

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

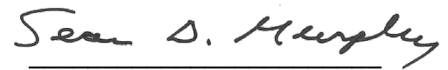
SECRETARIAT:

The Permanent Court of Arbitration

ON BEHALF OF THE COURT OF
ARBITRATION:

CERTIFIED PURSUANT
TO
PARAGRAPH 19 OF ANNEXURE G

27 April 2024



Professor Sean D. Murphy
Chairman

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

NJHEP Powerhouse Site
Pakistan-administered
Jammu and Kashmir Region

Day 5
Site Visit

Saturday, 27th April 2024

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 Trevor McGowan, Lisa Gulland,
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Presentation 8: Powerhouse Orientation1

 By Mr Miana1

 Court questions5

 Court questions8

 Court questions13

 Court questions18

 Court questions20

 Court questions23

Presentation 9: Dam -- Powerhouse Basics23

 By Dr Hayat23

 Court questions27

 Court questions34

 Court questions39

 By Mr Tariq41

 By Dr Hayat51

 Court questions56

Presentation 10: Power Production59

 By Mr Khan59

 Court questions74

 By Mr Malik84

 Court questions95

 Court questions97

Presentation 11: Powerhouse Inspection98

 By Mr Miana98

Final Remarks137

1 So we can see here the installation and
 2 construction/fabrication of the powerhouse, the
 3 generator rotors.
 4 Generator basically consists of two parts. One is
 5 a stationary part and one is the rotating parts. The
 6 stationary part is called the "stator", while the rotating
 7 part is called the "rotor", as per its name.
 8 The construction starts from the rotor hub. Then
 9 steel plates are installed over here, and at the outset
 10 of those steel plates we install the poles. The poles
 11 are then excited with the DC current. And with that
 12 excitation we can generate the electricity, and that
 13 electricity is collected at the stator, which is
 14 transported to the switchyard and to the national grid.
 15 So this is the phenomenon of the powerhouse, this
 16 one. So the cavern width is about 25 metres. And
 17 starting from top of generator hall up to the lowest
 18 part we have 54 metres height over there. So today
 19 we'll have chance to go all these floors when we'll have
 20 the powerhouse visit over there.
 21 THE CHAIRMAN: Mr Miana, can I just ask: I realise this is
 22 a photograph of the construction. Am I recalling
 23 correctly that there's ultimately four of these
 24 generators, and we're looking at basically two of them
 25 here, one of which is more constructed than the other?

Page 5

1 we'll see further unit 4 over there; and then 3, 2 and
 2 then 1.
 3 The capacity for each generating unit is 242 MW.
 4 It's 242.25 MW, more precisely. And it takes 70 cumecs
 5 of water to generate that electricity, because the head
 6 is quite high, about 420 metres, so the less water is
 7 required for generation of 242.25 MW by each unit. So
 8 adding all four units, we can get 969 MW of electricity,
 9 if the water is available for the generation, sir.
 10 Can we move to slide 8, please. Sir, this is the
 11 complex diagram of the tunnelling system, because all
 12 our facilities are underground except the switchyard and
 13 the control building for that one. So I will briefly
 14 explain about this thing, sir.
 15 So this is the headrace tunnel coming from the dam
 16 site, showing in green. And this is the surge shaft
 17 that we have seen, that we were comparing with the
 18 Eiffel Tower, 353 [metres]. So this is the surge shaft
 19 over there.
 20 And then we have four penstocks over here. And with
 21 that penstock, all the four units are connected, 1, 2, 3
 22 and 4, with each one.
 23 And this is the generator hall that I was just
 24 showing in the previous slide about this one. So
 25 everything is encompassed underground in the powerhouse.

