PCA Case No. 2023-01

IN THE MATTER OF AN ARBITRATION

-before-

**THE COURT OF ARBITRATION CONSTITUTED
IN ACCORDANCE WITH THE INDUS WATERS TREATY 1960**

-between-

THE ISLAMIC REPUBLIC OF PAKISTAN

-and-

THE REPUBLIC OF INDIA

CERTIFIED TRANSCRIPT
(SITE VISIT)

COURT OF ARBITRATION:

**Professor Sean D. Murphy (Chairman)
Professor Wouter Buytaert
Mr. Jeffrey P. Minear
Judge Awn Shawkat Al-Khasawneh
Dr. Donald Blackmore**

SECRETARIAT:

The Permanent Court of Arbitration

ON BEHALF OF THE COURT OF ARBITRATION:

CERTIFIED PURSUANT TO PARAGRAPH 19 OF ANNEXURE G

24 April 2024

Sean D. Murphy

**Professor Sean D. Murphy
Chairman**

Arbitration pursuant to Article IX and Annexure G
of the Indus Waters Treaty 1960

Pearl Continental Hotel
Muzaffarabad
Pakistan-administered
Kashmir and Jammu Region

Day 2 Wednesday, 24th April 2024
Site Visit to the NJHEP

Before:
PROFESSOR SEAN D MURPHY
PROFESSOR WOUTER BUYTAERT
MR JEFFREY P MINEAR
DR DON BLACKMORE

MR STEPHEN POMPER, NEUTRAL OBSERVER

BETWEEN:

THE ISLAMIC REPUBLIC OF PAKISTAN

-and-

THE REPUBLIC OF INDIA

Transcript produced by Lisa Gulland and Trevor McGowan

APPEARANCES

FOR THE ISLAMIC REPUBLIC OF PAKISTAN

MR RAJA NAEEM AKBAR, Ministry of Law and Justice
MR SYED ALI MURTAZA, Ministry of Water Resources
MR SYED MUHAMMAD MEHAR ALI SHAH, Commissioner for Indus Waters
Mr ILYAS MEHMOOD NIZAMI, Ministry of Foreign Affairs
MR SOMEIR SIRAJ, Office of the Attorney General for Pakistan
MS ZAINAB MALIK, Office of the Secretary of Law and Justice
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MR PETER J RAE, Technical Advisor

THE REPUBLIC OF INDIA WAS NOT REPRESENTED

SITE EXPERTS

MR MUHAMMAD AZAM JOYA, Pakistan Water and Power Development Authority (WAPDA)
MR USMAN-E-GHANI, Additional Commissioner for Indus Waters
DR TAHIR MAHMOOD HAYAT, Diamer Basha Consultants Group
MR MUHAMMAD ARFAN MIANA, Neelum Jhelum Hydropower Company (NJHPC)
MR MUHAMMAD AYUB MALIK, NJHPC
MR NAYYAR ALAUDDIN, NJHPC
MR MUHAMMAD UMAR FAROOQ, National Engineering Services Pakistan (NESPAK)
MR FIAZ HANIF SENDHU, Tarbela 5th Extension Project
MR ARSHAD MALIK, WAPDA
DR YASIR ABBAS, NESPAK
MR MUHAMMAD TARIQ, Tarbela 4th Extension Project
MR HAMEEDULLAH KHAN, Warsak Hydro-Electric Project

FOR THE PERMANENT COURT OF ARBITRATION

MR GARTH SCHOFIELD, Deputy Secretary General
MR BRYCE WILLIAMS, Legal Counsel
MR SEBASTIAN KING, Assistant Legal Counsel
MR DAAN NIEUWLAND, Videographer

Wednesday, 24 April 2024

MR JOYA: Good afternoon, everyone, Chairman Murphy and members of Court of Arbitration. My name is Muhammad Azam Joya, and I am General Manager of Pakistan Water and Power Development Authority, known as WAPDA.

In that capacity, it's my pleasure to welcome you and the wider delegation from the Permanent Court of Arbitration to Muzaffarabad for what will hopefully be an informative site visit of WAPDA's Neelum Jhelum hydropower plant -- known as NJHEP -- afterwards.

I'm speaking in the place of Lieutenant General Sajjad Ghani, Chairman of WAPDA, who unfortunately was unable to be with us today due to some urgent and unavoidable business.

Assisting me in this introductory presentation is Mr Usman-e-Ghani, Additional Pakistan Commissioner for the Indus Waters. I think he is here on the second seat.

By way of background, WAPDA is one of Pakistan's largest and oldest government agencies, created by Pakistan Water and Power Development Authority Act 1958, it's headquartered at Lahore. It's a public utility in charge of developing, maintaining and managing publicly-owned hydropower facilities in Pakistan.

At the present point in time, WAPDA controls some 23

hydroelectric plants, or HEPs, with a total installed capacity of 9,476 MW. By 2028, we hope to add a further 9,000 MW of hydropower to the national grid through megaprojects like Tarbela 5th Extension, Diamer Basha dam, Monmouth Hydroelectric Power Projects, and elsewhere as well.

It is an exciting time for us, and we hope that you will feel some of the excitement in the course of your visit.

Slide 2. The parameters of site visit as directed in your Procedural Order No. 10 are reflected, for the record, on the slides. It has been important for all of the site experts who will be making presentations to you to understand these parameters.

Sir, we all are engineers, not lawyers. And perhaps, with some exceptions here and there, we have no knowledge or familiarity with the details of the dispute between Pakistan and India that has brought you here for the site visit. Nor are we knowledgeable about the Indus Waters Treaty. Rather than discuss these matters, and mindful of the directions given in your Procedural Order No. 10, we have come here to prepare to talk to you about the design, construction and operation of HEPs in our part of the world in a relative ignorance of how these issues may be relevant to your task.

We understand that our task is to assist you in getting a better feel for the reality of HEP design, operation, by seeing a run-of-river plant in the flesh, through the lens of one such Pakistan plant, the NJHEP.

Having said this, you should please feel free to ask us questions as we go along. I cannot promise that we will be able to answer everything that you may ask. And we say so: if we cannot, please don't hesitate to ask.

WAPDA has accepted this mission with utmost seriousness, and has assembled from around Pakistan an array of leading experts in geology, hydrology, geography, design and power systems, as well as various branches of engineering, to discharge it.

Slide 3. It remains only for me to introduce you to the NJHEP itself. It is one of WAPDA's proudest achievements: a 969 MW run-of-river HEP, sitting 44 kilometres outside of Muzaffarabad, where we are right now. The NJHEP was designed and built between 2008 and 2018. It now contributes 5,150 GWh of clean and reliable energy to the national grid every year. So it is a test bed for many similar HEPs that WAPDA wishes to develop in this region.

Over the course of the next few days, you will become very familiar with the NJHEP and, through it, the process by which a run-of-river hydroelectric plant is

built and operated in these Himalayas rivers. The entire facility is at your disposal and, should you wish to inspect any element of it, you have only to ask for it, sir.

Thank you very much. I now turn the floor over to Chairman Murphy for any remarks you wish to make, sir.

THE CHAIRMAN: Thank you very much, Mr Joya, for those welcoming remarks. I will say a few words on behalf of the Court of Arbitration. But before I do that, perhaps I will allow the members of the Court of Arbitration to introduce themselves.

My name is Sean Murphy. I am the Chairman of this Court of Arbitration. I'm also a Professor of International Law at George Washington University in Washington DC. So to the extent that my questions are very simplistic, coming from a non-engineer, you'll understand why that's the case.

Mr Minear, would you like to introduce yourself?

MR MINEAR: Thank you, Sean. My name is Jeffrey Minear. I'm from the United States, and my training is as a lawyer. I'm here as a legal umpire on the Court of Arbitration. I also have training in natural resource management and as a chemical engineer, and I'd like to thank you at the outset for taking the time to share your knowledge about the facility with us. I look forward to learning a good deal today and in the days ahead.

THE CHAIRMAN: Mr Blackmore.

DR BLACKMORE: Thank you. My name is Don Blackmore. I'm a civil engineer. I used to run a water business in Australia that covers an area just a bit bigger than Pakistan, about 1 million square kilometres, and have owned and managed a number of hydroelectric plants in the past. I was a commissioner on the World Commission on Dams that looked at the development and effectiveness of the 50,000 large dams on earth, so I've seen dams in every setting, in every continent, bar Antarctica: they didn't invite me to Antarctica. So I bring an interest in what you've done with this dam, and I will listen with great interest, so thank you.

THE CHAIRMAN: Professor Buytaert.

PROFESSOR BUYTAERT: Thank you very much. Good afternoon, everyone. My name is Wouter Buytaert. I'm a Professor in Hydrology and Water Resources at Imperial College London.

In case you wondered about my accent, I'm originally from Belgium, but I've been based in London for now 15 years. I'm an environmental engineer by training, and have worked several decades already on mountain hydrology in particular, but all over the world: a long

history in South America, but to a lesser extent also here in this part of the world. So I'm particularly interested in the broader hydrological/geomorphological setting of the dam, and the way that the engineering design has adapted to these settings.

I really look forward to the visits, and thank you very much already for all your input.

THE CHAIRMAN: There is a fifth member of our Court of Arbitration who is not present here, Judge Awn Al-Khasawneh. He is unable to be present for reasons that have been made known to the parties. And while that is regrettable, we are not, as a Court of Arbitration, taking any decisions in the course of this site visit, other than what may be necessary to deal with the logistics of the visit itself.

Moreover, the video of the site visit that's being taken, and the transcript that will be made from the video, will be made available to him so that he can benefit from all of the presentations you'll be making, the questions we ask and your responses to them.

I'd also like to introduce three members of the Court of Arbitration, which sits in The Hague, and is the body that administers the arbitration that we're involved in. We have three members from that Permanent Court of Arbitration.

All the way at the end of the table is Mr Garth Schofield. He is the court's registrar, and he is also the Deputy Secretary General of the PCA.

Mr Bryce Williams is over there, just raised his hand. He is the court's treasurer, also a member of the staff of the Permanent Court of Arbitration, and is assisting generally in the arbitration.

And then Mr Sebastian King, here on my right, from the PCA staff.

So those are the individuals who are helping administer the arbitration.

We also have, as a part of the court's delegation, a videographer, who is standing behind the camera there, Mr Daan Nieuwland. He will be taking the video throughout the course of the visit.

And then we have a person who is serving as the Neutral Observer. That's Mr Stephen Pomper, towards the end of the table there. He is an individual who works at the International Crisis Group, although he is acting here in his personal capacity. And I'll say a little more about the Neutral Observer in just a minute.

So let me, first of all, thank the Government of Pakistan for organising this site visit. The Court of Arbitration is extremely grateful to you and to all of the site visit experts, who we know have already put in

a lot of work in preparing yourselves for the next few days. That's evident from the various slides that you've prepared and shared with us in advance, and I'm sure will be evident in the presentations that you're to make in the next few days.

We're very grateful also for all the logistics that has gone into this site visit. We know how difficult it is to arrange accommodations, transportation, security, the general well-being of those involved in the visit. It takes an awful lot of effort. We may not have security personnel in the room, but I hope that you will convey back to the security staff how grateful the Court of Arbitration is for their assistance as well.

So I'll just quickly note that I know there are a lot of different parts of the government involved in this. I do want to thank the Ministry of Law and Justice -- including Mr Akbar, the deputy agent -- for all of its efforts here; the Ministry of Water Resources, including Mr Murtaza, who I know has been involved here; Pakistan's Commissioner for Indus Waters, Mr Ali Shah. It's good to see you again, sir, and many thanks to you and your staff for the work here.

From the Ministry of Foreign Affairs, Mr Nizami. We very much appreciate all that the ministry has done to make this site visit possible.

We have several external counsel, led by Sir Daniel Bethlehem here. We are very grateful for all of the work you've put in to help bring this together.

And I'm sure I'm missing individuals or parts of the government, but please take thanks from the Court of Arbitration to everyone who's had a part in this process.

Let me also note, with regret, the absence of the Government of India at this site visit. The court would like to recall that it invited India almost a year ago to participate in the site visit process, and would have welcomed and benefited from its involvement in the process, both in reacting to presentations being made by the site visit experts here, but also we would have liked to visit sites in territory administered by India. We would have benefited from hearing presentations from India's site experts about their work and their dams, and so we hope that India will at some point decide to engage in this process. It would greatly assist the Court of Arbitration if they were to do so.

I'll note something that the engineers don't need to pay attention to, but India has not indicated an intention to file a counter-memorial in our process. So the next step in our process is a hearing on the merits regarding what we call "phase 1 issues", which

will be in mid-July. The court would certainly welcome participation by India in that hearing if they are able and willing to do so.

I will also note that this site visit is not -- is not -- an ex parte visit. Under Article 10.4 of the Supplemental Rules of Procedure of the Court, a meeting is not ex parte if both parties are given the opportunity to participate in the meeting and one party voluntarily elects not to do so.

