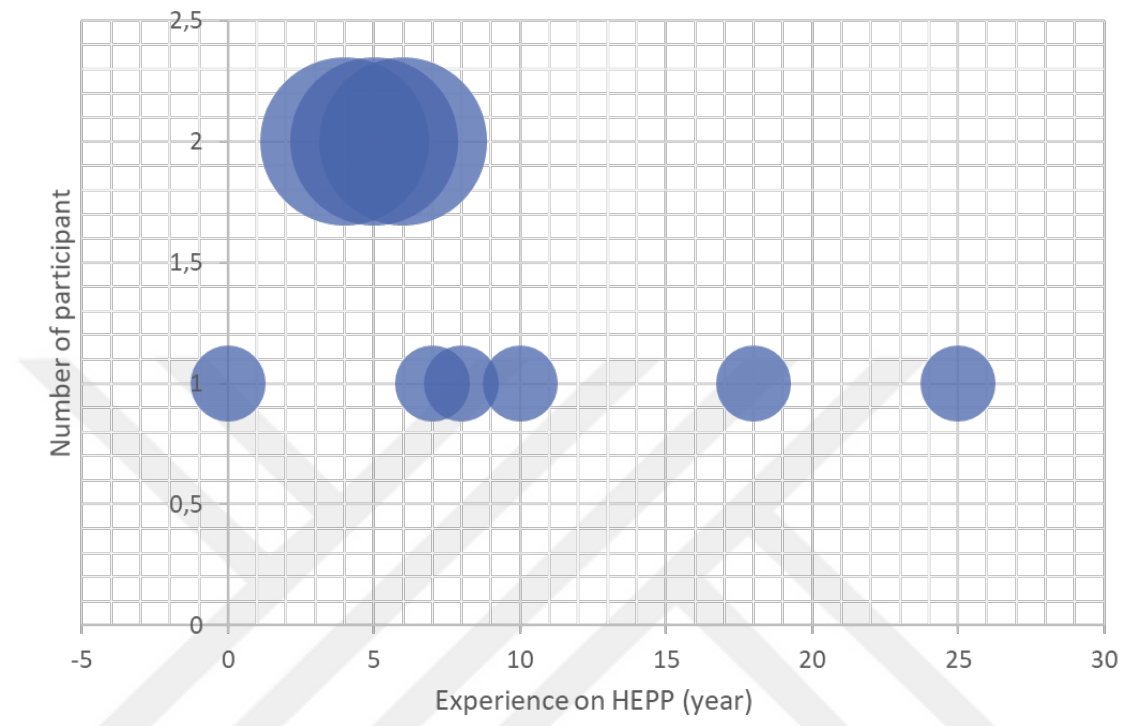


Figure 4.13 Total HEPP Finance Experience of Sample Group

As seen in Figure 4.14, 8% of the participants have 0-1 years of experience in the field of HEPP projects financing. While 17% of the participants have 1-5 years of experience, 50% have 5-10 years. While 17% is between 10-15 years, 8% has over 15 years of experience. 25% of the participants are experienced in 10 years or more.

■ 0 to 1 ■ 1 to 5 ■ 5 to 10 ■ 10 to 15 ■ more than 15

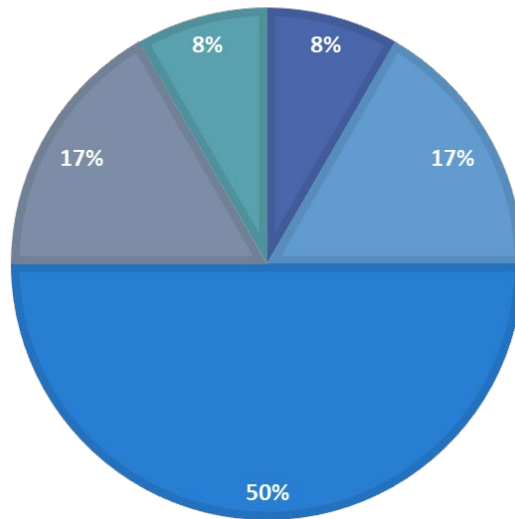


Figure 4.14 Total HEPP Finance Experience Percentages of Sample Group

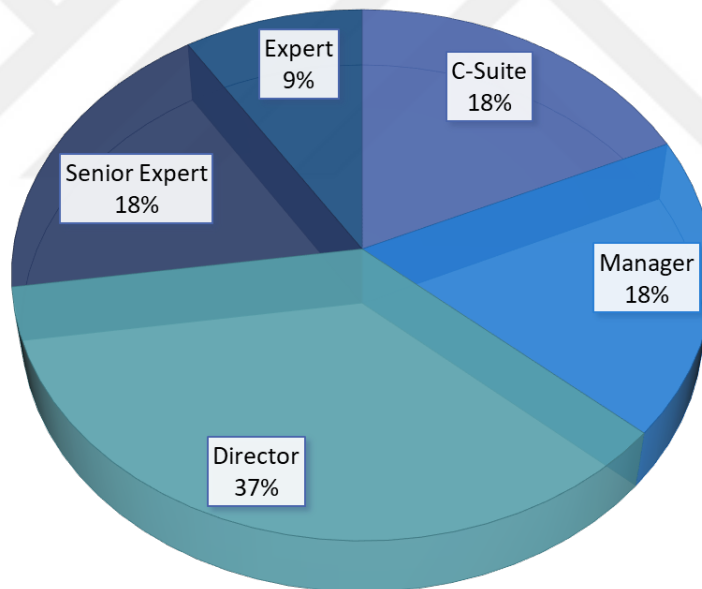


Figure 4.15 Workplace Positions of Participants

The positions of the sample group in their jobs were realized as 9% expert, 18% senior expert, 18% C-suite, 18% manager and 37% director.

4.3.1.3 Results

The first round of Delphi panels is the first step to identify 6 of the factors determined in the literature, making finance the most difficult. With the completion of the second round, the most important 6 factors will be determined with the help of the points given by the participants, and the factors that are not in the literature but deemed important by the participants can be added to the list. Thus, it will be contributed to the elimination of gaps in the literature (if any).

Analysis results were obtained by using SPSS software version 26. In the first round, degree of impact (mean), standard deviation, variance, minimum, maximum, percentiles (25-50-75) and Q3-Q1 (range) values were calculated for each ten indicators.