Page 7

1 MR MIANA: Yes, this is the sequence, because we have to
 2 construct the power units one by one. And the
 3 construction is done outside their unit place. You can
 4 see 1, 2, 3 and 4, but the construction is outside of
 5 that unit. So we have to construct it. And this is the
 6 heaviest part that we have to install inside.
 7 To lift this one, sir, we have two cranes over
 8 there. The capacity of two cranes, about 550 tonnes.
 9 Whereas the maximum capacity of one rotor is about 450
 10 or 460 tonnes. So we will have to go with the tandem
 11 operation of the two cranes. The two cranes are coupled
 12 together, and they are operated by one operator. So he
 13 has to lift the rotor with both cranes simultaneously
 14 and put it in the specified place in the generator.
 15 So the construction of the rotor is outside their
 16 unit place, it's not inside.
 17 Can we move to slide 7. Sir, this is the view. As
 18 you mentioned the four units over there, sir, this is
 19 units 1, 2, 3 and 4. This is a finished product of the
 20 powerhouse when all the units and their auxiliary were
 21 installed over there. And after their installation, we
 22 can now recognise all these four units very well over
 23 there.
 24 The numbering starts from this side, and it comes up
 25 to the distance. So when we'll go around this side,

Page 6

1 To access the powerhouse, we have this tunnel 5 --
 2 we call it adit A5. So we'll also go from this tunnel
 3 over there, and then we'll reach the powerhouse. With
 4 this tunnel we have also access to the headrace tunnel
 5 where we have one plug over there for the one headrace,
 6 and we have some drainage gallery and the monitoring
 7 instrument over here. So we can have access from this
 8 one tunnel to the powerhouse, the monitoring gallery, as
 9 well as to the upstream of the penstock over there.
 10 We can also access the powerhouse from this purple
 11 line, which we call adit A6. We call it the cable
 12 gallery as well, or cable tunnel as well. We can go
 13 over to the powerhouse directly to this one. Or if we
 14 want, we can go to the transformer.
 15 From the transformer, sir, we have the power
 16 evacuation through the XLP cable. So instead of
 17 conductor, we have the XLP cable coming from the
 18 powerhouse, and that are connected to the switchyard
 19 that is outside the tunnel.
 20 And these four --
 21 THE CHAIRMAN: So Mr Miana -- no, no, it's fine. So these
 22 tunnels that you just pointed to, these are actually
 23 tunnels that physically humans would go into to access
 24 these areas?
 25 MR MIANA: Yes, these are for the physical humans as well as

Page 8

1 transportation and the vehicles. We'll see -- we'll go
 2 in these tunnels today.
 3 THE CHAIRMAN: Oh.
 4 MR MIANA: We can also go in this tunnel as well!
 5 THE CHAIRMAN: Okay!
 6 MR MIANA: So these are the four outlets. These are draft
 7 tubes. After the draft tube -- the water comes out the
 8 draft tube. And then 1, 2, 3 and 4, they are combined
 9 over here. And then from this point we have the
 10 tailrace tunnel starts over here.
 11 The issue of tailrace tunnel was explained by
 12 Mr Nayyar yesterday briefly about the collapse. That
 13 happened somewhere over here. So I will be describing
 14 something more about it with the photographs in this
 15 presentation.
 16 We will also, sir, access this downstream surge
 17 tunnel because it was quite a big one to cover in
 18 photograph so we had to cut it overhead for the
 19 presentation. So we can go around this one and then
 20 come to this point.
 21 Usually during the inspection of the TRT, we have
 22 two exits. One is exit near the outlet that we have
 23 seen over there. And the second, going from this purple
 24 line that goes here, combines over here, and then we can
 25 walk through and come back to this one. So these are

Page 9

1 quite big tunnels, but this is small tunnel, so a small
 2 vehicle can go inside, instead of a big one.
 3 So this is all about the complex system. And
 4 this -- we have the transformer cabin, and all this
 5 is -- everything is underground. So today we'll have
 6 the chance to see all these components physically.
 7 Please move to slide 9. Sir, this is again the
 8 slide showing the four units over there. This is
 9 looking from top down. It is photo of a wall and not
 10 the floor.
 11 So we have the downstream wall over here. Four
 12 units, 4, 3, 2 and 1, over here. Just to show you that
 13 we have a scroll case, a spiral case, along with all
 14 the -- in all the units. That is before entering the
 15 water into the turbine system.
 16 You can recognise that shape is not a constant
 17 shape, it's a spiral shape like this one. Because the
 18 number of blades are more, but the energy required at
 19 each entrance of the blade should be the same. If it's
 20 not the same then it may cause vibration. So keeping
 21 energy the same at all the inlet points, we just can
 22 work the pressure into kinetic energy by reducing the
 23 dial of spiral casing.
 24 So the water entering the larger dial from this one,
 25 and then it has a reducing dial over there, and it ends