Mr Joya, you mentioned a little bit about the protocols for the site visit, and I appreciate very much that it's been passed through to everyone involved. I would like to stress a few aspects of what's in our Protocol No. 10, and indeed I have ten aspects that I would like to emphasise.

First, the purpose of this visit is to familiarise the court with general aspects of the design and operation of run-of-river hydroelectric plants along the Indus system of rivers.

Secondly, and I suppose conversely, the purpose is not to establish facts specific to any Indian run-of-river hydroelectric dams.

Third, the purpose is not to receive any legal arguments from Pakistan -- and I think you've already made that clear yourself, Mr Joya -- and also not to

receive arguments on the application of facts to the law, including with respect to the interpretation or application of the Indus Waters Treaty. So all the site experts can rest assured: we are not asking you any questions about the law. We're solely interested in some of the facts relating to this particular dam site.

My fourth point: all presentations by the site experts are intended to be succinct, neutral, solely technical in nature, and are presented by individuals who are not members of the Government of Pakistan's team or experts appearing before the court.

Fifth, the court's questions to the site experts will be exclusively on technical matters presented, and we will not stray into any legal issues.

Sixth, at any time during a technical presentation or after it, members of the court may have questions for the experts. So I hope you don't mind us occasionally interrupting you with something that we just don't quite understand, and we would welcome your response. I take the point that there may be some questions that you're not able to respond; that's entirely fine. Do your best, we expect nothing more than that.

Seventh, once a technical presentation is completed, to the extent that Pakistan's deputy agent or lead counsel believes that it would be helpful to the court

for a succinct and non-leading question to be put to the technical expert for purposes of clarification or correction, then the deputy agent or the lead counsel will direct the question to me, and the court will decide whether or not to pursue the matter.

Eighth, Mr Nieuwland, our videographer, will be recording all site visit activities, to include when we're walking around the facilities. In the course of this visit, please give him room to operate so that he can do his job of recording everything that we are embarked on.

After the visit is completed, a transcript will be produced from the video recordings. At the same time, our PCA team will be taking some still photographs during the course of the visit. If a party wishes to have a particular aspect of the visit captured by photo or video, please make that request to the Secretariat.

Ninth, other than that -- the videographer and our PCA staff taking photographs -- no one should be taking videos or photographs during this site visit. After the site visit is completed, in due course the video recordings, transcript and still photos will be made available to the parties, with a process in place for corrections to the transcript.

Tenth, my final point: outside of the orientation sessions and the technical presentations, the members of the court and the Neutral Observer on the one hand, and the representatives and site experts of Pakistan on the other hand, may exchange cordial greetings. But there shall be no substantive exchanges, either technical or legal in nature.

Finally, let me return to the presence of Mr Pomper as our Neutral Observer. His task is to be present throughout the site visit, to observe the proceedings and the overall conduct of the visit. He will alert me during the site visit if he has concerns in that regard, in which case I will address the matter promptly. He will then certify, at the end of the site visit, that it was -- or was not -- conducted in accordance with the protocols set out in Protocol Order No. 10.

Unless there are any further issues to be raised, the court is ready to receive the first presentation.

(A short break)

Presentation 1: NJHEP General Orientation

MR JOYA: So I will now give you a short introduction of NJHEP, with a view to situating you for the presentations to come.

Slide 5, please. On the slide, we have a map of the surrounding area, with major cities and hydropower features. I shall start from left of the site; that is

Muzaffarabad. You can see Muzaffarabad over here. This is the place where we are right now.

Muzaffarabad is the intersection of two rivers. One is called Neelum River, which is known as Kishenganga as well, by our Indian friends; and second is upper limb of Jhelum River, combines over here.

Sir, if we follow the Neelum River upstream, we will reach the headworks of NJHEP over here; the triangle shows it. By "headworks", I mean the dam, its associated structures, together with the reservoir.

So you can also see a tunnel over here from the headworks, which comes down to the Jhelum again. This tunnel is to generate the head of hydropower production, by which I mean it's a vertical distance between the reservoir and the turbines at the end. It removes water from Neelum River and discharges it back to the Jhelum River downstream of Muzaffarabad.

Around the NJHEP, we see a grey line over here. It encompasses the catchment area of Neelum River. Catchment area means that this area feeds the Neelum River in its discharges. So these discharges ultimately help out to operate the NJHEP project.

Furthermore, there is a red line as well. That's the line of control. If we see on other side of line of control, Indian territory, Indian-administered Kashmir,

we see the Kishenganga project over there, with the yellow, which is functioning right there. And with their tunnel as well, it is performing a similar function as I told earlier in the NJHEP project.

South of that is the upper limb of Jhelum River, and you can see Sirinagar as well. This Jhelum River discharges into and then emerges out of Wular Lake, located in India. And downstream of Wular Lake, you can see the Lower Jhelum project by India, the Uri 1 and Uri 2 projects.

Once again, crossing the red line of control, we can see Siran over here, the red triangle. It is our forthcoming hydroelectric project which Pakistan is in process of constructing. And once more, you see a route of tunnel over here, which removes water from Jhelum Upper Limb, and discharges it back into the Jhelum again downstream of Muzaffarabad.

Slide 6, please.

THE CHAIRMAN: Mr Joya, before you leave this slide, can I ask you to point out on the slide where the power station is located.

MR JOYA: So the NJHEP, we start from the headworks. The power station comes right after crossing the Neelum River -- Jhelum River right over here somewhere. That will come in detail later on, sir.

THE CHAIRMAN: So it's right on that part of the river?

MR JOYA: Yes, it's here.

THE CHAIRMAN: And second question is: as we go up here along the river, I looked down at a certain point and I thought I saw what might be the tailrace. Is that possible or are we not in the right location?

MR JOYA: In the coming slides, I will further bifurcate the tunnels, the headrace and the tailrace, with different colours and different details.

THE CHAIRMAN: Okay. I may revisit my question.

MR JOYA: Thank you. You really like questions, sir.

Because all project -- 90% -- is underground, so to understand it is very nice.

Slide 6, please. So let's now look a little more closely at NJHEP site. The headworks site is clearly marked with a triangle over here. And you can see the tunnel which comes out of that headworks from northeast to southwest. After coming out of the headworks, the tunnel splits into two different tunnels. Then after crossing the Jhelum River, as I told earlier, it recombines. And again, as a single tunnel, it enters into the power station, powerhouse. And from the powerhouse is the tailrace tunnel, which discharges water into the Jhelum River.

These green tunnels we have to construct due to the poor geology of this area. So instead of going for a single larger [one] there, we have to go for two smaller ones, to cater for the geology of the area, based on recommendation of the designers.

At the lower parts, you can see the powerhouse where the turbines and generators are located. And from there, as I told earlier, is the tailrace you can see at the bottom. It will come in more detail later on, sir.

Slide 7. So it's about the headworks. On the slide I will explain three things. Number 1 is the reservoir; number 2 is the dam wall; and number 3, the Neelum River flowing from south to north. These things are coming in detail in the forthcoming slides, sir.

Slide 8, please. Now I have tilted the previous slide at 90 degrees to give a more clear picture, sir, of the area. This shows the design in a little more detail with the key elements picked out. This image will be revisited in many presentations which will come after me by other presenters. It is included over here just to familiarise you with the orientation of the project.

As I told earlier, it's the previous slide: it has been turned at a 90-degree angle. It shows the Neelum River flowing from left to right. And the dam wall is shown in yellow, and its associated structures in

brownish over here.

Then there are two spillways, shown in red and in purple. And dissipation structure, and you can see a brownish colour. Then you can see the stilling basin over here; the "desanders", it's called. It's a desander structure, with the structure which is shown in pink. It is the operating building. And then, finally, there's a headrace tunnel, which comes in purple.

So it's the overall orientation of the project, just to show up the things, sir.

Slide 9, please. You can see here, for the first time, the detail of the two spillways. The low-level orifice spillway is on right side, whereas on left side is surface level crest-gated spillway. These are the structures by which HEP passes floodwater through the dam. In its background, you can see the reservoir, which is stretching away towards southeast as (indistinct).

Sir, foreground is denominated by these desander structures you can see over here. And at the very bottom of the desander structure, this one, it is a collecting canal which connects to headrace, which is somewhere over here. It goes in this way, sir, which I showed earlier in purple colour.

Slide 10, please. It's another view from the downstream side, to make things for the completeness of purpose. From this angle, the orifice spillway is completely submerged into water over here, whereas you can see the crest-gated spillway over here; and these are its gates, which are operated over here.

This image also gives a clear view of the freeboard. Freeboard is a structure extended above the surface level of the reservoir, you can see over here.

Slide 11, please. There is more about NJHEP powerhouse site. Turning now towards the powerhouse, this is a satellite image of it, obviously not showing the powerhouse itself -- it is only denoted by a word "P" -- which is well below the surface.

Same may be said to the headrace and tailrace, which run from top right to the bottom left. Running through the powerhouse, ultimately these enter into the Jhelum River to discharge water.

What you can see, however, is the switchyard above the ground, to connect the power to our national grid from here.

Sir, slide 12, please. Now the powerhouse. If we were to excavate the area around the powerhouse, you would find something very much like this. In maroon, this one, we can see the powerhouse itself. The

slightly larger triangle, this one, is power station house. It is housing the generators, so we call it "generator hall" as well; whereas the slightly smaller one is the transformer hall, where the step-up substations are located to ready the current for transmissions. You will see it later on as well.

More than that, there's a system of penstocks. You know that penstock, these are the pipes which take water for the turbines to rotate inside the generator hall, and then dispose it further into the Jhelum River, as I told earlier.

Sir, there are different tunnels as well over here. You can see there's a headrace tunnel which brings water from the dam and then feeds to the penstocks. And then ultimately that is the discharge tunnel, which is our other tailrace tunnel, and many other light tunnels as well, which we'll come to later on in detail.

And finally, looming above it, this one. It's the surge shaft. It starts from the headrace and goes above site, sir. It is to cater for emergencies, to allow pressure to escape from the headrace in the event of any emergency. Similar to surge shaft, we have a surge tunnel as well on the downstream side, to cater for similar emergencies.

Slide 13, please. It's again the powerhouse record (indistinct). We have shown powerhouse here in detail. Other presenters will take you back to this again and again, so I will just give an overview of this slide, sir.

As you can see, we have two main halls. One is a larger one, the other is a smaller one. The larger hall is a generator hall, whereas the smaller one is the transformer hall, which I showed earlier in red colour, sir. Then beneath the generator hall we have a structure of turbines, which stretches over the four floors.

We can see third generator unit over here. Then there's a connecting shaft to the turbine over here. The turbine is shown, sir, in yellow, whereas the distinctive scroll case, that is shown in red. It's the point where the water enters into the turbines to run this. Then this water is disposed to a draft tube over here.

Slide 14. The only thing which is above the ground, that is the NJHEP switchyard, which you can see over here, sir. And it will be shown to you during your site visit as well.

Slide 15. This is the NJHEP tailrace discharge tunnel. It comes over here and discharges into the Jhelum River, which comes this way. I think you might

have seen it while coming on the way to Muzaffarabad, sir.

THE CHAIRMAN: Yes.

MR JOYA: Slide 16, please. So this is the NJHEP hydraulic profile. When we pull out all this together, you get this, which is what is called the NJHEP hydraulic profile. Its purpose is to show the broad strokes, the main features of the NJHEP relative to the watercourses.

We start on the right side. The Neelum River, it flows into the reservoir; and from here, it runs ahead unless it joins Jhelum River again. But simultaneously, as I told earlier, the headrace tunnel comes out of the dam site, then it splits into two, moves as a twin tunnel. And before entering the powerhouse, it reunites, it again becomes single. And after its function of turbines rotating, through the tailrace tunnel it gets discharged into the Jhelum River over here, downstream of Muzaffarabad, as I told earlier.

Slide 17. Thank you. That's about the NJHEP tunnelling. We have just shown the hydraulic profile from the side, with the tunnel network you can see over here. There's the tunnel network, starts over here, and almost crossing under the Jhelum River. It reaches the powerhouse after traversing 30 kilometres, about, underground. And then from powerhouse, traversing

4.4 kilometres more tailrace, it discharges into the Jhelum River.

Next, please (slide 18). So thank you very much for your kind attention. You will see all these elements close up over the coming days, and these elements will be discussed separately as well by the experts. The purpose of this brief presentation was simply to orientate you what is to come. So if you have questions, I am over here, sir, at your disposal.

THE CHAIRMAN: I have one question. It's probably of no great significance, but I'm curious about the exact location of the power station. So if we go back to slide 17 for just a minute, it looks like the powerhouse is relatively close to the tailrace area. And yet if we go to slide -- I think it's 11, it looks as though the powerhouse is rather far from the tailrace. So if you could just clarify that.

MR JOYA: It's only -- you can see it's a satellite image. We have blown it up just to show the tailrace area more clearly. On the same scale, if I show the headrace as well, then well you can compare both areas.

THE CHAIRMAN: So I think my confusion was: it almost looks like that's the upper part of the Jhelum River. But that's not the case: that's just a divide in the topography, yes.