Table 4.6 Analysis of the First Round of Delphi Survey

	<i>natural conditions</i>	<i>political conditions</i>	<i>equity return rates</i>	<i>initial costs</i>	<i>transaction costs</i>	<i>construction risks</i>	<i>construction period</i>	<i>externalities</i>	<i>market conditions</i>	<i>loan tenor</i>
Degree of Impact (Mean)	5,25	3,50	3,75	4,33	2,92	5,17	4,50	3,75	4,08	4,33
Std. Deviation	1,05	1,24	1,48	1,21	0,99	0,93	0,79	1,21	1,37	1,61
Variance	1,11	1,54	2,20	1,51	0,99	0,87	0,63	1,47	1,90	2,60
Minimum	3	1	1	1	1	4	3	2	1	1
Maximum	6	5	6	5	4	6	6	6	6	6

Table 4.6 Analysis of the First Round of Delphi Survey (*continued*)

Percentile - 25	4,25	2,25	3,25	4,00	2,00	4,00	4,00	3,00	3,00	3,25
Percentile - 50	6,00	4,00	4,00	5,00	3,00	5,50	4,50	4,00	4,50	5,00
Percentile - 75	6,00	4,00	4,75	5,00	4,00	6,00	5,00	4,75	5,00	5,75
Q3 - Q1 (Range)	1,75	1,75	1,50	1,00	2,00	2,00	1,00	1,75	2,00	2,50

Interquartile Range (IQR) value was taken as basis in the analysis of the results. The IQR value is the measure of variability and defined as the difference between the largest and the smallest values in the middle 50% of a set of the given data. Therefore, Q1 (percentile 25) is the "middle" value of the first half of the data set, while the value of Q2 (percentile 50) is the median of the series. Q3 (percentile 75) is the "middle" value of the last half of the data set. IQR is formulated as Q3-Q1. The small IQR value indicates that the variability in the data set is low, so there is consensus. According to the results of the 1st round of Delphi surveys, min. IQR 1,00 max. IQR was determined as 2.50.

4.3.2 2nd Round

4.3.2.1 Questionnaire Form

In the second round, that was performed between 10 August – 3 September, the participants were asked to re-evaluate the categories they gave points to before via e-mail. The content of the 2nd round questionnaire form was created by removing the categories with the lowest IQR in the 1st round from the form. The language of the form is determined as Turkish and English and consists of 3 main parts. Questionnaire forms can be seen in the Appendix section.

- *Instructions:* Participants were informed about the purpose and method of the form. Participants were asked whether they want to change their answers in the first round according to the group average, and it was stated that they could keep their answers exactly if they wanted. Participants were also asked to rate the new categories added with consensus.

- *Key Indicators List:* In the first round, "high initial cost" and "long construction period" categories with an IQR of 1.00 were closed to scoring. "Excess amount of environmental and social risks" and "absence of standard contract format for HEPP projects" categories, which were added with consensus among the participants, were opened for scoring. Accordingly, the total number of categories reached to 12 and these are indicated in Table 4.7.

Table 4.7 Key Indicators List Sent to Participants at the 2nd Round

Number	Factors	Status
1	financing period	open to scoring
2	market conditions	open to scoring
3	externalities	open to scoring
4	construction period	close to scoring
5	construction risks	open to scoring
6	transaction cost	open to scoring
7	initial cost	close to scoring
8	equity return rate	open to scoring
9	political conditions	open to scoring
10	natural conditions	open to scoring

Table 4.7 Key Indicators List Sent to Participants at the 2nd Round (*continued*)

11	excess amount of environmental and social risks	open to scoring
12	absence of standard contract format for HEPP projects	open to scoring

- *Rating Scale:* In the rating scale, a 6-point Likert scale is given as the same as in the 1st round (Table 4.5). Besides, the 1st round point average for each category is given with arrows (↓ and ↑) showing the comparison of the participant's score in the 1st round and the average.

4.3.2.2 Sample Group

2nd round survey is realised with the same 12-person sample group in the first round. Statistical information of the sample group can be seen in the 1st round section.

4.3.2.3 Results

In the survey conducted with 12 people, 9 people re-evaluated their responses, while 3 people remained the same. As a result of the 2nd round of Delphi surveys conducted in 12 categories;

- $IQR \leq 1,00$ in 7 categories
- $1 < IQR \leq 2,00$ in 4 categories
- $IQR > 2.00$ in 1 category

has been found (Table 4.8). This situation shows that there is a consensus in 7 categories. These categories are equity return rate, initial cost, transaction cost, construction period, externalities, market conditions, and environmental and social risks, and will form a basis for the Analytical Hierarchy Process (AHP).

Table 4.8 Analysis of the Second Round of Delphi Survey

	<i>natural conditions</i>	<i>political conditions</i>	<i>equity return rates</i>	<i>initial costs</i>	<i>transaction costs</i>	<i>construction risks</i>	<i>construction period</i>	<i>externalities</i>	<i>market conditions</i>	<i>loan tenor</i>	<i>environmental and social risks</i>	<i>absence of standard contract format for HEPP projects</i>
Degree of Impact (Mean)	5,08	3,66	3,75	4,33	2,66	5,16	4,50	3,75	4,33	4,41	4,25	3,58
Std. Deviation	0,99	1,07	1,21	1,23	0,49	1,02	0,79	0,75	1,07	1,50	0,86	1,08
Variance	0,99	1,15	1,47	1,51	0,24	1,06	0,63	0,56	1,15	2,26	0,75	1,17
Minimum	3,00	2,00	1,00	1,00	2,00	3,00	3,00	2,00	2,00	1,00	3,00	2,00
Maximum	6,00	5,00	6,00	5,00	3,00	6,00	6,00	5,00	6,00	6,00	6,00	5,00
Percentile - 25	4,25	2,50	4,00	4,00	2,00	4,25	4,00	3,25	4,00	3,25	4,00	3,00
Percentile - 50	5,00	4,00	4,00	5,00	3,00	5,50	4,50	4,00	4,50	5,00	4,00	3,00
Percentile - 75	6,00	4,00	4,00	5,00	3,00	6,00	5,00	4,00	5,00	5,75	5,00	4,75
Q3 - Q1 (Range)	1,75	1,50	0,00	1,00	1,00	1,75	1,00	0,75	1,00	2,50	1,00	1,75

The 7 factors determined as the result of 2-round Delphi interviews do not have a significant relationship with the most mentioned factors in the literature. Although the initial cost and political conditions factors are the most mentioned factors in the literature, a consensus has been reached only on the initial cost as a result of Delphi. A consensus was reached on the market conditions, which were important for the 3rd degree in content analysis, and only externalities were included in the 4th order important factors. Surprisingly, a consensus was reached on all factors

that were least mentioned in the content analysis, and these factors were included for later stages. In addition, the factor of excess environmental and social risks, which is not mentioned in the literature, was included in the list as a result of the consensus among the participants. Accordingly, when the factors obtained because of systematic literature review and content analysis are evaluated alone, the order of importance cannot be obtained.