Page 10

1 very small over there. Since all these are underwater,
 2 we cannot see this one at the moment. But this is the
 3 phenomenon of having the same energy at the inlet of
 4 each turbine.
 5 To this, we are connected with MIV. I will explain
 6 more about MIV in my next slide. So this is all about
 7 the spiral case and the installation process of the
 8 turbine and the associated parts during the
 9 construction.
 10 One more important thing, sir: you can recognise the
 11 water is coming in this direction, really in this one.
 12 But when it passes through the turbine, it is along the
 13 axis of the shaft over there. The water is also
 14 changing its rotation during the power generation.
 15 Slide 10, please. Sirs, this is the cross-section
 16 of turbine engine rotor. So let's start from this side.
 17 So this we call the upstream side of the main inlet
 18 valve; it is over here. And this is connected with the
 19 penstock, and the penstock is connected with the
 20 headrace tunnel. So this is the scheme over there.
 21 The main inlet valve is provided just to shut down
 22 the unit or isolate the unit in case we need maintenance
 23 inside the particular unit.
 24 The operation of the MIV, the main inlet valve, is
 25 such that it is operated with counterweights. So

Page 11

1 advantage of counterweight is that in case of failure of
 2 electricity, and in emergency, the counterweight can
 3 automatically close the main inlet valve to avoid any
 4 damages to the turbine parts.
 5 After that main inlet valve, the spiral case or the
 6 scroll case starts. You can recognise the small dial
 7 and then the big dial there. This is just before the
 8 entrance of the water to the "stay rings", we call it,
 9 it's named the "stay rings", that guide the water
 10 directly to the blades of the turbine or the runner.
 11 And after giving the rotation to the turbine, the
 12 water releases from here to the draft tube, and from the
 13 draft tube it goes to the tailrace tunnel. And
 14 I already described very in detail in my previous
 15 diagram.
 16 With this -- there are many different other parts
 17 I will explain one by one. With this runner we have
 18 a shaft over there, and that shaft is connected with the
 19 generator.
 20 So this is the generator. In purple, it is shown
 21 the rotor of this one. Whereas this one is -- this is
 22 the stator of this one. So when the turbine rotates,
 23 the runner rotates, it also rotates the rotor of the
 24 generator. And with this rotation, the electricity is
 25 produced and collected at the stator.

Page 12

1 To excite and to give the continuous supply for the
 2 generation of electricity, we have the excitation system
 3 at the top of that rotor -- generator.
 4 So altogether they function in a very systematic
 5 way, and with all protective instruments over there,
 6 because change of any one parameter can impact on the
 7 other parameter as well. So all these are covered with
 8 the protection system, instrumentation system and
 9 electrical and mechanical protection system over there.
 10 There are a number of protection systems, starting
 11 from the mechanical to the electrical and electrical to
 12 the protection system. A number of protections are
 13 available just to avoid any damage to the plant. And
 14 from this one, the tailrace, we have then going outside
 15 this one. The grey structure is all the steelwork
 16 structure where all these have been embedded in.
 17 And this one, we can recognise these are some
 18 bearing supports over there, turbine guide bearing, the
 19 generator guide bearing, the thrust bearing. So many
 20 kinds of the equipment, very small and tiny equipment.
 21 These are small, but they are very important with
 22 respect to the smooth operation of the plant.
 23 Slide 11.
 24 THE CHAIRMAN: Mr Miana, before you leave this slide, can
 25 I ask: you have not yet had to replace any of the