MR JOYA: It's just to show the tailrace more clearly. Otherwise length is the same, 3.4 kilometres, as I showed earlier, sir.

THE CHAIRMAN: I understand. Thank you very much.

MR JOYA: You're welcome, sir.

THE CHAIRMAN: Questions? I don't think we have any other questions.

MR JOYA: Thank you, sir.

And now I hand over to Mr Usman-e-Ghani, Additional Commissioner for Indus Waters, who will take you through the schedule of the site visit, sir. Thank you.

THE CHAIRMAN: Thank you very much, Mr Joya.

MR USMAN-E-GHANI: Thanks very much, Joya Saab, Chairman Murphy, members of the court. You will all be very familiar with the schedule, as it was finalised upon your directions. So I would like to run simply through briefly, in case you have any questions, so they can accordingly be taken.

In particular, I must note some changes to the schedule which I understand the court is considering. In particular, Day 3 of the site visit -- it is tomorrow -- has now been split into two, so that it will occupy all of the activities of Day 3 and Day 4. This means the events of Day 4 will now be shifted to Day 5. The events of Day 5 will be shifted to Day 6, and so on and forth. The order of presentations will remain the same.

Once I have described the schedule, I will hand back to Mr Joya for the final limb of this introductory presentation, being the introduction of the speakers. I should add, the schedule is subject to change, maybe because of some weather conditions. Thank you very much.

Our next slide, please (19). Day 1 was yesterday, and so we are at the start of Day 2. It is a shorter day, with two presentations only. The first one is this one which is being currently made.

It will be followed by presentation no. 2, which will start diving a little deeper into the higher level features of the run-of-river hydroelectric plants, specifically on Himalayan rivers. Design, construction and operation issues will be examined in brief.

After that, the court will be able to identify any specific questions or issues that it wishes to see addressed on the following days.

Next slide, please (20). As you can see from the slide, Day 3 was intended to be a long day at the dam site. The schedule for this day has been modified a bit. We will depart early from Muzaffarabad, at 8.00 am in the morning, aiming to arrive at the dam

site, some 44 kilometres upstream, at around 9.30 am in the morning.

We will then have four presentations over the course of the morning and afternoon, which are the site orientation, the presentation no. 3, to enable you to see the physical layout of the dam site before we go on to the conference room for the detailed presentations.

Presentation no. 4 will provide an overview of the physical elements of the site, including geography, topography, geology and hydrology.

After lunch, we will have two presentations on the basic elements of the headwork of the run-of-river hydroelectric plants. In terms of broad themes, the presentation no. 5 will address the sewerage and the flood control issues, and presentation no. 6 will address sediment management issues.

As the subject matter of these two presentations also overlaps with the five questions that the court put to the site experts a few days ago, the site experts in these presentations will also address the court's questions.

After these presentations, we will have an inspection of the dam and the reservoir of the site by the court. This presentation no. 7 on the schedule has now been moved to next day, on Day 4.

On Day 3, the objective is to depart from Muzaffarabad after the presentation at around 5.00 pm, returning in time for closing the day, and for the dinner and other activities like that.

Next slide, please (21). With Day 4 now being occupied with presentation no. 7, the dam and reservoir inspection, the presentation[s] of Day 4 [have] been moved to Day 5.

It is another long day, taking place entirely at the powerhouse. We will depart from Muzaffarabad at 9.15, travelling downstream this time, arriving at the powerhouse at around 10.15.

There will be four presentations over the course of the afternoon: presentation no. 8, which is general site orientation; presentation no. 9, which is basics of powerhouse; presentation no. 10, which is on power production; and presentation no. 11, which is the inspection of the powerhouse itself. The court will then have the opportunity to deliberate on-site before issuing the instructions for Day 5.

The object is to depart from Muzaffarabad at around 5.00 pm, arriving back again in time back to the hotel.

Next slide, please (22). The events of Day 5 have been moved to Day 6, as I said earlier, which was originally the first contingency day. The Day 6 agenda

is to be sent by the court. Once you have given us your directions, we will work with you to provide a schedule for this day.

Next slide, please (23). The events of Day 6 have been moved to Day 7. It is currently listed as a contingency day in case of some inclement weather conditions or other interruption preventing some proper site instruction from taking place. If it is not required, then we anticipate departing from Muzaffarabad for Islamabad at around 1.00 pm, to arrive back to Islamabad by around 5.00 pm. An administrative meeting will be held thereafter to discuss the departure from Islamabad.

Next slide, please (24). The events of Day 7 have been moved to Day 8, so we do not need to stay on this slide.

Next, please (25). On Day 8, the court will depart from Muzaffarabad.

And unless some clarification is needed, I may hand the floor back to Mr Joya.

THE CHAIRMAN: Thank you very much, Mr Usman-e-Ghani. The only question I have -- it's not a question, it's just a confirmation that the idea of splitting the dam site into two days is very agreeable. We view it as very important to focus in particular on that site, and the decision that the timing would be optimised by having the two days is certainly agreeable to the court. And we're also aware that weather conditions may affect sequencing here, and we certainly are amenable to that as well.

Any questions from anyone about the itinerary? No questions then beyond that. Thank you so much.

MR JOYA: Thank you very much, Mr Ghani, for giving me a chance to speak again.

Slide 27, sir. It's about the presenters to come here. Members of the court, Pakistan has assembled a range of hydropower experts from many different organisations within Pakistan. Many of them work at NJHEP and other hydropower facilities, both operational and under construction, throughout Pakistan. So they are now under the umbrella of WAPDA and in this house here as well, the experts.

We also have two representatives with us from NESPAK. NESPAK is National Engineering Services of Pakistan, a government enterprise, an energy contractor which provides consulting, construction, engineering and management services globally. Its headquarters is at Lahore. It's one of the largest engineering consultant management companies in Africa and Asia as well. They are with us in this room.

As I point out on the slide, I would ask them to raise their hands so as we can identify them. Thank you.

So in front of you, sir, are the group of presenters number 1. Mr Ghani, the chairman of WAPDA, Mr Ghani Saab, he couldn't join us, as I told earlier.

At the top, it's me, sir. Thank you very much for listening a lot. I had been general manager at Tarbela Dam as well, and project director at T5 extension in Tarbela as well. Now I'm general manager, coordination and monitoring in WAPDA.

And Mr Usman-e-Ghani, please raise your hand, sir. He is from Additional Commissioners with us, thank you very much.

Slide 29. This is our next group of presenters: Dr Tahir Hayat, Mr Ayub Malik and Mr Arfan Miana.

At the top, we have Dr Tahir Hayat. Sir, please.

Dr Hayat is one of Pakistan's most experienced megaproject engineer and administrator. He holds a bachelor's degree, master's degree in engineering, as well as doctorate. He is currently the chief executive of the consulting consortium, building the Diamer Basha Dam on the Indus. When completed, it will be the tallest roller-compacted concrete dam in the world, almost 272 metres high.

We have another two members from NJHEP team: Mr Arfan Miana and Ayub [Malik]. Mr Miana, sir, please.

Mr Miana has bachelor's and master's degree in mechanical engineering, and has worked with WAPDA since 1992. He was involved in commission of 1,410 MW Tarbela 4th Extension. He has been project director over there, and currently he is chief executive officer here at and NJHEP.

And Mr Malik, he has bachelor's degree in civil engineering and a master's degree in irrigation engineering. He has 34 years of experience in construction management and contract administration, particularly in relation to the megaprojects. He is presently deputy project manager of NJHEP.

Slide 29, please. So that's our next group of presenters: Mr Fiaz Hanif, Mr Umar Farooq and Mr Nayyar Alauddin.

At the top is Mr Fiaz Hanif Sendhu, over here. He is our geology expert. He holds bachelor's degree and master's degree in geology and geohydrology, as well as a further master's degree in hydrology. He has 35 years of experience in the field of hydropower, and presently he is chief geologist of 1,530 MW Tarbela 5th Extension project.

Then we have Mr Umar Farooq, who is the senior

engineer in the Water & Agric division of NESPAK. He holds a bachelor's degree in civil engineering and master's degree in hydraulic and irrigation engineering. He is in the process of completing his doctorate on water source engineering.

Mr Nayyar Alauddin. So Mr Alauddin has a bachelor's degree in civil engineering, and was employed by WAPDA in 1983 to 2019, finishing as a project director and general manager of NJHEP, the same project. He was thereafter hired as an advisor on NJHEP in 2019, and remains as a key part of the team today.

Slide 30, please. And then we have our final group of presenters: Mr Tariq, Mr Arshad Malik, Mr Hameedullah Khan and Mr Yasir Abbas.

Mr Tariq, he is over here. Mr Tariq holds bachelor's and master's degrees in engineering, and has over 30 years of hands-on experience with WAPDA in the field of hydropower operation and maintenance. He is currently one of the chief engineers of Tarbela 4th Extension.

And then Dr Yasir Abbas. He is the chief engineer in the Water and Agric Division of NESPAK, and has been a practising water source engineer for 20 years. He holds a bachelor's degree in civil engineering, master's degree in hydraulics and irrigation engineering, and a doctorate in civil engineering.

Mr Hameedullah Khan, he has a bachelor's degree in electrical engineering, and currently he is serving as chief engineer at Warsak HEP, which is undergoing intensive rehabilitation these days.

Mr Arshad Malik. He holds bachelor's and master's degrees in electrical engineering. He has deep experience in thermal and hydropower throughout Pakistan, including as an additional chief engineer at the NJHEP as well. He is currently a chief engineer at WAPDA's hydropower projects.

So that concludes this introductory presentation on behalf of Chairman Ghani, WAPDA, and the staff of NJHEP. Thank you, sir, for your kind attention, and we wish you a very successful site visit. If you again have some questions, we are at your disposal on this.

THE CHAIRMAN: I don't think we have questions, but I do want to thank you for those introductions. They were very helpful, and I feel like there's a lot of degrees in this room! It's very impressive, and we're very grateful for all the time that you've taken to help put together this very distinguished cast of experts. So thank you, Mr Joya, and thank you to everyone.

MR JOYA: Sir, thank you. With this, we are proceeding towards a break for coffee, if you like, sir.

THE CHAIRMAN: Absolutely.

MR JOYA: And then we'll come back after ten minutes for presentation no. 2 in the same [room].

THE CHAIRMAN: Yes, that's fine. Why don't we resume in about 15 minutes, quarter past the hour. Thank you very much.

MR JOYA: Thank you, Mr Chairman.

(A short break)

THE CHAIRMAN: Okay, I think we are reassembled, so why don't we proceed now with presentation no. 2.

Presentation 2: HEP Design, Construction and Operation

DR HAYAT: Thank you, sir. Mr Chairman, members of the court of arbitration, good afternoon.

By way of introduction, although the introduction has already been made by Mr Joya, my name is Dr Tahir Mahmood Hayat. I'm presently working as chief executive of Diamer Basha Dam Consultants Group, which is a joint venture of six firms, like Stantec, AFRY and others. And we are providing consultancy services for construction of Diamer Basha Dam Project, which is a 272 metres high roller-compacted concrete, and 4,500 MW hydroelectric plant. And it is in the [Khyber Pakhtunkhwa] Gilgit-Baltistan area of Pakistan.

Alongside me is Mr Muhammad Ayub Malik, and he's the deputy project manager for Neelum-Jhelum hydropower

project, and he'll be making part of the presentation, the latter half.

So we have been asked to make the first substantive presentation of the site visit on hydroelectric projects, "HEP" for an acronym. And you will hear a lot of this "HEP", "HEP", and this is basically hydroelectric project: design, construction and operation.

This presentation is intended as an introduction to the design and development process behind the run-of-the-river hydroelectric project on a Himalayan river, and the presentation will be basically in four parts.

So in the first part, I will provide you with an overview of the HEP development process, setting out the various challenges that its designer and others associated with it will face, and eventually and hopefully overcome as part of that process.

Secondly, I will address the question of HEP development, explaining how we start from a blank sheet of paper and actually design through various stages and phases to a design which can be put into practice by the contractor, and thus have a fully functional hydropower project.

Thirdly, Mr Malik will explain the HEP itself,

taking you through its major components and explaining how these fit together. And again, in the last part, Mr Malik will give you an overview of the HEP construction process: what challenges are faced in that process and at that stage. And basically, he'll be talking through the lens of the Neelum-Jhelum hydropower project, in which he has been associated for the last 15 years.

Your questions have been gratefully received, and will be answered later in presentations 5 and 6. If anything that I say or Malik Saab says you find it's not clear, and problems occur in your minds, you should feel free to ask questions at your convenience, please, and we'll be glad to answer.

Slide 2, please. Before I go into the substance of the presentation, I would like to make a brief opening observation. The HEP design and development process may be described in three words: it is lengthy, it is expensive and it is challenging. It's lengthy, expensive and challenging.

When we speak of a hydropower plant above a certain capacity, we are actually talking in terms of a megaproject. And these large-scale complex ventures, costing upwards of $1 billion, take many years to develop and build. To be designed, constructed and operated successfully, any megaproject must overcome numerous hurdles across multiple dimensions. And when you are talking about the Himalayan region, all these hurdles are magnified.