4.4 Analytical Hierarchy Process (AHP)

Analytical Hierarchy Process method was developed by Saaty in 1987. The method enables making pairwise comparisons among different options. In the study, AHP method is used for determining the financing channels which presents optimum solutions to characteristic factors of HEPPs that complicating the financing process.

4.4.1 AHP Questionnaire Form

Questionnaire form of AHP was sent to participants between 17-30 December 2021 via e-mail. Since the sample group formed both local and foreigners, the questionnaire forms are organized in English language. Content of the AHP questionnaire consists of 4 sections and indicated below:

- Instructions: Participants were informed about the purpose, subject and method of the study. Detailed information on AHP method was provided.
- Personal Information: Participants were asked about the same information with the Delphi questionnaires including names, institutions, positions, total experience and experience in the field of HEPP projects financing. Participants were informed that their personal information would be kept confidential and used as anonymous data.
- Hierarchy: Participants were informed about the general structure of the study. In this section, hierarchy within the criterion was explained graphically.

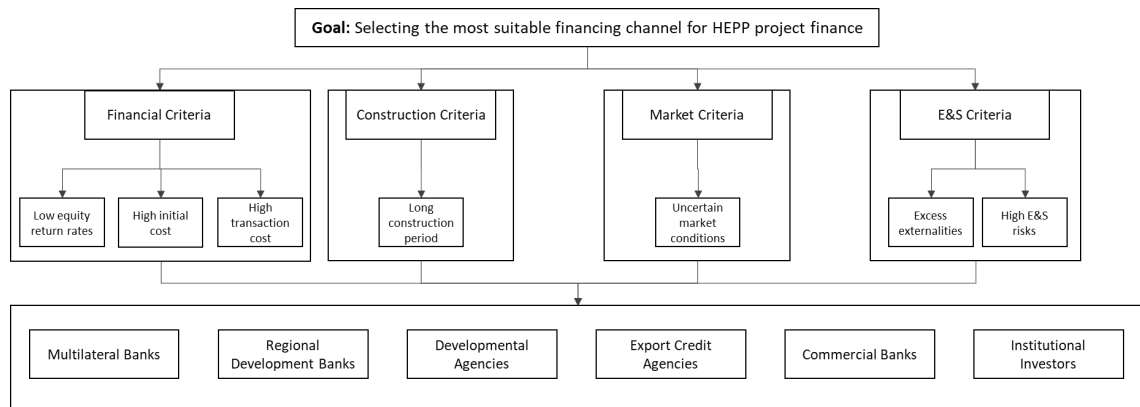


Figure 4.16 Hierarchy Formed in the Study

- *Importance Values:* Saaty's [59] importance values was provided to participants.

Table 4.9 Importance Values [59]

Values	Meaning
1	Equal importance
3	Moderate importance
5	Strong importance
7	Very strong importance
9	Extreme importance
2, 4, 6, 8	Intermediate values

- *Questionnaire:* Participants were asked to make pairwise comparisons between the financing channels. All factors gathered from the Delphi study were included as separate questionnaire. Questionnaire forms can be seen in the Appendix section.

4.4.2 Sample Group

A 4-person sample group was created for AHP study. Participants are selecting to create heterogeneous group and employed commercial banks, regional development banks and consultancy firms. Statistical data of the sample group can be seen below graphics.

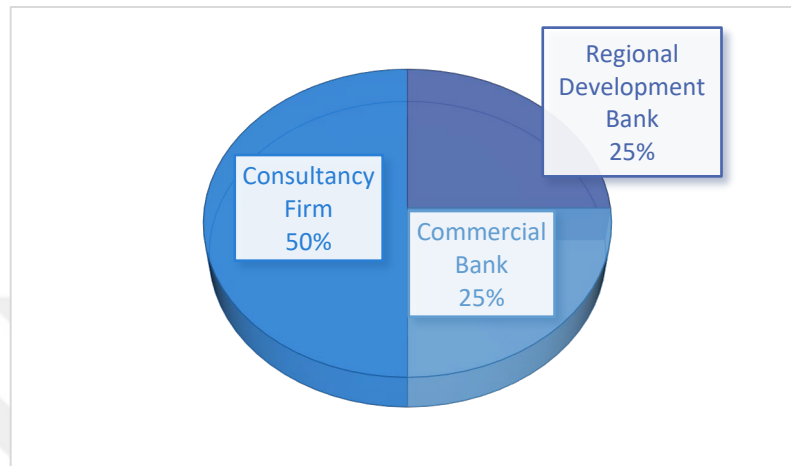


Figure 4.17 Institutions of Participants of AHP Study

50% of the participants are consultants, commercial bank and regional development bank employees are both constitutes 25%.

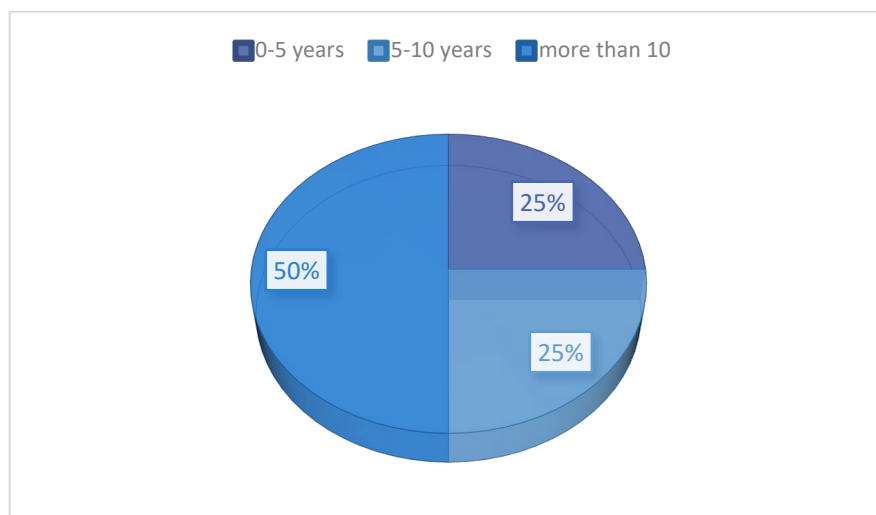


Figure 4.18 Total Experience of the Participants of AHP Study

Total experience of the participants is various. 50% of the participants have more than 10 years' experience, while 0-5- and 5-10-years experienced participants are constituting both 25%.