Page 13

1 turbines or generators; is that correct?
 2 MR MIANA: No, not yet, sir.
 3 THE CHAIRMAN: And if you did have to replace, let's say,
 4 the turbine because of a problem from sediment or
 5 anything else, do you have to remove the generator
 6 before you can get to the turbine, or is there
 7 a different way of ...
 8 MR MIANA: It's a different way. We have, sir, opening over
 9 here at the bottom. So we have to take it out, lower
 10 down the runner from here and take the runner outside,
 11 put the new runner on the rails and put it inside,
 12 hanging up with the shaft, and put back the start of --
 13 we call this the drafted cone -- so put back the cone
 14 inside over there. So in this way we can convert months
 15 into weeks for the replacement of a runner.
 16 THE CHAIRMAN: And I assume you regularly inspect the
 17 turbines to see their condition. How do they look now
 18 that it's six years after your start?
 19 MR MIANA: Since all was submerged in the water, we inspect
 20 annually, because approaching the turbine is a lengthy
 21 process, because first we have to put -- close the inlet
 22 valve, put the bonneted gate at the outlet over there,
 23 then dewater the system, open the very big holes
 24 (inspection window) -- so we'll see the holes open
 25 there -- and then go inside.

Page 14

1 So we do all this activity during the annual
 2 maintenance of each unit. So far we feel that the
 3 turbines are not in a very good -- in a good condition
 4 over there. So they can be operated next few years over
 5 there.
 6 THE CHAIRMAN: And so based on their current condition, you
 7 think that you would not need to replace them for
 8 another five years, maybe even ten years? Or: no,
 9 there's a pretty clear point at which you may need to
 10 replace them?
 11 MR MIANA: Not five/ten -- we cannot specify the number of
 12 years. But maybe next few years, maybe two/three years
 13 or four years we can operate easily. But that also
 14 depends on the sediment load coming to the turbine side.
 15 So if more sediments are coming, they will have this
 16 one.
 17 And we also -- another thing, thank you very much,
 18 that I can mention over here: the turbine and the
 19 runners. They are already coated with a high-velocity
 20 oxygen fuel, so we have a protective film on the
 21 runners, so that protects the parent material of the
 22 runner.
 23 THE CHAIRMAN: Thank you.
 24 MR MIANA: Slide 11, please. So I briefly said about the
 25 tailrace collapse and that repair we did. Mr Nayyar

Page 15

1 already explained very briefly about this one yesterday.
 2 So I will go and show you more photographs, and what we
 3 did with this collapse, and how we get out of this
 4 collapse, in how much time.
 5 Next, slide, number 12, please. Sir, this is
 6 a photograph showing the collapse area. We had
 7 a collapse just 250 metres below the powerhouse, and
 8 that was chainage 0+251 over there. And that collapsed
 9 lasted up to 0+293 over there. These are photographs of
 10 August 2022, sir.
 11 One thing we can recognise over here: that we can
 12 see that these are small pebbles or small stones over
 13 here; whereas at the outlet side we have big boulders
 14 like this. So this indicates the complex geology inside
 15 the TRT that was explained by Mr Fiaz during his
 16 presentation, that all along the part of the HRT and the
 17 TRT we have very complex geology changing from the
 18 sandstone, siltstone and mudstone over there. So this
 19 is an indication of that as well.
 20 So we have a collapse of 42 metres, but that was
 21 full collapse since it closed the tunnel, so we are
 22 forced to shut down our plant, and to repair this one
 23 and to handle this situation.
 24 I will explain on next slide, 13. Sir, since when
 25 there is a collapse inside the tunnel, the most

Page 16

1 important thing: how to take that rubble from the
 2 collapse area. Because it is not just to excavate that
 3 and go inside as we do not know about the cavity above
 4 that collapse, we do not know about the geology, what is
 5 going on there, and we do not know how big is that
 6 cavity.
 7 The most important as per the advice of the
 8 consultant: we have to use the forepoling method.
 9 Forepoling is a common method used in the collapse
 10 system for the recovery of that part. This is the start
 11 from the downstream side, sir, as you look 0+293. So we
 12 have to move up, sir, to the powerhouse side.
 13 First protection was provision of the lattice girder
 14 over there. And this protection was just to hold the
 15 ceiling of the area before the collapse. With this, we
 16 have to put forepoles over there, all along this
 17 periphery. And after putting that, perforated metallic
 18 pipes were there and then they were grouted with
 19 high-pressure grout. That created some kind of false
 20 ceiling above that one.
 21 The length of each forepole was 7-8 metres. So
 22 8 metre area of the false ceiling was, you can say,
 23 temporary ceiling was provided over there. Once that
 24 was provided, then it was easy to excavate this 1 metre
 25 by 1 metre. So we have to excavate this one say