With that, sir, slide number 3, please. We'll talk now about the HEP development process.

And slide 4. So at the centre of this diagram, you see the HEP design, which actually is HEP development, let's call it. And it entails basically six main components of design.

The first one is the technical studies and engineering. And as we move clockwise, it's: contractor selection and contracting; social impact assessment, resettlement and compensation; environmental impact assessment, mitigation and management; regulatory activities, power planning and power sales; and, of course, financial planning and financing.

Now, these six processes, they must run in parallel, and they start almost from the conception stage, to a certain degree. And then they are refined and more detailed as the process goes along. And these must be carried [out] in parallel. And failure of any one of these could mean the failure of the project, or its prolongation, or it's been put in "cold storage", as you may call it. So all these are important. And I will

take you through each of these later in the presentation.

Let's look at slide 5, please. So here we have the design phases of hydroelectric power project, HEP. They go from concept, to pre-feasibility, to feasibility, engineering design, and construction design. And one by one, I'll explain.

So in each phase there is a yes-or-no answer to proceed to the next phase. From the concept, yes, it is good: you go to pre-feasibility. Okay, go ahead. Then feasibility, and then of course all the others. So at each phase there is an answer whether to proceed with the next level or not.

Slide 6, please. Next we return to our contractor selection, which obviously is a critical phase in any project. So the life-cycle is shown on the left.

So actually the project gets built by the contractor. It is designed by the engineers, but it gets built by the contractor, unless and until it is an EPC contract. So for normal projects, the idea is that the engineers design, the consultants design, and the contractors who win the tender build this project.

So from the initial stages of the project, you have to have a project procurement strategy, contract strategy and packaging, tender preparation, contract

preparation, tendering process and bid evaluation, and negotiation and award.

So these processes may take many months and involve experts like advisors, lawyers, in-house and external, to go through all these processes. So the early steps are typically carried out in parallel of the feasibility studies or pre-feasibility studies. And then, later on, during the next phases, these are refined. And during this process, the assistance is also taken from internationally recognised construction precedents, such as those produced by FIDIC, which is the International Federation of Consulting Engineers.

Now, FIDIC produces typical templates of multiple contracts. But the most important of these for the purpose of the HEPs are the Red Book, which is applicable to large construction projects generally; the Yellow Book, which deals with electrical and mechanical works; and the Silver Book, which deals with what I just said: EPC, or engineering procurement and construction, which is basically a turnkey project. So these are the internationally recognised templates which, with some modification, people normally use to make these tenders.

Slide 7, please. Next we have the social impact of the project. So no project is without social impacts. These social impacts are usually measured using a range

of internationally recognised standards, such as the Equator Principles or the standard guidelines which are produced by institutions such as the International Finance Corporation or World Bank or the Asian Development Bank.

So HEPs are actually very intrusive into the fabric of geography and communities in which they are located. However, due to the typical small size of the run-of-the-river reservoir, they are typically less impactful than the storage projects, which have much larger reservoirs.

So the HEP construction can significantly impact the community in or adjacent to the construction area. We have some examples on the slide which I'll show you. So there could be involuntary displacement of communities, we can have water quality reduction and increase in waterborne diseases, loss of agricultural land, loss of commercial opportunities -- fishing, mining, tourism -- loss of spiritual or other indigenous site, to name a few.

And there are mitigation strategies and mitigation processes available. For example, appropriate site selection. If a dam site is near to a community, we will try to look for an option where it is far from a community so that we don't have that much of impact.

Restoration of resettlement and livelihood. So we make better villages, give them better facilities; so whatever they had before, they will have a much better life in that area. And payment of compensation, of course, for their movement and all of the things. But if no mitigation is possible, however, then the site would be basically unsuitable.

And by the way, if the social impacts of the projects are not managed, the project will fail at the very least, and become more challenging to implement, including because the investors and lenders will be shy to support such a project. So if the project backers insist on pushing on the project regardless of the legitimate objections of the locals, then they will find it very hard to get international or private funding.

Slide 8, please. So the environmental impacts are also similar in nature, somewhat. And this details some of them, like impact on wildlife, which is flooding of natural habitats, possibly including some endangered species; effects on fish and other aquatic life, floating aquatic vegetation, loss of terrestrial wildlife.

Wider impacts could be downstream hydrological changes due to stream flow, sediment transport, water quality, because there will be reduced flow downstream,

reservoir sedimentation, greenhouse production from reservoirs, and waterborne diseases.

There are again potential mitigation strategies available. For example, we select an appropriate site so that it does not impinge on any natural habitat.

There are environmental offsets. For example, if you have greenhouse gases production from the reservoir, it is normally because there's a lot of jungle in the reservoir that will be submerged, and it will decay and produce the gases. So one strategy would be to go ahead and cut the jungle in that area before you inundate that area, and then replant the trees all around the reservoir so that you have a positive effect of that. Because at that time, you have a reservoir, you have more ambient moisture in the air, so that will support vegetation in the area.

So all these techniques are used to overcome these environmental impacts. Again, if no mitigation is possible, the site may be rendered unfeasible.

Slide 9, please. So the next challenge is financing. You have to build a project, you need money for that.

The total cost of a major Himalayan HEP can run into billions of US dollars. For this reason, lack of financing is one of the most common reasons for

a project failure or its being put into cold storage. The project is okay, everything is fine, all the indicators are good, yet you don't have the money to build it. Then it will be put into cold storage.

So as the slide shows, it starts with financial analysis and tariff analysis, which is basically how much it's going to cost to build, obtain all the permits, all the resettlements, all the costs, everything included; and what are the tariffs and what are the returns that you're going to get. So is that positive? Is the EIRR, FIRR, all the economists, they do all those things, and cost-benefit ratio. So if that is positive then the project is positive.

THE CHAIRMAN: Dr Hayat, can I just ask you a question? When you say "tariff analysis", we're speaking about the tariffs in essentially selling the power from the plant?

DR HAYAT: Selling the power to a utility or to the government, sir.

THE CHAIRMAN: Thank you.

DR HAYAT: Yes, sir.

So then there are options that are available to the builders, whether they go for debt funding options or they go for equity funding, or there could be a mixed bag. And then they have to go for financing agreements with various agencies to secure all the funds that are

required before they actually embark on the construction. And these are all -- so final stage is of course negotiations, signatures of financial agreements, and all that.

Slide 10, please. So the financing track is actually usually tied to the next significant challenge, and that is the regulatory activity. By this, I mean the process in which the project acquires the various agreements and permits that it will need for the HEP to operate in due course. So the project financing will only be available, or contingent, if you have all the permits in place. And these must either be obtained in advance or in accordance with precisely defined timelines set out in the financing agreements.

So on this slide, we have illustrated a selection of kind of regulatory instruments that the project must have in place. And most probably, the most complicated of these is the power purchase agreements, as you pointed out, Mr Chairman.

This is a long-term contract between the electricity generator and the customer, usually a utility or a government or a company. The PPA, or the power purchase agreement, can last anywhere between 5 and 20 years, and it's a good measure of the financial viability of the HEP.

So PPA can either be for a predefined amount of energy or a predefined percentage of energy that the HEP will eventually generate.

Beyond PPA, there are of course other instruments that the project will need to obtain. So there are land acquisition agreements. The land that is inundated, or the land that is required for building the dam or the reservoir area which is inundated, it could be government land: then you will need government permission. If it is private land, you'll have to talk to the private owners and give them compensation. So all those agreements have to be in place.

And water right agreements, because you will be using water of the river. So agencies will be responsible for the water of the river, and you'll have to go to those agencies to get the permit that, "I want to use this water for building the dam", because there will be some storage for some time. The effect is not that much for a run-of-the-river project, but it is more for a storage dam. But in any case, you need water rights agreements.

And you need project implementation and concession agreements, and mostly the government agencies are responsible for this. And any other necessary permits.

So with this review, you'll be able to see the

reality. I mean, going through all of this is not easy, to say the least. This is some exercise that you have to carry out. I see some smiles on some faces here! And as I said earlier, it is lengthy, it is expensive and it is challenging. And with that said, it is not for the faint of heart, you know? So the projects that do succeed and see the light of day often stand as a testament to the designers' and backers' creativity and tenacity.

Can we move to slide 11, please. So we have looked at the challenges in development.

DR BLACKMORE: I was interested in that list. I'm just wondering: when you have a sequence of hydropower facilities on the one river, and you need each of those things for an individual site -- so I understood all of that -- does the government have a -- who owns the grand plan for how the river will be developed? So we generally don't just put one hydroelectric plant in: you have one --

DR HAYAT: Cascade.

DR BLACKMORE: And you have a cascade, and so on. And I was looking up there to see whether -- it's embedded in water rights, and all sorts of things. But I was just wondering whether, for something like this dam, the one we're talking about now, was that seen as part of

a cascade of facilities, or was it seen more as a standalone facility?

DR HAYAT: At this point in time, it is a standalone. But there are possibilities of sites downstream which could make into a cascade. But, you see, if you see all the projects -- because Neelum or Kishenganga is only part of the river: it joins Jhelum. So in that sense, it is part of Jhelum also. And on Jhelum, you have Kohala, you have many other projects before you hit Mangla: you have Mahl, you have Karot, and all those other projects. So it can be considered as a part of a cascade also in that sense.

DR BLACKMORE: Thank you.

MR MINEAR: Excuse me, Mr Hayat, now that we've interrupted you, can I ask: are water rights in Pakistan administered at the national, regional or local level?

DR HAYAT: To my understanding -- I think I will refer this to one of my colleagues here, and I will come back to you later on that. But very briefly, I think both the provinces and the central government gets involved in this. But we will clarify that more in detail as we go along.

MR MINEAR: Thank you.

THE CHAIRMAN: I have a question that relates to contractors that you discussed. And again, if you're not in

a position to answer, that's fine. But I'm just curious whether, as a general proposition, there's a limited number of contractors -- global contractors -- that do this kind of work, or whether it's a very fragmented population that you can sort of pick and choose from?

DR HAYAT: Normally, when a large hydropower project comes into being and it is designed, it is then put up and the tenders are ready, it is put up for international bidding. For such hydropower projects, it is not uncommon that there is not one entity and not one company that can undertake single-handedly such large projects. Yes, the bag is maybe limited. I mean, there'll be maybe a dozen companies or two dozen companies that do hydropower, and there'll be a dozen companies -- or less than that even -- who do the hydromechanical and the electrical part of that, and I can maybe count them on my fingers.

But what happens is that they form joint ventures, because it's such a -- you know, Diamer Basha Dam, where I'm working, its expected cost is to touch $16 billion. Now, this type of a project requires -- there's no company, or construction company even, that can single-handedly handle all this thing. So normally they come in a group of two or three.

And what normally happens is you have a civil side of the contract which the civil contractor takes up, and then you have the electrical, which maybe another person or another entity. And then the hydromechanical, like gates and other things, they go to another party, and they come and join hands. Or maybe sometimes even the designers or the client, let's say WAPDA, they also sometimes package them differently, so they are not let out as one single contract.

For example, in Diamer Basha, we are making six contracts, which is main works 1, main works 2, hydromechanical 1, hydromechanical 2, electrical-mechanical 1, electrical-mechanical 2; so six contracts. So it depends on various scenarios and how you want to proceed.

Does that answer your question?

THE CHAIRMAN: Thank you, yes, very helpful.

DR HAYAT: Thank you, sir.

So we have looked at the challenges in HEP development. Now, let's look at how the design process functions from concept to execution.

You will recall that we set out five stages of HEP design by way of introduction. Now I will examine them in slightly more detail. Obviously there are different methodologies, but this is the generic one that I will be explaining.

Slide 12. Project conception. So this is basically a desk study, and this is where you conceive a project. And this is done, for instance, first time, by screening the national inventory.

By the way, this is a small -- you will see the full scale of this later on, but this is a glimpse of the Pakistan hydropower potential inventory, prepared by WAPDA. For example, here you see the ones in this bluish colour are those in operation; under construction; ready for implementation, for example. Like here, here, here. In operation, of course. Then detailed design of those which have been carried out; under study.

So this is the national inventory. So depending on where you need your power -- and you can find something in the national inventory which has gone to maybe a slightly advanced stage, or you know that this is a potential site which is a good site, then the first site is the project conception. So we screen this inventory, or the investors screen this inventory and see which one is the one that they would like to take ahead.

So using this basic information available at each site -- for example, available seasonal flow, because flow is necessary for power generation -- the screening

process will determine whether it is worthwhile even considering the site for hydropower production. I mean, if you have stream gauging -- normally it is there in Pakistan and all the other countries also -- you have the data on river flows throughout the year, and normally spanning many decades: 60, 70, 80, sometimes more than 100 years. So you know how much water is coming in that stream, and whether it is viable to actually put hydropower in there. Is there firm water available throughout the year, or most part of it?

So at the concept stage, the power demand that the project will aim to meet will also need to be identified. And once the site is selected, a desk study to develop the concept is undertaken, which will involve selecting the basic design of the HEP, together with its proposed capacity.