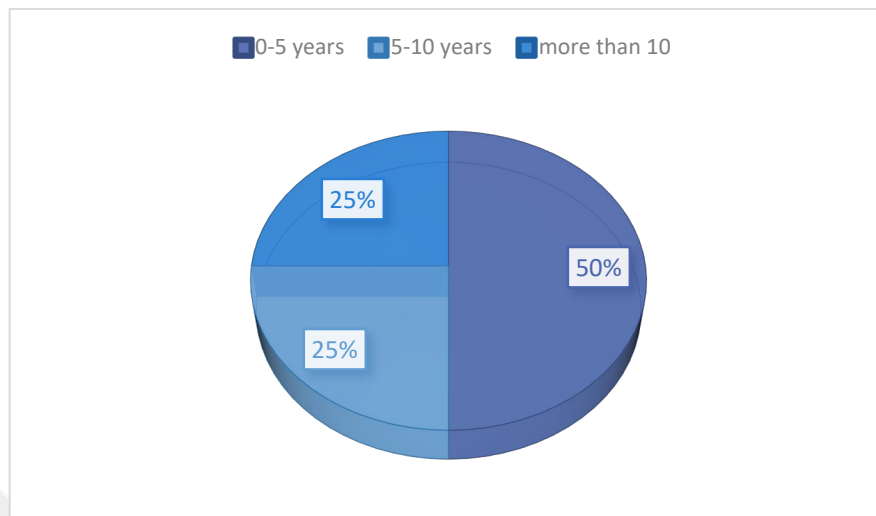


Figure 4.19 HEPP Financing Experience of the Participants of AHP Study

Participants' experience on HEPP financing changes between 0 and 10+ years. 50% of the participants have 0-5 years HEPP financing experience, while 5-10 and more than 10 years experienced participants constitute both %25.

4.4.3 Findings of the Analysis and Discussion

For the AHP study, Super Decisions software is used. The software is designed for computational analysis of the AHP and ANP methods. Factors gathered from the Delphi questionnaires are group according to their categories. 4 main group are created, consisting of 7 factors.

Table 4.10 Main Groups and Factors

Main Group	Factor
Financial Criteria	Equity Return Rates
	High Initial Cost
	High Transaction Cost

Table 4.10 Main Groups and Factors (*continued*)

Market Criteria	Uncertain Market Conditions
Construction Criteria	Long Construction Period
E&S Criteria	Excess Externalities
	High E&S Risks

Criteria and alternatives are structured in the software, shown in the Figure 4.20.

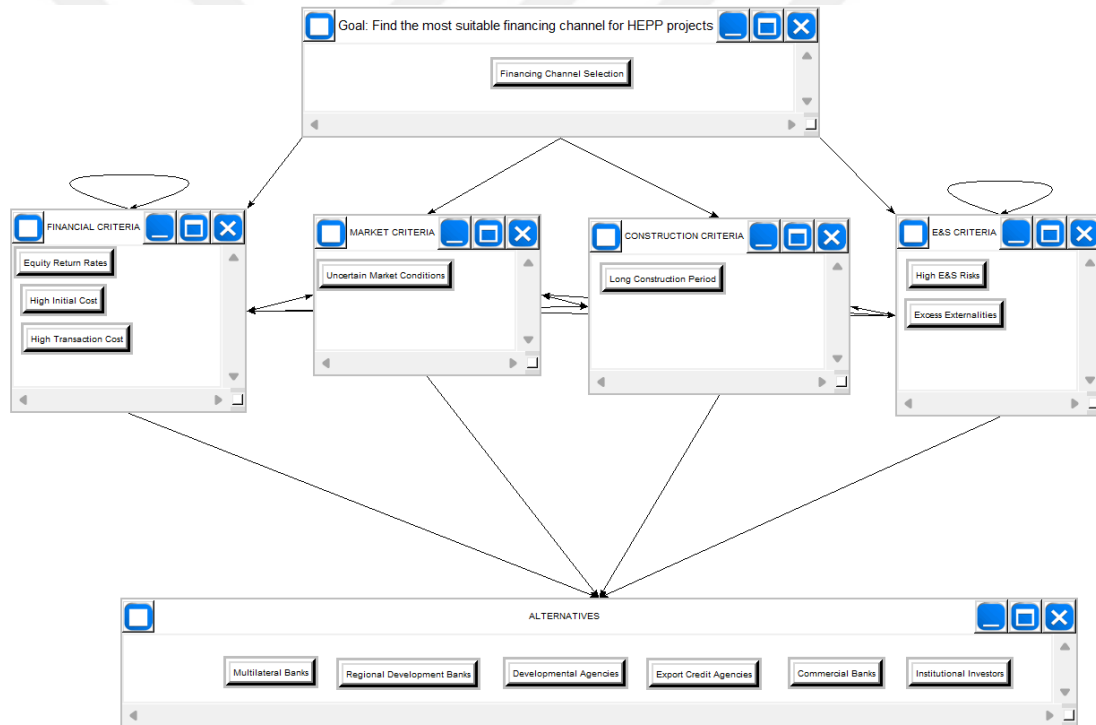


Figure 4.20 Structure and Relations of the Study

4 main groups of the factors are classified as financial, market, construction and E&S criteria and relation between them are defined. After the identification of the relations between criteria, criteria clusters related with alternatives which includes financing channels. Results of the pairwise comparisons from the experts are inputted to the Super Decision software. After the process, geomean values are

calculated and limit matrix, unweighted super matrix and weighted super matrix have been created. After the definition of the relations, the limit matrix is created. Limit matrix identifies the weights of the factors. There are no zero value in the limit matrix, therefore defined relations are considered adequate.