Page 17

1 3-4 metres, and then we have to again overlap the
 2 previous forepole with the new forepole.
 3 So in this way, sir, we succeeded to safely cross
 4 and have the breakthrough for this collapsed area.
 5 And the most important thing is that during that
 6 collapse there was no accident over there, and with very
 7 much safety. All the precautions related to the
 8 excavation were taken to prevent any kind of accident.
 9 Slide 13. Having the time for this one, we also
 10 inspected the remaining tunnel instead of the 42 metres,
 11 and wherever we find some weak points, so we addressed
 12 them with the different methods.
 13 One of the methods was that we also used the RRS.
 14 RRS is the reinforcement rebars support. There are two
 15 kinds. We have already seen on a previous slide the
 16 lattice girder over there, and in this we can see steel
 17 bars over there, a juncture of six steel bars over
 18 there, which were put in the tunnel with rock bores over
 19 there. And after putting the rock bores, it was
 20 shotcreted just to give the support.
 21 So these are different kinds of methods applied as
 22 per the requirement of the damages and the weaknesses.
 23 So this was the area about 1+585 metres to 1+700 metres.
 24 THE CHAIRMAN: Mr Miana, looking at this picture, I think
 25 I'm now maybe realising something I didn't understand.

Page 18

1 So the water is flowing through the pipe, not through
 2 the tunnel as a whole, is that correct?
 3 MR MIANA: No, in fact this is an air duct.
 4 THE CHAIRMAN: It's an air duct.
 5 MR MIANA: This is repair method.
 6 THE CHAIRMAN: So that's just for the repair process?
 7 MR MIANA: Yes.
 8 THE CHAIRMAN: Once you've finished, you take that air duct
 9 out and the water flows through the entire tunnel; is
 10 that correct?
 11 MR MIANA: The entire tunnel, sir.
 12 THE CHAIRMAN: Okay.
 13 MR MIANA: So we'll see that photograph next, that we have
 14 done with the 42 metre collapse area. So that will give
 15 the clear picture of the tunnel over there. In the next
 16 slide we are going there.
 17 So for the 42-metre collapse area, reinforcement was
 18 provided over there, two layers of reinforcement
 19 provided over there for getting more strength in that
 20 area. And then the concrete was put in in that area.
 21 So next slide will be slide 16. So this is the
 22 finished product of that 42-metre collapse area. That
 23 is starting from 0+251, and going up to 0+293 metres.
 24 However, we extended -- we started from 0+248, 3 metres
 25 ahead of that one, and we went up to 0+308. So

Page 19

1 60 metres of that portion was properly strengthened with
 2 the method I have just shown in the previous slide: the
 3 reinforcement bar, then the concreting properly.
 4 Proper drainage system has been provided just to
 5 provide drains for release of water; and after the
 6 concrete, even, we also put the concrete grouting, to
 7 give further strength in case of any -- in future if
 8 something happens. So this concrete is sufficiently
 9 supported and strengthened to avoid any kind of -- such
 10 like of incident in this portion of the tunnel.
 11 Can we move to slide 17.
 12 THE CHAIRMAN: Just one question before you do the safety
 13 briefing. At the moment when the collapse occurred, did
 14 it block water completely from going through the tunnel,
 15 or was there still water able to go through the tunnel,
 16 it's just you knew there was a collapse?
 17 MR MIANA: It's a very good question, sir. It was
 18 completely blocked because I have already shown on
 19 slide 12, so you can see that this was completely
 20 blocked. This is the crown of the tunnel, and this is
 21 the lower part of the tunnel; "invert", we call it. And
 22 so tunnel was completely blocked. And we recognised
 23 that whenever we were operating the plant for one or
 24 two days or just to observe this thing, as soon as the
 25 water flows, the pressure inside, beside this one,