So basic design and proposed capacity, and developing the basic operational procedures that will determine the concepts, energy generation and daily income in very broad -- it's like a broad brush, you know. It's the early stages. So that is the concept.

If the resulting concept is sufficiently positive, then the HEP designer will set down a budget for future development. It all boils down to money that you have to spend, you know, eventually. So you have to see: is

it worthwhile going ahead on this one? At each step you ask that question as you go along the process.

But the most important decision that has to be made at this stage is whether a hydroelectric plant will be a storage dam or a run-of-the-river project. I wish to pause here, and I will point out the difference between the two, because you will be hearing a little bit about this over the next presentations also.

First, I'll talk about storage dams. As the name suggests, a storage dam incorporates a reservoir upstream to store water. So the question is: why do we store water? Answer is: because the flows in the river vary from season to season, and even from year to year. So there are months in the year when the river will receive a lot of rainfall, and abundant flows are available which are more than required. So these are called the "wet months". So in Pakistan, the wet months are typically from May to September. Monsoons come in, and we have catchment, and snowmelt is there.

On the other hand, we have the dry months, in which the flow is low. And normally in Pakistan it is from October to April.

So regardless of the flow variation, the demand of the water remains, and that is for electricity generation and also for irrigation, for a country like

Pakistan, for example. You need water for irrigation. So you need that also in the dry months when only the river flow is not sufficient to meet all the demands. Therefore, at that point in time you use the water that you have stored in the reservoir during your wet months, and use it during the dry months for your irrigation needs and your power generation.

Second are the run-of-the-river projects. These are only used for generation of electricity or power. In general, very broad terms, in a run-of-the-river project, the water coming into the river is equal to the water that goes out of the power station back into the river. So that is, in very broad terms, a run-of-the-river project, unless the water coming in the river is more than what is required at the power plant. In that case, as you see in the Neelum-Jhelum, we have spillways: you can spill over back into the river.

However, since these plants are basically for power generation, and power generation is -- and power demand actually, power demand, I would say, is variable during the day. During the night, when people sleep, the power demand goes down. And during the day, when people start, and businesses start opening, factories start and everything, the power demand surges. So in a 24-hour

day period, there are ups and downs in power demand.

Therefore, a small reservoir is needed as an operational pool. So that during the lower demand period, you will store enough water in that small reservoir or pondage so that, during the high demand period, you will release that water that you have stored in that 24-hour period into the power station to generate more electricity.

So the powerhouse will be working at different levels: it will generate more electricity when it is needed, and it will be generating less electricity when it is not needed. So this is the typical run-of-the-river situation, and this is called "peaking" also. When you peak the power during the peak demands, that is called the "peaking operation". So for a 24-hour period, you store that much water during the low demand, and use it during the high demand. So this cycle is repeated daily.

So relating to the choice between a storage or a run-of-the-river project is the power production. Now, the power equation is simple. The power that you can produce from a power plant, in very simple terms, is: you multiply the head of water with the amount of water that flows through the turbines. And what is the head of water? It is the level of water in the

reservoir that you create, and basically your tail water level. So higher the head, higher will be the energy that you will produce because it will give you that much higher pressure at that.

And the other variable in that is the amount of water, the volume of water in cubic metres per second that you flow through the turbines. So higher the flow through the turbine, higher will be the energy that you will produce. If you have higher volume of water and higher head, it is very good, you will be able to produce very good electricity.

So an engineer who is actually designing a project, or the financer or anybody that is backing the project, he would like to maximise the power potential of a site. That is natural because you want to get the maximum money out of your project, you want to get the best return on your project. Now, in a storage project, this is usually done by creating a tall dam or a very high dam. As I said, in Basha we are creating 272 metres-high dam, with a very high storage.

So that is the head that is available at the dam site. So that is used for storage, and you use that head with a high dam to produce electricity, because higher the head, you produce more electricity.

In a run-of-the-river project, a massive reservoir

is not needed. The necessary head can be created through a low dam with a small reservoir, and which is connected to the turbine via a tunnel, in a descending tunnel.

So you use the topography, which in Himalayas is quite steep. So you have a small reservoir, and you divert the water in a tunnel, and the tunnel is then taken to a powerhouse which is, due to the topography, at a much lower elevation. So your reservoir, which is a small one, is at a high elevation; your powerhouse is at a lower elevation because of the distance. In a smaller distance, you get -- the topography changes a lot, there's a high head.

Like in Neelum-Jhelum, with this 28.5 kilometres of tunnel, the height of the dam at Neelum-Jhelum is only 47 metres, yet the head that we have created is 420 metres. If you were to build a dam to create that head, a high dam, the dam would have been at least 420 metres high at this place.

So this is the difference between a storage dam and a run-of-the-river project. So you use the topography to your advantage.

And this advantage -- yes, sir, please, Mr Blackmore.

DR BLACKMORE: I'm just interested, given that we're talking

about the philosophy here, and the planning for the country, and the elements that go into run-of-river and storage, so I was just thinking as you go through it -- because it's a very powerful presentation, so thank you for that. I just haven't heard the word "climate change". Is climate change a key part of the thinking for some of these dams?
DR HAYAT: Very good question, sir. Very good question, sir. Everybody is worried about --
DR BLACKMORE: I have two more, but we'll do climate change first.
DR HAYAT: Okay. I'm most glad to answer your question, sir. Most welcome, sir.
Yes, it is on our mind, sir. Again I'll refer back to my own project, which is the Diamer Basha Dam Project. Indus is the most snowmelt-fed river in the world, sir. We have more than 18,000 glaciers in that area.
When the project's feasibility was done, it was thought that the maximum flood that could be generated in that river will be by a GLOF event. "GLOF" stands for "glacial lake outburst flood", G-L-O-F. So as the glaciers melt -- that is their behaviour -- there are glacial lakes. And at any given point in time, a glacial lake my burst unexpectedly. And then you get

all that flow and debris coming into the river.
So we studied that at the feasibility stage that was done in 2002, 2003 and 2004. And at that time we thought that we would get a 49,500 cumecs flood because of the GLOF. But because of the large reservoir -- by the way, the reservoir here holds about 8 million acre-feet of water, and it's 100 kilometres long. So it has some absorption capacity.
So the outflow in that flood was only about 35,000 cumecs, the spillway capacity. So that was the probable maximum flood; and you'll hear more about that in presentations 5 and 6 as we go along.
Later then, when we were doing this construction design, we were looking at what your question is, climate change. And we said: what has happened to the glaciers? What has changed in the snow cover? Is there anything that is required that we should change their design or we should have a re-look at that?
So again we contacted the same professor -- and by the way, he is Professor Reynolds; maybe you are familiar with his name. We contacted Professor Reynolds, and we requested him that he carry out this study for us. And over a few months, he did that study, and he came up with a very surprising answer. And now we are talking about the difference

only between the last 20-25 years. And he said that many of the glaciers have melted, the track from GLOF has reduced significantly. This is the climate effect, you know?
And now, instead of the 49,500 cumecs, the GLOF event can only generate about 14-15,000 cumecs. So that was a sigh of relief also. But there were other factors that came in, and our flood was high; that is another reason.
And the other reason for climate change is: previously the monsoons never went in the catchment area of Diamer Basha Dam. But in the last one decade we are seeing that monsoons are ingressing into the catchment of Diamer Basha Dam. And when we take that into account, the combination of snowmelt and the monsoon ingress actually creates the PMF, which in this case we calculated, with climate change added for the duration of the project, adding that 10% extra in that to take care of any future climate change also, it comes out to be 42,000 cumecs. But the previous GLOF was a duration of only like two days. This one is sustained over three weeks. So 42,000 over three weeks, and then we had to discharge, but the discharge capacity came out to be similar, like 35,000 cumecs, so we designed the spillway to that.

So yes, climate change is real, it is here and we have to take care of that. And I will talk about later that it is thought that in the Indus Basin, in the Indus, we are going to see something like, people say, 17% reduction in the volume of water that is going to flow in this river, because of climate change, annually.
DR BLACKMORE: So my next question: I look at this as hydropower, right, hydropower potential in all of its forms. There are many forms, which you've discussed.
But over here, I see countries such as Pakistan and others that are going down a journey of green power -- wind, solar -- and using hydropower or hydropower storage as an offset for the times when the wind doesn't blow and the sun doesn't shine. So I'm just wondering: is the background to the way we're now thinking about this network here of opportunities, looking for what a green future might be -- you've got climate change, which you've just discussed, thanks. But I'm just wondering about whether solar now is by far the cheapest. Like in Australia, it's by far the cheapest unit of power you can get, but [there's] not too much solar at midnight. And we're looking to invest very heavily.
THE CHAIRMAN: What's the question?
DR BLACKMORE: The question is whether we're integrating,

into the planning of the hydropower, solar and wind.
DR HAYAT: Sir, we are. As you know, sir, already the energy mix in Pakistan is skewed. And that's why our energy bills are out of the roof, you know? Normally it should be 70/30: 70% hydro -- ideal mix -- and 30% other. Here, we have almost the other way round.
The problem with hydro is also it's seasonal variation also. During high-flow season, you have enough water that you can release and generate electricity all the way round. And that is when we have, by the way, peak demand also, because those are the hot months in Pakistan, all the air-conditioning is going on and things like that.
But during winter months, the power-plants normally go down to almost 30% or 25% of their capacity because of the low flows; and you're storing water also for your crops and things like that. So you have to have something additional coming in. That is one factor where our other thermal and nuclear power-plants come in.
That being said, yes, we have -- the government has a very aggressive policy of pursuing other green alternatives. This is a green alternative also, because it doesn't emit any gases or things like that, hydropower. But in terms of wind and solar.

But that being said, somebody quoted me an example from Australia. We have to be very careful when we go on that path, you know? Because when you rely too much on your solar or your wind, as you said, it is not a very stable power system, and your system could become unbalanced. And now I'm told that the Australian Government is plugging in other like hydropowers and things like that to make their system stable.
So yes, we are pursuing that, but with caution that -- yes, especially in rural areas, for example, where it is difficult to even take transmission lines and all that, solar and wind could be -- you take them off the national grid, you just keep them independent. Or even from larger plants.
I mean, the technology is evolving day by day. The problem with solar and wind is their storage, because it is only -- not so much with wind, but with solar. So unless you have some good power storage capacity -- which is, by the way, advancing day by day, [Tesla] and I don't want to name other companies. They are producing these power banks and power systems where you can store power.
So as it grows, I'm sure there will be a time when these will become much more attractive, and I think that is the way to go.

You had a third question, sir?
DR BLACKMORE: No, I'll stop, that's fine.
PROFESSOR BUYTAERT: As a quick follow-up question on the discussion about energy storage, has Pakistan any plans for pumped hydropower?
DR HAYAT: I think, to the best of my knowledge, there was some talk of pump storage. This is one of the good options that is available to any country that, during low demand, you actually use the electricity that you're producing to take water up, store again. So it's a cyclic sort of situation, pump storage: you pump the water back and use it for peaking.
So to my knowledge, I think the sites may be an issue. But yes, that is an option that must be studied. But I'll come back to you with more information when I get that.
PROFESSOR BUYTAERT: Thank you.
THE CHAIRMAN: Thank you very much. Continue, please.
DR HAYAT: Thank you, sir.
So slide 13, please. Pre-feasibility study. So with the basic concept in hand, the next step is to undertake the pre-feasibility study. Now, the starting point is, for example, a site visit to get further data -- in particular, hydrology -- to ensure sound basis for the computation of future energy; more

comprehensive data on basic layout of the hydropower, HEP; cost-benefit analysis.
And this whole analysis is not actually absolutely confirming that the hydropower is going to work as a technical and economic prospect. Rather, the pre-feasibility study is intended to determine whether a full feasibility is needed or not, because full feasibility is quite a substantial undertaking.
And again, it boils down to money. So the investor or the government entity wants to make sure in the pre-feasibility that it is worthwhile moving to the next stage, i.e. feasibility stage. So we take one step at a time. So in the pre-feasibility we see that, yes, there was a concept, we've gone through the pre-feasibility and all the boxes [are] checked, so we now can move to the feasibility level.
So this is not confirming absolutely the viability of the project, but to say: yes, we move to the next stage, which is a full feasibility.
Slide 14, please. So a full feasibility study is actually taken to determine, with a high degree of probability, that the project is technically, environmentally and financially viable. Three main boxes that have to [be ticked]: whether it is technically, economically and environmentally feasible.

So this study actually focuses mainly on these three aspects and there are other things which run in parallel, as I said, but these are the three main things.

And then of course you decide what further studies are required. So a full hydrological and geological analysis of the project site is done at this stage. Environmental studies are done to a greater extent. A lot of site investigations are done: drilling, taking samples, testing.

And then, with all the data that is coming in, you basically develop alternatives, which dam site will be suitable. So it's not one type sometimes that suits every place. So you will say: should I go for a CFRD, ECRD, or should I go for a concrete dam? Is it gravity? Is it arch? All those things. Where will be the powerhouse? What will be the capacity?