Table 4.11 The Limit Matrix

	<i>Equity Return Rates</i>	<i>Initial Cost</i>	<i>Transaction Costs</i>	<i>Construction Period</i>	<i>Externalities</i>	<i>Market Conditions</i>	<i>Environmental and Social Risks</i>
Equity Return Rates	0.8507	0.8507	0.8507	0.8507	0.8507	0.8507	0.8507
Initial Cost	0.5783	0.5783	0.5783	0.5783	0.5783	0.5783	0.5783
Transaction Cost	0.4460	0.4460	0.4460	0.4460	0.4460	0.4460	0.4460
Construction Period	0.1875	0.1875	0.1875	0.1875	0.1875	0.1875	0.1875
Externalities	0.4022	0.4022	0.4022	0.4022	0.4022	0.4022	0.4022
Market Conditions	0.1875	0.1875	0.1875	0.1875	0.1875	0.1875	0.1875
Environmental and Social Risks	0.1472	0.1472	0.1472	0.1472	0.1472	0.1472	0.1472

Table 4.12 Unweighted Super Matrix

Cluster Node Labels		ALTERNATIVES						CONSTRUCTION CRITERIA		E&S CRITERIA		FINANCIAL CRITERIA			MARKET CRITERIA
		Commercial Banks	Developmental Agencies	Export Credit Agencies	Institutional Investors	Multilateral Banks	Regional Development Banks	Long Construction Period	Excess Externalities	High E&S Risks	Equity Return Rates	High Initial Cost	High Transaction Cost	Uncertain Market Conditions	
ALTERNATIVES	Commercial Banks	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.179065	0.081302	0.117715	0.339348	0.521191	0.082394	0.288890	
	Developmental Agencies	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.050813	0.101816	0.041397	0.030538	0.037180	0.227711	0.024371	
	Export Credit Agencies	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.093284	0.051223	0.042268	0.319406	0.113550	0.077023	0.146459	
	Institutional Investors	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.036460	0.046323	0.059638	0.035756	0.039620	0.083805	0.135336	
	Multilateral Banks	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.314823	0.378211	0.495571	0.069051	0.068991	0.191289	0.181241	
CONSTRUCTION CRITERIA	Regional Development Banks	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.325555	0.341125	0.243412	0.205901	0.219468	0.337777	0.223703	
	Long Construction Period	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	
E&S CRITERIA	Excess Externalities	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	
	High E&S Risks	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	
FINANCIAL CRITERIA	Equity Return Rates	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	
	High Initial Cost	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	
	High Transaction Cost	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000		0.000000	0.000000	0.000000	0.000000	0.000000
MARKET CRITERIA	Uncertain Market Conditions	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	

Table 4.13 Weighred Super Matrix

Cluster Node Labels		ALTERNATIVES						CONSTRUCTION CRITERIA		E&S CRITERIA		FINANCIAL CRITERIA			MARKET CRITERIA
		Commercial Banks	Developmental Agencies	Export Credit Agencies	Institutional Investors	Multilateral Banks	Regional Development Banks	Long Construction Period	Excess Externalities	High E&S Risks	Equity Return Rates	High Initial Cost	High Transaction Cost	Uncertain Market Conditions	
ALTERNATIVES	Commercial Banks	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.179065	0.081302	0.117715	0.339348	0.521191	0.082394	0.288890	
	Developmental Agencies	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.050813	0.101816	0.041397	0.030538	0.037180	0.227711	0.024371	
	Export Credit Agencies	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.093284	0.051223	0.042268	0.319406	0.113550	0.077023	0.146459	
	Institutional Investors	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.036460	0.046323	0.059638	0.035756	0.039620	0.083805	0.135336	
	Multilateral Banks	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.314823	0.378211	0.495571	0.069051	0.068991	0.191289	0.181241	
CONSTRUCTION CRITERIA	Regional Development Banks	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.325555	0.341125	0.243412	0.205901	0.219468	0.337777	0.223703	
	Long Construction Period	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	
E&S CRITERIA	Excess Externalities	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	
	High E&S Risks	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	
FINANCIAL CRITERIA	Equity Return Rates	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	
	High Initial Cost	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	
	High Transaction Cost	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	
Goal: Find the most suitable financing channel for HEPP projects		0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	
MARKET CRITERIA	Uncertain Market Conditions	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	

Limit matrix also enables the priority values of each factor. Priority values can be seen in Figure 4.21.

Icon	Name	Normalized by Cluster	Limiting
No Icon	Financing Channel Selection	0.00000	0.000000
No Icon	Equity Return Rates	0.45371	0.085071
No Icon	High Initial Cost	0.30840	0.057825
No Icon	High Transaction Cost	0.23789	0.044604
No Icon	Multilateral Banks	0.26614	0.066536
No Icon	Regional Development Banks	0.26377	0.065943
No Icon	Developmental Agencies	0.05226	0.013065
No Icon	Export Credit Agencies	0.12055	0.030137
No Icon	Commercial Banks	0.22804	0.057010
No Icon	Institutional Investors	0.06924	0.017310
No Icon	High E&S Risks	0.78547	0.147275
No Icon	Excess Externalities	0.21453	0.040225
No Icon	Long Construction Period	0.50000	0.187500
No Icon	Uncertain Market Conditions	0.50000	0.187500

Figure 4.21 Priority Values

According to priority values, the most important three factors are determined as high E&S risks, long construction period and uncertain market conditions. High E&S risks mean the impact area of HEPP projects is very wide and cause changes in the flora and fauna in the ecosystem where they are located, and they can cause migration and economic activity losses due to expropriation. It is very important to define the E&S risks in HEPP projects well and to structure a sound risk mitigation plan accordingly. The nature of HEPP projects requires a lot of excavation, tunnelling and construction work in the site, which causes significant changes in the natural ecosystem. In addition, noise and air emission problems may be experienced due to intense construction activity. The major change in the ecosystem is the conversion of a river ecosystem to a lake ecosystem. The loss of flora and fauna experienced in this process causes significant effects on endemic species, especially if they exist in the site. Finally, in many storage type HEPP projects, due to the inundation of human habitats, expropriation and therefore

migration needed. In this process, there are problems arising from migration and losses in the fields of economic activity. The long construction period factor refers to the length of the construction period, especially for large-scale HEPP projects. This period varies from approximately 2 to 10 years. Since reimbursement cannot be started during the construction period, the construction period of HEPP projects brings with it special requirements for financing therefore, the grace period found in some loan structures is critical for HEPP projects. Finally, uncertain market conditions express the uncertainty of the price of the electricity produced at the power plant. Turkish FiT, which was recently terminated, largely eliminated this risk, but this risk is present for all power plants as of the end of the FiT period. Uncertainty of electricity sales prices casts doubt on the certainty of loan repayments, so it is much easier to finance power plants that will be covered by FiT. As mentioned before, HEPP projects are mainly construction projects, therefore E&S and construction period factors ranking is not a surprise. Externalities and high transaction costs are ranked as the least important factors for HEPP financing.