Page 20

1 started rising over there. So that was indication that
 2 either water was not or less flowing in this one.
 3 So there was no other way, just to tackle this one
 4 and take this rubble outside and give the clearance to
 5 the whole of the tunnel for a smooth operation. And
 6 since last August, TRT is in operation, and we are
 7 operating safely, sir, without any problem.
 8 THE CHAIRMAN: And at the moment of the collapse, was there
 9 any harm to the turbines or the generator from the
 10 sudden stoppage of the water, or was the system able to
 11 handle the sudden blockage?
 12 MR MIANA: As soon as we recognised the increase in
 13 pressure, we already started slowing down the output, so
 14 that avoided any kind of damage to plant -- so there was
 15 no incident or accident or damage to mechanical parts.
 16 It was only the tunnel that we have to repair.
 17 THE CHAIRMAN: Thank you.
 18 MR MIANA: (Slide 17) Sir, about the safety briefing, this
 19 is similar to that one we had, except with a few
 20 additions because the power plant is in operation, and
 21 all the electrical panels are energised. The control
 22 panels are also energised, so we have to take a little
 23 bit of extra care when we are walking through the
 24 powerhouse site.
 25 So slide 18. We all are using rubber soles so it is

Page 21

1 THE CHAIRMAN: Oh, sorry, please.
 2 PROFESSOR BUYTAERT: Two days ago we discussed the wicket
 3 gates, or the "coaster gates", I think my colleague
 4 calls them. Would you be able to indicate where they
 5 sit in the configuration?
 6 MR MIANA: Okay. So wicket gates are configured over here,
 7 just upstream of the runner. This is a runner in the
 8 red, and yellow is the wicket gate over there.
 9 PROFESSOR BUYTAERT: Great. Thank you.
 10 THE CHAIRMAN: Okay, I think now we are done. So if
 11 I understand correctly, maybe we take a tea break now,
 12 and then we'll come back for the next presentation.
 13 MR MIANA: Thank you very much.
 14 (Pause)
 15 THE CHAIRMAN: I think we are now ready to hear from
 16 Dr Hayat on presentation no. 9. Please proceed whenever
 17 you are ready.
 18 Presentation 9: Dam -- Powerhouse Basics
 19 DR HAYAT: Thank you, sir. Mr Chairman and members of the
 20 Court of Arbitration, it's a pleasure to address you
 21 again, sir. Alongside me is my fellow presenter -- the
 22 presentation will be shared by Mr Muhammad Tariq -- can
 23 you raise your hand, please; thank you -- who is the
 24 chief engineer at Tarbela 4th Extension.
 25 Already you have been given a general orientation of

Page 23

1 very excellent that we are using that one. In the dry
 2 air powerhouse we'll also be wearing helmets, hi-vis
 3 vest, and we'll also have the hand gloves if we want to
 4 touch any equipment which is dirty and we want to have
 5 some discussion on that one. We'll also be using the
 6 safety goggles inside, if someone would like, because
 7 it's better to, when you go inside, we should have the
 8 safety goggles over there.
 9 And rest, we should avoid the electrical equipment,
 10 which is energised. We'll go in group, and will not be
 11 scattering everywhere over there, so that we have
 12 sufficient distance from the energised panel. And
 13 I think -- I believe we are going first to the machine
 14 hall, the generator hall, and then going all around the
 15 powerhouse, and ensuring this will be a very safe visit
 16 over there.
 17 Next slide (19). So, sir, this is all about from my
 18 side. I will conclude my presentation for this one, and
 19 thank you very much for your kind attention and the
 20 questions. I hope we'll have a successful visit of the
 21 powerhouse in the afternoon. So if you have, sir, any
 22 questions, I'm available to answer.
 23 THE CHAIRMAN: Any questions? We have no further questions,
 24 Mr Miana, so thank you very much.
 25 MR MIANA: Professor Wouter has one?