So you make five, six, seven alternatives. Then you design them with a broad sort of brush to an extent and then select, with all these things, which is the best alternative out of these that you can then take forward in your feasibility study. So first you do a broad sort of a sweep, and then you narrow down to your one or two preferred alternatives in this feasibility, and you then finally go with one.

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So the selected alternative will be designed, and its cost estimated reasonably. That will include the cost of equipment and construction, and the analysis of HEP operation strategies, a computation of expected energy production, analysis of tariff values/markets together with project finance alternatives; analysis of social/environmental impacts, together with appropriate mitigation strategies, which we talked about; development of comprehensive plan for project implementation.

So again, at the end of all these studies -- and by the way, there is a whole gamut of experts of various fields that come together to do this, all across the board, and combine together. Then, as I said, we decide whether the project is technically, environmentally and financially feasible. And if it is, then we take the next step. And the next step is the engineering design.

Slide 15, please. This, by the way, in here shows a drawing that is produced of many drawings, thousands of drawings. Actually, in a project like Neelum-Jhelum, even you have 15-20,000 drawings. Let that sink in: 15-20,000 drawings.

So this is a drawing looking from the top of the powerhouse. You can see the generator or the turbine setting and all that.

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So this runs in parallel with the environmental, social, financial, regulatory, contracting activities which I have referred before. It serves three purposes: first, it allows for further optimisation of the concept which was developed at the feasibility stage, and each element is designed to a higher degree. And it serves as a basis in which the tender drawings are made.

This is important, because these are the drawings based on which you will develop the bill of quantities, you will cost the project, and that will become a part of the tender, i.e. the drawings and the bill of quantities, and of course the other specifications and things like that, they will become part of the whole tender document which will be floated on the international market. The contractor will have that information. He will look at that and then he will bid for the project.

So when this is done, this allows the implementer of this project that he can then proceed to the construction phase. So the engineering design is actually a bridge between the design and construction.

And if you engage the contractor early, you can start early. And as a rule of thumb which we normally use: that 1,000 MW produces electricity which is valued at $1 million per day. So this is just a basic rule of

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thumb. And so this gives you an idea that if the project is late, how much you are losing. And if you start early, you are good at design, how much money actually you start making as early as possible. So people are very keen to start their project early.

So at this point in time, only 20% of the expense has actually been made, or less than that. Actual money starts flowing out when you go into construction. So the 80/20 principle applies here also. So only 20% is what you have spent up till now. The big chunk is still ahead of you; that's the big challenge. So you have to be very sure that all that you have done is of due diligence, and it is workable, it is doable. And as I said, with all the other permits and all those other things coming in.

So, as I said, all relevant national, state and local permits must be secured. The power purchase agreement must be either executed or, at least to a certain degree, project financing must be in place. So this is the actual gelling up of the whole project at this stage. Then you know that you have something viable going ahead now.

Slide 16. And next we go to the construction design. Normally, when a project is tendered and the contractor comes in, during construction there is

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actually a little bit of tweaking, generally speaking; generally, and I'll qualify that. There is generally a little bit of tweaking in design that you have done at the tender stage, unless there are changed conditions which are exposed during construction, or come to light during construction. Then, if they are substantial -- small changes are no problem. But if they are substantial, then you have to change the design, and this could be substantial. Like you may have to add -- if your hydrology tells you something, you may have to add another spillway, or increase the capacity of your spillway.

So I'll give you three recent examples in which, at the construction stage, we had to change the design. Going back to Mangla Dam, I'm sure you're aware it's one of the largest projects. When the construction started, the designers were Binnie and Partners, and Atkins was I think the contractor.

When they started the project, the foundation revealed that the clays were sheared. Actually, from there, the concept of sheared clays and their lower shearing resistance came into being in the area of soil mechanics and geotechnical engineering. And Professor Alec Skempton of Imperial College actually was engaged in those studies. And because of that, because

of the lower shearing resistance which was found during the construction phase, we had to change the design of the dam, with much flatter slopes to make it safe.

Now, at Basha that I'm involved in, there are many changes that we had to make. For example, during the time the detailed design was done, which was something year 2012 or 2011, the "guidelines", I call it -- the International Congress on Large Dam guidelines -- on earthquakes changed. From 50 percentile, they went to 75 percentile or 80 percentile for the selection of safety evaluation earthquake, SEE, or what was previously called the maximum credible earthquake, or MCE.

So our design earthquake, or the maximum credible earthquake, or the safety evaluation earthquake, which is called SEE or MCE, changed from a value of 0.46g, which is the gravity value, to 0.64g, a 50% increase. So you can imagine what effect that had on the design. You had to apply that earthquake to all the features of the project -- during the construction phase, by the way -- to see that it was safe or not.

Similarly, in the diversion, we had to change a lot, because during investigation we found out that the diversion canal was passing over alluvium, and such high flows could not be allowed over alluvium. So we had to

change the alignment of the canal with an additional 3 million cubic metres of rock excavation. And the canal is now totally running on solid gabbronorite rock, which is the main rock in that area, and so we are safe in that sense.

Then we found out that the rock stresses in the area were different, and that has a major effect on the orientation of the powerhouses. Previously, it was reported that the main stress in the area in the rock was vertical. We found out: no, it is horizontal. Vertical always told us there was something wrong there, vertical could not be, maximum rock stress being vertical did not make sense. So we found out through over-coring test, and all other hydraulic fracturing, and things like that, that it, maximum rock stress, is horizontal. And based on that information, we had to reorient our powerhouses.

And also the spillway. When we applied the earthquake forces on the dam with the excitation, we found out that this spillway was previously a crest-gated spillway. Now, we found out those gates would not withstand the amplification: with that amplification, they would fly off the trunnion support, you know, basically. So we then went for an ungated spillway.

Not only that, but the sedimentation studies that we have carried out, we have mid-level outlets now for sediment venting, that is opening in the dam body at various levels.

So all these changes are being made in the project as it is being built. So it is like making the aircraft as it is flying, you know? So sometimes this is how the challenges are in a hydropower project.

The other example is of course of Neelum-Jhelum, where you're going to visit. And there were a lot of design changes made in this project during the construction process. And as you go to the site, and people will be giving you presentations, they'll be telling you about all those design changes that were required. And they were substantial, they were not minor.

So at the end of the project or the construction, then we produce what are called the "record drawings" or "as-built drawings", because there are minor details which are slightly different than the tender drawings or the construction drawings that were issued, like half an inch there, a few millimetres there and a few millimetres there. So to have a proper record of what is there, there's a whole big set of drawings that is produced which is called "as-built" or "record drawings".

This shows part of the drawings of Neelum-Jhelum orifice spillway, one of the drawings that was produced. So this is just a snapshot of that.

Now, unless you have any questions, sir, I will pause here, because we then move to the next part of the presentation.

THE CHAIRMAN: No questions from us. This was a very helpful presentation. So please, I think we're on to Mr Malik. Thank you very much though, Dr Hayat, it was very, very helpful.

DR HAYAT: Thank you, sir. You are most welcome, sir.

MR MALIK: Mr Chairman, members of the court, good afternoon. It's late afternoon now.

My name is Muhammad Ayub Malik. I am associated with this project since 2009, very early in the project. We just started construction of the project when I joined, and I'm still here. So a lot of things have changed, whatever he has been telling, a lot of changes, a lot of challenges. And we'll be telling you a little bit on this one.

My presentation is in two parts. One is I will take you through the basic hydroelectric components, very basic. My colleagues later on, at the dam site and at the powerhouse, will be telling you in details about

those things.

And then I'll tell you the construction challenges of building a hydropower project in this area. And this will be based on the Neelum-Jhelum: pictorial things, what are the challenges, how we managed things. As Dr Tahir Hayat says, we have to come up with innovative ideas while designing and constructing these projects.

I mean, there are places where you have got not enough space. Like if you go to the Neelum Valley, when you go to the project site, it looks huge. But when we were constructing it, we were seeing: how are we going to build it? It's only 50 metres wide. So you have to excavate it, you have to build that thing. So whether you can put a gated spillway there, or you have to have an ungated spillway.

If there is sediment, you might have to go for a desander that we opted for in this project. We have another project where they said, "We don't need a desander, our reservoir is good enough to act as a desander".

Then if there is a very windy area, then you have to make sure that your wave action doesn't make the water overtop the dam. This is something that most of the design engineers don't want their dam to do. Even for the concrete dams, they don't want them to be overtopped

because it can damage the foundations when the water goes over it, damage your equipment. It's very costly to fix.

Next slide, please, 18. So this is a basic schematic of a hydropower project. I'm sure you will be seeing these sort of drawings quite a few times in the next two days. This is a dam which we put in the river to create a reservoir.

This looks very steep, but if you look at the longitudinal cross-section of Neelum River, it's almost like this: it's a very steep river. And we have got -- within a very short time, if you go on our reservoir, you will reach the flowing river. So it's 3 kilometres and you reach the reservoir. In case of storage dams, you can go 100 kilometres and you still don't see the river, it's still a reservoir.

We have an intake from where we take the water. I'll explain later on their functions, later on. From there, the water is drawn into a filling basin, which is, in our case a desander. From the desander, the water enters the headrace tunnel. This looks very short, but in our case it's 28.5 kilometres, so it will give you a ... you can imagine the scale.

At the end of the tunnel, we have a surge tank, which is a sort of pressure release valve so, in case of

a sudden closure on the tunnels, the water doesn't damage the tunnels. And from there, the water goes into the penstocks, which are highly pressurised, so most of the time they are steel-lined. And that is connected to the spiral casing through an inlet valve, which is another safety thing, safety valve.

The water goes into the turbine, it rotates the turbine, and it generates -- it converts this hydraulic head into mechanical power. And this mechanical power then rotates the generator, which converts this mechanical power into electrical power.

And this electrical power then is sent to these transformers, which steps it up for the transmission voltage, which can be 132 volts, 220, 500. In our case, it's 525 volts, which is our national grid voltage.

Next please, 19. I'll start with individually the components of the structures. Which is the dam? The dam's purpose is to create a barrier in front of the river and impound water behind it. It can be different types of dam: it can be made of concrete, it can be earthen dam, or it can be a combination of concrete-faced rockfill dam, which is a combination of both of these. The selection depends upon your location, availability of the material, and what is suitable for your environment. Earthen dams are normally built where you have got wide valleys, because they can take a lot of pressures. Concrete dams, normally you go for narrow valleys where you go for concrete dams, like in our case, in the Neelum-Jhelum River.

Next, please, 20. So these are the basic three types of dams which I just discussed. The middle one is the basic earthen embankment dam, which is an earth-filled dam. Now, an earth-filled dam will have the tendency that the water can pass through the dam and it can damage the dam. So you put in an impervious core, which is generally clay core, or you can have an asphalt core that will stop the water migrating from upstream to the downstream side. Still some water might migrate from this core, so you put in sand drains on the downstream side so that it doesn't have a catastrophic failure of the dam.

Second is your concrete dam, which can be either gravity dam, massive concrete, or you can have an arch dam, which is a thin structure, but if you have strong abutments then you can put an elliptical-shaped structure that can transfer the forces to the abutments.

The third type is your concrete-faced rockfill dam, where you make the (indistinct) of crushed rock, and then you put on top, on the upstream face, concrete

slabs. That will act as an impervious barrier to the water.

On all three sites, three types of dams, you have to put cutoff walls with it so that the water doesn't seep under the dam. Anything that can seep under the dam can undermine the dam foundations. Their purpose is to elongate the seepage part so that the water that comes out from the downstream side comes out a long way down the dam side in the river.

21, please. Spillways. Spillways, like the name suggests, it is a structure to spill or release flood waters to the river from the structure. Now, this picture is a spillway of the Tarbela Dam, the main spillway of the Tarbela Dam. I think its capacity is something like 840,000 cusecs, a huge capacity -- 860,000 cusecs. So this is a huge structure. It's amazing to see the water flowing from this one when it's flowing.

Now, this can have different types of spillways. I'll explain in the next slide. But this is a crest-gated spillway, like Dr Tahir Hayat was saying that they had initially planned for the Diamer Basha project, where you can control the amount of water flowing from the reservoir.

Next, please (22). These are the three types of

basic spillway designs. One is surface spillway. That means basically there's an opening on top of the dam with no gates there. The water, as soon as it reaches the full pondage level, it can start flowing over the dam. The operators have no control over this water, at what time they can release or how much they want to release. So this is dependent upon the flow in the river.

A similar spillway, if you put a radial gate on top of it, becomes a crest-gated surface spillway. With this one, the operator has got two advantages: he can control the flow going over the reservoir, over the dam body, and he can raise the water that is stored behind the dam by the height of this opening, with a gate. So this is the crest-gated surface spillway.

And the third one is where you put the spillway deep in the dam body. This has the advantage that you can have smaller gates because you can pass a similar amount of water because it has got a pressure on it to pass through. But it comes with its own problems: your gates have to be much stronger, you have to make sure that you don't have -- the velocities of water coming out are much higher, so your downstream concretes and the ogee surfaces have to be catered for that one.