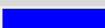
Name	Graphic	Ideals	Normals	Raw
Commercial Banks		0.856835	0.228040	0.057010
Developmental Agencies		0.196356	0.052259	0.013065
Export Credit Agencies		0.452946	0.120548	0.030137
Institutional Investors		0.260157	0.069239	0.017310
Multilateral Banks		1.000000	0.266142	0.066536
Regional Development Banks		0.991095	0.263772	0.065943

Figure 4.22 Results of the Analytical Hierarchy Process

When all the factors complicating HEPP finance are evaluated together, the financing channels that can best meet the needs of HEPP projects have been determined as multilateral banks, regional development banks and commercial banks. Multilateral banks and regional development banks were selected with very close results. These financial institutions contribute greatly to renewable energy projects all over the world. The advantageous financing conditions, risk insurance

opportunities and development financing approach provided by multilateral banks and regional development banks are the most important reasons why they are preferred in HEPP projects. Multilateral agencies points out the World Bank Group, which includes different type financial institutions incorporated.

The World Bank Group offers many products such as risk guarantees, private sector financing supports, public financing supports. Since the main purpose of the group is to provide development finance, the products are quite cost-effective compared to the market, however The World Bank Group does not contribute more than 30% of the budget in private sector projects. Regional development banks are border upon multilateral agencies, but they have limited range. Similar to multilaterals, regional development banks have cost-effective and various financing solutions, contributing more to private sector. In countries such as Turkey where there is a financial market, one of the most important sources of financing for HEPP projects is commercial banks. Commercial banks can be local or global banking groups, providing the financial instruments with market level price. With the spread of renewable energy projects, commercial banks accept these projects as less risky and are more involved in financing transactions. The results found agree with these data. Since most of the costs in HEPP projects consist of construction works, it is normal for export credit agencies to have relatively lower importance in HEPP financing. Developmental agencies and institutional investors can be expected to have a more significant share in developed countries. As a result, the most advantageous sources of financing for HEPP projects were determined as multilateral banks, regional development banks and commercial banks. Looking at the financing resources of renewable energy projects in Turkey from past to present, the results are in line with the past data.

CONCLUSION AND DISCUSSION OF RESULTS

The most significant change has occurred in the financing processes, as hydroelectric power plants have ceased to be projects for public benefit and have become investment projects. Projects that were previously financed entirely by the public are now projects in which many financial actors are involved. In this process, different products of different financial institutions constitute the financial structures of HEPP projects. HEPP projects contain many difficulties due to their nature. HEPPs, which are large-scale construction projects rather than energy projects, contain factors that make financing complicated due to these features. The main purpose of the study is to determine which financing channel responds to these factors that make the financing of HEPP projects complicated. In this context, firstly, the factors that make HEPP financing complicated were compiled from the literature, and then the most important ones were determined in the light of expert opinions by subjecting them to a 2-round Delphi study. Development steps of the findings is indicated in Table 4.14. After the Delphi study, experts determined that low equity return rates, high initial cost, high transaction cost, long construction period, excess amount of externalities, uncertain market conditions and high E&S risk factors are the factors that make the financing of HEPP projects the most difficult.

Table 5.1 Development Steps of Findings

Initial Set of Factors	Evaluated Set of Factors	Delphi 1 st Round Set of Factors	Delphi 2 nd Round Set of Factors	AHP Set of Factors
financing period	financing period	financing period	-	-

Table 5.1 Development Steps of Findings (*continued*)

market conditions	market conditions	market conditions	market conditions	market conditions
externalities	externalities	externalities	externalities	-
construction period	construction period	construction period	construction period	construction period
construction risks	construction risks	construction risks	-	-
production cost	-	E&S risks	E&S risks	E&S risks
transaction cost	transaction cost	transaction cost	transaction cost	-
initial cost	initial cost	initial cost	initial cost	-
technological cost	-	absence of standard contract format for HEPP projects	-	
equity return rate	equity return rate	equity return rate	equity return rate	-
political conditions	political conditions	political conditions	-	-
natural conditions	natural conditions	natural conditions	-	-

At the beginning, all the factors that made the HEPP financing complicating were compiled from the studies in the literature and twelve factors were obtained at this stage. Two of the twelve factors are valid for other types of renewable energy but not for HEPP projects, so they are eliminated. Afterwards, the ten factors were presented to industry experts through Delphi surveys. Since consensus could not be obtained in the first round, the second round of Delphi surveys were conducted. In the first round, the participants were asked to add maximum of two factors if possible, and the majority opinion was received on the factors E&S risks and absence of standard contract format for HEPP projects. As a result of the Delphi surveys, the most important factors that make the financing of HEP projects difficult have been identified and the number of factors has been reduced to seven. These seven factors were evaluated with the AHP study, and the financing channels were compared accordingly. As a result of the AHP, the three most important factors were determined as E&S risks, construction period and market uncertainties. In order to eliminate E&S risks in HEPP projects, risk coverage should be included in the financing package. In the initial stages of the project, a sound E&S due diligence study should be carried out, risks should be defined properly, and a strong risk mitigation plan and action plan should be structured. In addition, the sponsor company's corporate sustainability strategy will facilitate the transfer of similar processes to the project. For the length of the construction period, the loan structure must include a grace period and this period must coincide with the construction period. Finally, the negative effects of the market uncertainties factor can be eliminated with the FiT mechanism. At this point, it is necessary to create risk protection packages in the financing package and also reserve accounts in the loan structure. Afterwards, these factors were evaluated within the scope of multilateral banks, regional development banks, developmental agencies, export credit agencies, commercial banks and institutional investors options that provide the most financing to HEPP projects. Evaluation was made with the AHP method, and a sample group of experts was applied. As a result of the AHP study, the most important financial institution providing financing to HEPP projects was determined as multilateral banks.

Regional development banks are in the second place, and commercial banks are in the third place.

When the financing of renewable energy projects in the last ten years is evaluated, it is seen that the contribution of multilateral banks and regional development banks to these projects is quite high [12]. Financial products with favourable conditions for development financing provided from these resources are of great importance for renewable energy projects. Financial products provided by multilateral and regional development banks are needed for the financing of pioneering projects, especially in countries where the renewable energy market is just beginning to emerge. In addition, in established markets such as Turkey, commercial banks seem to come to the fore. This situation is a result of the financial institutions' ability to provide financing at favourable terms as a result of the change in the risk perception towards these projects as a result of the increase in renewable energy projects. In line with the studies of Brunnschweiler [10] and Kulikova [11], financial intermediaries must be developed in order to finance renewable energy projects in the market.