Third problem is that they, by virtue of their size,

they are limited to the maximum design capacity. So in case of an exceptional flood, they are then combined with either surface spillway or a gated spillway on top, so that there's a combination of both gates, or three types of gates, for the safety of the dam.

[Slide] 23, please. Now we come to the intakes. The intakes are the structures through which you take the water from your reservoir and you take it into the tunnels or the conveyance system. The run-of-the-river projects have a problem that they are susceptible to sedimentation. So you want to take this water as high as possible from the reservoir. Because when the river flows, the sediments are mainly -- as you go up in the reservoir, the sediments are less and less, final sediments. Most of the sediments are at the bottom or in the lower part of the reservoir.

But if you take -- so you can have a surface intake. But in case of a storage dam, you can even go for deep intakes, because by virtue of the reservoir being [so] long, most of the sediment settles many kilometres or tens of kilometres away from your intake structures.

Next slide (24). There are two types of intakes in the run-of-the-river. One is you can have a deep intake. But the problem with that one is that your silt slowly migrates near your intakes, and they can then start migrating into your tunnels, which can damage your electromechanical equipment.

For that, you go for a surface intake. In case of surface intake, you cannot put it too high because you can draw air in the intake. So in this case, you have a separation between your tunnel intakes and the intake from the reservoir, so that your clean water comes in and then you've got the water intake coming from the tunnel.

In case you've got more silt, you can put a desander in between, which is a long settling pond for the sediment to settle down. We have got a settling pond; you just saw a picture in Mr Joya's presentation earlier, and we'll be showing you tomorrow those settling points.

Next slide (25). Now, the conveyance elements. To take water from the intake to the powerhouse, you have got tunnels, canals, and then you've got penstocks. And right next to the powerhouse, you will have this inlet wall.

This is a picture of the inlet valve of our Neelum-Jhelum project. The penstock terminates here. From there, it's connected to the inlet valve, and the inlet valve is then connected to our scroll casing, which takes the water into the turbine.

These are designed so that, in case of an emergency, they can shut down. They have got these massive counterweights, which are 20 tonnes. So in case you have an electricity failure or something, they can just drop on their own under gravity. So they've got a big ball valve inside that rotates, with that load dropping down. This is required in case of a problem in the powerhouse; or you want to do some maintenance on one of the units, and you want no water flowing in because you have to send your technicians into the turbine to [do] maintenance or checking the conditions of the units.

Next [slide] (26). Now, these are the various conveyance elements. We have got a headrace tunnel. In our case, it's headrace tunnel. But in case of some of the projects, we have got a channel also. It can be an open channel also. Like Ghazi Barotha, we have got a 52-kilometre-long power channel. Here, we have got a 28.5-kilometre pressurised tunnel.

Then we have got the surge tank, and we have already told you. I will show you the pictures of this surge tank later on. We have got a surge shaft. In our case, we have a shaft which is 353 metres high.

From there, we go to the penstocks. And then after it generates electricity, the water is taken out to the tailrace tunnel, back to the river. In our project, we

have a 3.5-kilometre tailrace tunnel, which is unpressurised -- or low pressurised. I won't say it's unpressurised, but it has got only 20 metres of head on it.

Next, please (27). Now I come to the turbines. Now, turbines are the elements that convert hydraulic head, hydraulic power into mechanical power. Now, we have got two main types of turbines: Francis and Pelton. Francis turbine we call the "reaction turbine", and the Pelton we call the "impact turbines".

Now, in case of a Francis turbine, the water comes in through the spiral casing and you see the diameter reducing gradually. That is so that the water enters through these guide vanes. The turbine sits here. This is during the construction. And as water goes in, it maintains the pressure while the water keeps on getting in, and it hits the turbine runner and it rotates. And then it's connected on the top to a shaft with a generator that rotates and generates electricity.

Next, please (28). As I was saying, there are two main types of turbines. One is the reaction turbine, where the water comes in through the spiral case, which you just saw the picture. It goes in, rotates the Francis runner, and then the water goes down into the turbine. This whole system is pressurised. And this

pressure is equivalent to the pressure you have got in your system; which is, in our case, 420 metres of head.

Whereas in case of a Pelton wheel, you have got a nozzle and a needle valve, which sprays a jet of water on these buckets or cups. And this rotates this wheel, and there's a horizontal shaft connected to a generator.

Now, the advantage of this one is there's no pressure in it -- it's not pressurised, it's normal pressure -- and it is very simple to maintain. So if you have damage on one of these buckets, you can easily disassemble, repair and put it back in a day or two. Whereas in case of a Francis runner, normally you have to take out the generator -- which weighs something like, in our case, 400 tonnes plus -- you have to take it out, you have to take out the shafts, then you remove the runner, and then you can repair it.

But in Neelum-Jhelum project, they made some changes. They have introduced a part of the draft tube that can be taken out at the bottom, and the runner can be dropped at the bottom. So it is one third the time you can take it out. And if you want to replace it or do some major repairs on the runner, you can do it, in our case.

29, please.

DR BLACKMORE: On the Francis turbine, do you have coaster

gates on it that regulate the flow?
MR MALIK: Yes, we have got the gates. We have got the wicket gates. We call them "wicket gates".
DR BLACKMORE: What do you call them?
MR MALIK: "Wicket gates".
DR BLACKMORE: "Picket"?
MR MALIK: "Wicket".
DR BLACKMORE: Ah, well, that's Australian!
MR MALIK: We got it from the British!
DR BLACKMORE: Ah, I can't comment on that!
MR MALIK: So with that, you can adjust the opening and the water that goes in, how much you want to open it. Our turbines are at 300 rpm. They run at 300 rpm.
Next, please (29). The last element, once you generate electricity, you can't see this, the 3.5-kilometre tunnel that discharges the water back to the river.
Now, this is the outlet structure. You were saying that you might have seen it. It is visible. When you are travelling on the road, you can see this part, because you are travelling on top of this road. So you have seen this one.
So this water is then diverted back. It's conveyed back to Jhelum River. So basically the water, you can touch it. It's coming from Neelum, untouched by

anything else, and now it's going into Jhelum River after 31.5 kilometres.
Next, please (31). Now I'll give you a small overview of the construction challenges that we have gone through during construction of this Neelum-Jhelum Project, five/six slides. It took us ten years, so ... to build it! Not to take the slides, but it took us ten years to build the project. And we had to go through 2010 flood, not shown here. We were just very early, and we had a huge flood, and our diversion tunnel was not connected yet, and it got filled up with sand so the contractor has to go back and dig it out again. So it was big challenges from day 1.
Next, please (31). As I said, it took us ten years to do it. Our major challenges during construction was diversion and excavation. This is our diversion dam during construction. You will be seeing only this much portion when you will go there, hardly the top 10 metres. The rest of it is underwater now.
Then we have got the tunnelling. The biggest challenge on this project was tunnels, because we had in total 58-68 kilometres. It has got the main tunnels, our diversion tunnel, our tailrace tunnel, and we had about 15 kilometres of access tunnels, which were excavated just to reach the main tunnels, and which were

abandoned later on.
And then the surge shaft, I said 353 metres high.
And the powerhouse. Powerhouse is a huge cavern that we have to go and -- and like Dr Tahir Hayat was saying, there were changes. In this case, we had to change the orientation and the location of the powerhouse before we started excavating.
Next, please (32). The first one was to divert the Neelum River. This is our construction site. So to make it dry or make it free of water, we excavated a diversion tunnel on the right bank, 505 metres long. This, you can see on the right side, is the water coming out from the diversion tunnel. On the bottom left side, this is the foundation concretes for the main structure of the dam.
And incidentally, if you see this long wall, during construction we realised that this water that we can divert to the river is not enough, so we'll be overtopped, our coffer dams will be overtopped. So we came up with the idea to use this area on the right side as an open channel. And we built a longitudinal coffer dam, and put RCC, roller-compacted concrete flooring here, on which we'll later on build one element, which was the rockfill dam on this part. Rest of them was concrete dam.

So we used this thing, and we were able to pass 1,500 cumecs during construction, without overtopping our coffer dams.
Now, this left side you see is the excavation for the desanders. And this block you see is basically the opening of the tunnel. This is the start of our tunnel. Now, when you'll go there, we have got a collecting tunnel here and the desander built at this place.
Next, please (33). Now, for the tunnelling, we started this tunnelling with what we call the conventional drill and blast method. We started that thing. But very early this in the project, we realised that there is a stretch of 12.5 kilometres where there's no access tunnel available in between them. And that was the critical most part where going with a drill and blast would have been very slow, because the drill and blast produces a lot of noxious gases, dust, and it's a slow process.
So WAPDA decided to acquire these hardrock tunnel-boring machines, two of them. And they were acquired -- brought to site in 2012. They started excavating. This is 8.5-metre diameter tunnel TBM. They were, I would say, running factories, 185 metres long. So it was like a snake going through the tunnels excavating, chewing up the rock.

Our tunnels, the lowest point was when we passed under the River Jhelum. You saw the drawing where the river comes in from -- on the inside, we call it "upper limb"; and then it goes to Muzaffarabad, and then comes back lower limb. So the tunnel came from Neelum River, it went under the Jhelum River, and then it discharged into Jhelum River. So we were around 178 metres under the Jhelum River.

Next, please (34). Now I'll show you the profile of our tunnels. This is the dam site where the Neelum River is flowing. From here, this is how our tunnels were. You see the profile of the tunnel. This part of the tunnels have a very -- I would say gradient is very less because we used the TBMs on that. TBM has -- I was told that they have a restriction, or they can't go above 6% gradient, these light TBM. So the TBM incidentally started here, just downstream of this added A2, and we excavated up to here with the TBM tunnels. And you can see the overburden. At the highest point, it was around 1.5 kilometres of overburden on top of the tunnels.

From here, the tunnels go in a steep slope. In the original design, this dotted line, this was in the original concept or feasibility design, because the tunnel engineers say that you need to have sufficient

rock cover on top of you to have a safe tunnel. So the designers had this thing 400 metres below the river.

But with this thing, the gradients were coming out more than 14% so our electromechanical -- our earth-moving machine couldn't drive on 14 degrees with mud and wet ground. Plus it was very -- it was found to be very difficult to drain out. And if it has got silt accumulated, it will choke the tunnels.

So it was decided to remove the tunnels -- remove this dip. We used to call it the "Jhelum Dip". So we moved it up, but then your rock cover became only 178 metres. Rather, the depth was 178 metres, our geologist said the rock cover is only 100 metres.

So in this area we put in a steel liner to strengthen the tunnels. For 732 metres -- these are twin tunnels so we put 732 metres steel lining on both sides.

After that, the tunnel flattens out and it goes to the powerhouse, and from powerhouse this is our tailrace tunnel.

Next, please (35). Now, the twin tunnels. Our tunnels started as a single tunnel; I showed you in the dam picture. And after 0.8 kilometres it is split into two tunnels. So this is our tunnel bifurcation. There's another bifurcation where they come back. After

the Jhelum crossing, they come back and they again merge into one tunnel.

These tunnels are 8-metre diameter excavated, and then they were concrete-lined. All the tunnels which were done by drill and blast are concrete-lined. The tunnels that were excavated with the TBM are shotcrete-lined.

Next, please (36). This is the steel liner factory. I told you under the Jhelum River we put in the steel liner. These are 6.6-metre diameter steel pipes. We used to call them "cans". And each piece was 12 metres long, 72 tonnes of weight. It's 38-millimetre high-grade steel. And these were transported through low-bed carrier from this factory inside the tunnel where they were to be placed. And then they were offloaded on a rail carriage which will take them where they were to be installed. And there, they were welded together. And once they were all welded together, they were filled up with concrete from outside.

Next, please (37). This is the surge shaft I was telling you. And for comparison, we put the Eiffel Tower along it. Eiffel Tower is 330 metres high. Our surge shaft is 353 metres.

Yesterday somebody asked me from Chicago, they were doing another exercise, and they say in Scotland they

are having a pump storage where they have got a surge shaft which is higher than Burj Khalifa. Burj Khalifa is 828 metres high, so you can imagine a surge shaft which is 828 metres high.

So this was a very challenging one because the contractor has to first drill a pilot hole coming down 353 metres, making sure that it stays inside that tunnel geometry, although it veered off by 4 metres or 5 metres, because to keep it straight is a very, very difficult job. And then at the bottom they put in a huge cutter, and then they took it up, which we call "raise boring". So it created a hole which was 1.6 metre diameter. That was our mucking hole.

So then the contractor started excavating from the top, and he would throw all the rock in that hole, and he would haul it from the bottom. And once it was done, then it was concreted all the way up by slip forming. So it was a very complicated and dangerous job. Going down in an Elemac, it gives you religion! Especially if the Chinese are operating it!