As a result of the study, a template was created in which the most important basic issues for HEPP projects investors and financial institutions were determined. Within the scope of this template, the factors that complicate the financing processes of HEPP projects and which financial institutions provide solutions for these factors are revealed. The results may differ if the study is conducted in a different country, as the results of the study depend on the financial market situation in the countries where expert opinions are obtained. While similar results can be achieved in developing economies such as Turkey, the importance of commercial banks will decrease in less developed countries. As the market depth increases in the results obtained in developed countries, the importance of financial resources such as institutional investors will be more. In addition, in countries where the financial market is developed and has a certain depth, it would be correct to include the crowdfunding, financial citizen participation and bonds mentioned in the literature in the list. However, since such instruments are not common in developing economies such as Turkey, they were not included in the study.

There is no source in the literature regarding the financing of HEPP projects. At this point, an important contribution has been made to this field, which has a limited literature. In addition, it has been determined that the E&S risk issue, which is not mentioned in the literature, is determined as the most important factor for HEPP projects. With the study, a roadmap was created for future studies in this area. In addition, the outputs of the study can be adapted and used for different types of renewable energy projects. As renewable energy projects have some similar characteristics, the outputs of the study still remain valid for construction-intensive types of projects.



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APPENDIX:

QUESTIONNAIRE FORMS

Questionnaire Form of Delphi Round 1

Aşağıda listelenen HES projelerinin finansal aranjman seçim kriterlerinin önem derecesini belirleyiniz. Değerlendirme ölçeği 1-6 arasındadır. – *Please rate the importance of the following criteria using 1-6 scale.*

- 1- önemsiz – *not at all important* 2- daha az önemli – *less important*
3- biraz önemli - *slightly important* 4- önemli - *important*
5- çok önemli – *very important* 6- son derece önemli – *vital*

HİDROELEKTRİK SANTRAL (HES) PROJELERİNİN FİNANSMANINI ZORLAŞTIRAN FAKTÖRLER – <i>FACTORS COMPLICATING HYDROELECTRICAL POWER PLANT (HEPP) FINANCE</i>	En az etkili						En çok etkili					
	1	2	3	4	5	6	1	2	3	4	5	6
Projenin üretim değerlerinin doğal koşullara bağlı olması - <i>The production values of the project depend on natural conditions</i>												
Projenin bazı süreçlerinin politik koşullara bağlı olması – <i>Some phases of the project depend on political conditions</i>												
Özsermaye karlılığının düşük olması – <i>Low equity return rates</i>												
İlk yatırım maliyetinin yüksek olması - <i>High initial cost</i>												
İşlem maliyetinin yüksek olması – <i>High transaction cost</i>												
İnşaat risklerinin fazlalığı – <i>Excess construction risks</i>												
İnşaat süresinin uzun olması – <i>Long construction period</i>												

Dışsallıkların fazla olması ve bunları fiyatlamamanın zorluğu – <i>Excess externalities and difficulty in pricing them</i>						
Piyasa koşullarının olumsuz olması – <i>Unfavourable market conditions</i>						
HES projelerinin uzun vadeli finansman gerektirmesi – <i>Need of long term financing</i>						
Diğer (lütfen belirtiniz) – <i>other (please indicate)</i>						
Diğer (lütfen belirtiniz) – <i>other (please indicate)</i>						

Questionnaire Form of Delphi Round 2

Aşağıda listelenen HES projelerinin finansal aranjman seçim kriterlerinin önem derecesini belirleyiniz. Değerlendirme ölçeği 1-6 arasındadır. – *Please rate the importance of the following criteria using 1-6 scale.*

- 1- önemsiz – *not at all important* 2- daha az önemli – *less important*
3- biraz önemli - *slightly important* 4- önemli - *important*
5- çok önemli – *very important* 6- son derece önemli – *vital*

HİDROELEKTRİK SANTRAL (HES) PROJELERİNİN FİNANSMANINI ZORLAŞTIRAN FAKTÖRLER – <i>FACTORS COMPLICATING HYDROELECTRICAL POWER PLANT (HEPP) FINANCE</i>	1. Tur Puanları – <i>1st Round Scores</i>	Grup Ortalaması – <i>Average Scores</i>	Durum- <i>Status</i>	2. Tur Puanları – <i>2nd Round Scores</i>
Projenin üretim değerlerinin doğal koşullara bağlı olması- <i>The production values of the project depend on natural conditions</i>	6	5,25	↑	

Projenin bazı süreçlerinin politik koşullara bağlı olması – <i>Some phases of the project depend on political conditions</i>	4	3,50	↑	
Özsermaye karlılığının düşük olması – <i>Low equity return rates</i>	5	3,75	↑	
İlk yatırım maliyetinin yüksek olması- <i>High initial cost</i>	5	4,33	uzlaşma sağlandı - <i>compromised</i>	
İşlem maliyetinin yüksek olması – <i>High transaction cost</i>	3	2,92	↑	
İnşaat risklerinin fazlalığı – <i>Excess construction risks</i>	5	5,17	↓	
İnşaat süresinin uzun olması – <i>Long construction period</i>	5	4,50	uzlaşma sağlandı - <i>compromised</i>	
Dışsallıkların fazla olması ve bunları fiyatlamamanın zorluğu – <i>Excess externalities and difficulty in pricing them</i>	3	3,75	↓	
Piyasa koşullarının olumsuz olması – <i>Unfavourable market conditions</i>	3	4,08	↓	
HES projelerinin uzun vadeli finansman gerektirmesi – <i>Need of long term financing</i>	5	4,33	↑	
Diğer (lütfen belirtiniz) – <i>other (please indicate)</i>	-	N/A		
Diğer (lütfen belirtiniz) – <i>other (please indicate)</i>	-	N/A		

Questionnaire Form of AHP

In the following questions you will be asked to make relative comparisons of the factors complicating HEPP finance by using a 1-9 scale of importance. You can use each number more than once. Intermediate values should be used when there is no significant difference in significance as much as the core values.