But luckily we had no accident. Luckily we had only one accident, where somebody broke a leg. There was a stone that fell off and he had a simple fracture. But this project, I don't know why, but somehow with -- I mean, I hear about other projects, safety ones. We had less than a dozen fatalities in 12 years of construction, and accidental ones. And half of them were traffic-related. Somebody drove off the bridge and the dumper went into the river, or somebody drove over somebody sleeping in the tunnel. I mean, people do it. It's idiotic but people still do it.

The main accidental deaths were I think six or seven. Three we had an incident in the TBM, and five or six where the form work fell down.

Next, please (38). Now, this is the powerhouse cavern. The powerhouse cavern, when we'll go tomorrow what you will see is 50% of the powerhouse. This powerhouse is 25 metres wide, and from the top to the deepest point is 54 metres, and the length is 137 metres long.

So we excavated. Starting from the top, we excavated a pilot hole, started -- put a tunnel through the top, and then we took out the shoulders while we put in 15-metre long strand anchors to support the crown. And then we came down.

When we came to this height, we put in these crane beams. In the original design, these crane beams were resting on concrete columns. But we said I mean, I was part of that, that if we ever do it, these cranes have to wait for two years. So we decided to put these crane

beams by putting these cranes and anchoring these crane beams into the rock by 15-metre-long stand anchors and 7.5 metre-long rock bolts. So these crane beams are designed to take a load of, I think, 600 tonnes.

We have two bridge cranes running on that, 275 tonnes each. At this elevation, our powerhouse, being such a wide one, and the geology is not the best, they started converging, the walls started moving in. Maximum I think we calculated was around 235 millimetres of movement on this wall, on the downstream wall. So we stopped the excavation. Contractor brought in around 15,000 tonnes of muck inside, to build ramps and then install 15-metre-long rock anchors to stabilise the rock.

Now we do -- I mean WAPDA and we have been doing regular measurements. There's no movement at all, it's stabilised.

Next, please (39). That's all for the construction. Ten years in ten minutes! Any questions?

PROFESSOR BUYTAERT: A slightly more general question on power generation. How is the power output of the generators controlled?

MR MALIK: I have to ask my electrical engineers. I am a civil engineer; I don't go near the electrical parts. Mr Arfan [Miana]?

MR MIANA: Can you repeat the question?

PROFESSOR BUYTAERT: How do you control the power output of the generators?

MR MIANA: The power from the generator is dependent upon the head and the flow rate. So if the flow rates are less then the power generation is obviously less. And the controlling is through our regulation of the wicket gates or the stairways, what you were describing over here. And the rest is the governor system, which controls the system frequency, as well as the speed of the turbine.

So these are the parameters, which are interconnected and which control the output of the generator.

PROFESSOR BUYTAERT: Thank you.

DR BLACKMORE: I'm just interested in what was the design criteria for earthquake loading. What did you allow for? I'm assuming you allowed the same for the powerhouse, the tunnel and the structure, but I'm not sure what it would be.

MR MALIK: I have to find out. We have changed -- when it was tendered, this project was designed -- original design was done in 1996. What happened was that in 2005 there was a major earthquake. In 2007 the contract was awarded. But after they awarded the contract, based on

that earthquake the Government of Pakistan changed the earthquake criteria for this part of the world. It was a 7.8 magnitude earthquake. So I can get you the seismic parameters from where -- we changed both underground parameters and the aboveground parameters to cater for earthquakes.

DR BLACKMORE: So 7.8 was the number --

MR MALIK: I think something around 9. Our maximum credible earthquake is 9 plus.

DR BLACKMORE: Alright. Make sure --

MR MALIK: Although somebody wanted it to be 10. But then somebody said, "If we have to design something for 10" -- and I said one thing. I said: I'm not a seismologist, but if a 10 earthquake comes, your structure might be safe but there'll be no mountains around it! So then we settled for 9 plus, or something like that, one in a thousand year event, something like that.

DR BLACKMORE: It's an extremely high number.

MR MALIK: Very high number.

DR BLACKMORE: Yes, it's a very high number.

MR MALIK: I can get you the actual figures also.

THE CHAIRMAN: I hope we don't test that number while we're here!

MR MALIK: No! In 2016 we were having a meeting. Our panel of experts were here. We were sitting in the design office in Muzaffarabad and I was giving a presentation on the schedule of the project. And I have done hardly three lines when there was a sound like there was an accident on the road. Our building was right next to the main highway. And I thought there's an accident. And I turned around and everyone has disappeared. And then I realised that this was an earthquake.

So I went out, and we were standing there, and you can see -- there's a vehicle showroom right next to that building, and you can see a wave going on the facade of that glass building, and it was for 30 seconds.

Later on we found out it was a 7.4 earthquake. So when I came back, I commented: never again talk about schedule on this project: even the earth shakes!

THE CHAIRMAN: Well, again, I hope we don't test that number here. I also hope that they're not constructing the aircraft as we're flying home!

MR MALIK: It's already been constructed!

THE CHAIRMAN: I had a few questions. This relates to the powerhouse, but it's a very basic one. It looked like there were at least two turbines there. How many --

MR MALIK: Four turbines.

THE CHAIRMAN: Four turbines.

MR MALIK: Four turbines.

THE CHAIRMAN: And the value of having multiple turbines is not to use them all at once; is that correct?

MR MALIK: No, if we have full water supply available, like in high-flow seasons, and our dam can supply 280 cumecs to the powerhouse, we can run all four units flat out.

THE CHAIRMAN: Okay. So you would in some situations run all of them?

MR MALIK: We run them for five months a year usually, although WAPDA have their own criteria for running the project that, after certain hours of running, they stop one unit for a day, and they do a monthly maintenance on all of them. But as a routine, they run those turbines flat-out for five to six months, as long as the water is available.

THE CHAIRMAN: The next question is relating to slide 31, so if Mr Miles could take us back to that. Could you just point out, using your pointer, the basic components? I find this photograph very helpful because it strips away the water. The basic components of the dam.

MR MALIK: This is looking downstream. This is the left bank, this is the right bank of the river. These are the intakes, this is the intake structure from where we take the water. These are the intake gates. The water goes into the desanders. What you see behind it being constructed are the desanders.

At the end of the desanders is a collecting canal from where the water goes into the tunnel; so this is the left-hand structure. Underneath the desanders you see these small gates. These are called under-sluices. This is for flushing any silt that accumulates in front of our intake structures.

In the middle, these are our orifice spillways. These are three gates. And we have to design these gates so that in case of an emergency, even if one gate is out of order, these can pass the maximum flood. This is called "N minus 1 criteria" on any dam. So these gates are huge. In Pakistani standards, normally our gates are 12 metres by 8 metres. Our standard gates on most of our projects are 12 metres by 8 metres. These are 12 metres by 15 metres: 12 metres wide, 15 metres high.

Then on the right, which is under construction -- you don't see it here -- is -- we call it debris channel. This has got -- this is crest-mounting gates and it's got flap gates. The radial gates, they move like this upwards, and the water goes below that. The flap gates are like this and they fall down.

Basically, in this reservoir, in case of floods, you get a lot of floating debris. And especially sometimes when you've got exceptional floods, you get these logs

coming in because there's a big logging industry going on in the upper reaches. So you get logs. So to pass them through this structure, you lower the gates and the water takes these debris downstream. So these are the three ...

And then on the right of this structure, where you see this wall going, this is where we built a rockfill dam, which is a flexible dam. The reason is that this line where you see this wall, this is where we have got a main boundary thrust. Our dam is situated on the main boundary thrust. When we'll go to the site, you will see that on the right the rock is greenish colour. On the left side it is greyish to brownish colour. This left side is Indian subcontinent tectonic plate. Right side is Eurasian plate. So you can stand there and your one foot is in India, the other foot is in Europe!

It's not like that, but we have done it. When we excavated it we found a seam of very crushed rock. It was crushed to like powder. And when our people were -- I mean, our geologists, when we did that foundation, they have to go and grout that at the bottom so that water doesn't come. They said in that area it was so dense that they couldn't even grout it.

So this is an interesting area. This is Eurasian plate, and this side is Indian subcontinent. The Indian

subcontinent, as per the tectonics, it's going beneath the Eurasian plate and that's why Himalayas are still rising.
THE CHAIRMAN: But we don't need a visa to cross from one --
MR MALIK: No, no!
THE CHAIRMAN: So my last question was relating to the surge shaft, which I think was at slide 37. Could you just indicate: the idea here is not that there would be water that would go necessarily go all the way up and out the shaft?
MR MALIK: No, no.
THE CHAIRMAN: It's just a pressure release where there might be water possibly?
MR MALIK: It contains water to the level where the dam water level is. Because the liquid maintains its level. So it's not like there is a lot there. So even if the water level in the reservoir is 1,000, the water in this tunnel will be 1,000. It has got another snake going on top of it.
But that tunnel, our reservoir level, maximum level is 1,015 above sea level. This shaft has a tunnel on top of it. That has outlet at 1,040. So the water will be at 1,015 all the way in that tunnel. When the pressure comes, it's like that pump, and the water rises up in that one. And then if it is above 1,040, that

tunnel opens on the side of the mountain and the water goes out.
We have tested this phenomenon in 2019. It's part of the commissioning. We had four units running at full, and then we made a sudden shutdown of all four units. "Sudden" means within a minute. So it created a shock wave above. And we had people in the upper tunnel to monitor that. The water went maybe 20 metres higher than the normal and then it came down. So there was a surge going on. I was standing on the downstream of the outlet structure. Hardly a ripple came out. So it performed excellent.
THE CHAIRMAN: You were looking in the outlet to see the --
MR MALIK: No, I was standing at the -- there was a wall -- there's a bridge on the downstream of that. This picture you saw, I took that picture from that bridge downstream of the outlet structure.
THE CHAIRMAN: Okay.
Did you have a question?
DR BLACKMORE: Well, I was going to ask -- sorry, I do have one question. I'm just interested in how deep you had to drill your grout curtains. How far did you go down?
MR MALIK: In the dam site?
DR BLACKMORE: Yes, the dam site.
MR MALIK: I think they were 25 or 30 metres. 24 metres?

He's the geologist so he knows exact, but I knew that it's around 25 metres.
DR BLACKMORE: That must be pretty good rock --
MR MALIK: Yes.
DR BLACKMORE: -- because I put them down 120.
MR MALIK: No, we put it at 25. And then when we started raising the reservoir, for the first few months a lot of water came up from our drainage system in the drainage galley. But now hardly one third of that water is coming out, very little water comes out.
MR MINEAR: First of all, Mr Malik, Mr Hayat, thank you for your presentations, they were very, very helpful.
When we drove up this morning, we were looking at the Jhelum River, and it was both more turbid and a higher flow than I would have expected during this time of year. Am I right about that or is that typical?
MR MALIK: No, it's normal. Mr Tahir Hayat is working on Indus River, which he says is fed by snowmelt. Similarly with the Jhelum River, but the Jhelum River we call it an "early riser". You can see the snow from the dining room.
MR MINEAR: Yes.
MR MALIK: Similarly you've got mountains on this side which feed into the Jhelum River, like on the inside, Srinagar Valley and all that. This snow is at a lower altitude,

so it starts melting earlier.
So in hydrological terms, the flow in the Jhelum River starts rising from 15th March, that's our criteria. In case of Indus, it is 15th May. So there's a difference between them.
MR MINEAR: And can I ask you, do you know approximately what the flow of that river is in cubic metres per second right now?
MR MALIK: I have no --
MR MIANA: It's about 380 --
MR MALIK: No, that is in the Neelum River. But what's in the Jhelum also?
MR MIANA: Jhelum, I can get the data and [tell you] tomorrow.
MR MINEAR: That would be great.
MR MALIK: I've got another thing: if you see the river dark brown colour, that means most water is coming from Jhelum. If it's greyish, it's coming from Neelum. Both of them have different coloured waters.
THE CHAIRMAN: So this talk of the Jhelum River prompts another question: why did you not build the powerhouse at the first -- the Jhelum dip, if you will?
MR MALIK: The first feasibility done for this project had the powerhouse where we had the Jhelum dip: it was there. But at that time I think it was 560 -- 550 MW.

It was a 550 MW. This was in the feasibility studies. And then there was another weir there that will take it and bring it here, another 250 or something like that.

Later on there was another study, like Dr [Hayat] said, that you keep on refining your inventory. And they said that instead of having these two powerhouses, you make one and you can get 969 MW here; and you put another weir upstream of our Jhelum dip, and then you have the Kohala hydropower project that generates another 1,150 MW. So instead of having 1,000 MW, you are now getting 2,000-plus MW.

THE CHAIRMAN: More head, basically, yes.

MR MALIK: Yes.

THE CHAIRMAN: Okay. Well, thank you very much, Mr Malik, for your presentation. Thank you, Dr Hayat, for your presentation. They were very helpful and very informative. Thank you as well to Mr Miana for jumping in in the midst to answer a question. We very much appreciate all the work you put into these presentations.

I think that brings us to the end of today's session, so we will retire now, but with thanks to everyone who's present. We very much appreciate all the work you've put into this, and we're looking forward to the next few days as well. Thank you very much.

(The day concluded)

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