Ratings	Meaning
1	Equal importance
3	Moderate importance
5	Strong importance
7	Very strong importance
9	Extreme importance
2, 4, 6, 8	Intermediate values

1st Criterion	1st criterion is more important.								Equal Importance	2nd criterion is more important.								2nd Criterion
	9	8	7	6	5	4	3	2		1	2	3	4	5	6	7	8	
Low Equity Return Rate					x													High Initial Cost
Low Equity Return Rate							x											High Transaction Cost
Low Equity Return Rate						x												Long Construction Period
Low Equity Return Rate									x									Excess Externalities
Low Equity Return Rate													x					Uncertain Market Conditions
Low Equity Return Rate																x		High E&S Risks

High Initial Cost				x														High Transaction Cost
High Initial Cost							x											Long Construction Period
High Initial Cost			x															Excess Externalities
High Initial Cost					x													Uncertain Market Conditions
High Initial Cost								x										High E&S Risks
High Transaction Cost																	x	Long Construction Period
High Transaction Cost											x							Excess Externalities
High Transaction Cost																	x	Uncertain Market Conditions
High Transaction Cost																	x	High E&S Risks
Long Construction Period							x											Excess Externalities
Long Construction Period						x												Uncertain Market Conditions
Long Construction Period																	x	High E&S Risks
Excess Externalities												x						Uncertain Market Conditions

Low Equity Return Rate

Please rate the financial institutions considering which ones products are more effective to overcome the low equity return rate problem in HEPP projects.

1st Criterion	1st criterion is more important.								Equal Importance	2nd criterion is more important.								2nd Criterion
	9	8	7	6	5	4	3	2		2	3	4	5	6	7	8	9	
Multilateral Banks											x							Regional Development Banks
Multilateral Banks							x											Developmental Agencies
Multilateral Banks													x					Export Credit Agencies
Multilateral Banks																x		Commercial Banks
Multilateral Banks						x												Institutional Investors
Regional Development Banks				x														Developmental Agencies
Regional Development Banks								x										Export Credit Agencies
Regional Development Banks												x						Commercial Banks
Regional Development Banks							x											Institutional Investors

Development al Agencies																	x			Export Credit Agencies
Development al Agencies																		x		Commercial Banks
Development al Agencies										x										Institutional Investors
Export Credit Agencies									x											Commercial Banks
Export Credit Agencies				x																Institutional Investors
Commercial Banks		x																		Institutional Investors

High Initial Cost

Please rate the financial institutions considering which ones products are more effective to overcome the high initial cost problem in HEPP projects.

1st Criterion	1st criterion is more important.									Equal Importance	2nd criterion is more important.									2nd Criterion
	9	8	7	6	5	4	3	2	1		2	3	4	5	6	7	8	9		
Multilateral Banks											x							Regional Development Banks		
Multilateral Banks							x											Developmental Agencies		
Multilateral Banks											x							Export Credit Agencies		
Multilateral Banks												x						Commercial Banks		

Multilateral Banks										x									Institutional Investors
Regional Development Banks				x															Developmental Agencies
Regional Development Banks						x													Export Credit Agencies
Regional Development Banks														x					Commercial Banks
Regional Development Banks			x																Institutional Investors
Developmental Agencies												x							Export Credit Agencies
Developmental Agencies																x			Commercial Banks
Developmental Agencies										x									Institutional Investors
Export Credit Agencies																x			Commercial Banks
Export Credit Agencies					x														Institutional Investors
Commercial Banks			x																Institutional Investors

High Transaction Cost

Please rate the financial institutions considering which ones products are more effective to overcome the high transaction cost problem in HEPP projects.

1st Criterion	1st criterion is more important.								Equal Importa nce	2nd criterion is more important.								2nd Criterion
	9	8	7	6	5	4	3	2		2	3	4	5	6	7	8	9	
Multilateral Banks						x												Regional Developme nt Banks
Multilateral Banks								x										Developme ntal Agencies
Multilateral Banks									x									Export Credit Agencies
Multilateral Banks							x											Commercial Banks
Multilateral Banks							x											Institutional Investors
Regional Developme nt Banks									x									Developme ntal Agencies
Regional Developme nt Banks							x											Export Credit Agencies
Regional Developme nt Banks				x														Commercial Banks
Regional Developme nt Banks							x											Institutional Investors

Multilateral Banks							x											Developmental Agencies
Multilateral Banks					x													Export Credit Agencies
Multilateral Banks							x											Commercial Banks
Multilateral Banks		x																Institutional Investors
Regional Development Banks						x												Developmental Agencies
Regional Development Banks				x														Export Credit Agencies
Regional Development Banks							x											Commercial Banks
Regional Development Banks				x														Institutional Investors
Developmental Agencies												x						Export Credit Agencies
Developmental Agencies												x						Commercial Banks
Developmental Agencies									x									Institutional Investors

Uncertain Market Conditions

Please rate the financial institutions considering which ones products are more effective to overcome the uncertain market conditions problem in HEPP projects.

1st Criterion	1st criterion is more important.									Equal Importa nce	2nd criterion is more important.									2nd Criterion
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9			
Multilateral Banks								x										Regional Developme nt Banks		
Multilateral Banks			x															Developme ntal Agencies		
Multilateral Banks									x									Export Credit Agencies		
Multilateral Banks						x												Commercial Banks		
Multilateral Banks		x																Institutional Investors		
Regional Developme nt Banks				x														Developme ntal Agencies		

1st Criterion	1st criterion is more important.								Equal Importa nce	2nd criterion is more important.								2nd Criterion
	9	8	7	6	5	4	3	2		2	3	4	5	6	7	8	9	
Multilateral Banks					x													Regional Developme nt Banks
Multilateral Banks				x														Developme ntal Agencies
Multilateral Banks			x															Export Credit Agencies
Multilateral Banks					x													Commercial Banks
Multilateral Banks			x															Institutional Investors
Regional Developme nt Banks	x																	Developme ntal Agencies
Regional Developme nt Banks			x															Export Credit Agencies
Regional Developme nt Banks							x											Commercial Banks
Regional Developme nt Banks						x												Institutional Investors

Developmental Agencies										x									Export Credit Agencies
Developmental Agencies														x					Commercial Banks
Developmental Agencies										x									Institutional Investors
Export Credit Agencies												x							Commercial Banks
Export Credit Agencies										x									Institutional Investors
Commercial Banks										x									Institutional Investors

PUBLICATIONS FROM THE THESIS

Papers

1. S. Ipin, and T. Ercan, “Financing Hydroelectric Power Plants: a review and evaluation of financing channels” *IJESM*, vol.15, no.1, pp. 58-80, Jan. 2021.

Conference Papers

1. S. Ipin, and T. Ercan, “Determining and Evaluating the Factors Complicating Hydroelectric Power Plant Project Financing”, in *IPCMC*, 2020, pp. 9-17.