Page 22

1 the powerhouse with Mr Miana, Arfan Miana. So this
 2 presentation is an overview of the powerhouse design,
 3 construction and operation, turbine design, with some
 4 brief comments on generation and transmission, which
 5 will be further developed in the next presentation.
 6 First, I will cover the role of tunnels in the
 7 powerhouse, and features of construction. Second,
 8 Mr Tariq will focus on turbines, their operation and
 9 different types, and how to ensure their longevity. And
 10 third, I will come back again to explain the role of
 11 different elements needed for power generation and
 12 transmission.
 13 Slide number 2, please. I start with
 14 a cross-section of the powerhouse, which was excavated
 15 underground. You are already familiar with this. This
 16 is a cutaway view that gives you the configuration of
 17 the main equipment and major equipment within the
 18 cross-section of the underground excavation. Notice
 19 also the human that has been placed there just to give
 20 you an idea of the scale.
 21 You will notice that there is considerable height
 22 above the main generator floor. So I would also like to
 23 point out towards the rails that have been placed, and
 24 this is for the cranes that are installed here to lift
 25 heavy equipment. And already Mr Miana has also shown

Page 24

1 you some pictures of that.
 2 So notice that generally -- generally -- it is
 3 necessary to remove the generator and then the shaft,
 4 and then you can go to the Francis turbine. And that is
 5 the general situation.
 6 However, in the case of Neelum-Jhelum, as I think
 7 previously mentioned also in one of the presentations,
 8 arrangements have been made to remove part of the spiral
 9 casing, and have possibility of removing the Francis
 10 turbine from the bottom, which saves a lot of time and
 11 hassle basically.
 12 While I'm talking about taking out the turbine,
 13 which is necessary after a few years for maintenance
 14 purposes, because of the abrasion that you have, I will
 15 make a small clarification in matter of the
 16 abrasion-resistant runner coating.
 17 On slide 33 of presentation no. 6, we showed you
 18 a photo of a turbine runner from Neelum-Jhelum with
 19 coated and uncoated portions, showing abrasion on the
 20 uncoated portion. The coating on the runner is only
 21 applied on the leading edge of the turbine blade, which
 22 showed no abrasion after four years of use.
 23 This photograph -- or that photograph, actually --
 24 therefore not only demonstrates the effectiveness of the
 25 coating, but also the effectiveness of the desander at

Page 25

1 the Neelum-Jhelum Project.
 2 Beyond that, let me walk through the major features
 3 of the facility. So as previously shown also, this is
 4 the generator hall. It is 25 metres in width, 53 metres
 5 in height, and 137 metres long, along the axes of the
 6 paper, perpendicular to the paper.
 7 Within the generator hall you can see the control
 8 room also. However, the real complexity is below this
 9 floor level. You only see this part when you walk into
 10 the generator hall, but actually the complexity is below
 11 this. So this extends exactly four floor actually
 12 below: 1, 2, 3, 4.
 13 So starting from the generator which is shown in
 14 greenish colour here, we have the shaft, and below this
 15 is the turbine. So the shaft connects the turbine to
 16 the generator. So if you strip the machinery from all
 17 of this, just to give you an idea of the scale of this,
 18 from the bottom to the top you can fit in a 12-storey
 19 apartment building in this space. And this is all
 20 underground. So that gives you an idea of the
 21 complexity of the underground construction and its
 22 actual size.
 23 So on the right you can see a blue arrow, and this
 24 is from where the water comes in, and this connects to
 25 the penstock, which is not shown here. And this of

Page 26

1 course drives the turbines. And after that the water
 2 exits through the draft tube into the tailrace tunnel.
 3 Slide number 3, please.
 4 THE CHAIRMAN: If I can just ask one question. The entire
 5 structure is underground.
 6 DR HAYAT: Sir.
 7 THE CHAIRMAN: Is that because the angle with which the
 8 water is coming into the facility requires it to be
 9 underground, or are there benefits in having the
 10 structure underground separate from that?
 11 DR HAYAT: Very good question, sir. I think both ways, sir.
 12 You maximise the head as you are underground. In fact,
 13 sometimes when you calculate, even a centimetre of
 14 height difference will make, over a period of the
 15 lifetime of the project, a lot of difference in the
 16 energy that is generated. That is number 1.
 17 Number 2: in terms of -- because the Himalayan
 18 region is also quite seismic-prone area. Having
 19 a structure inside actually is less prone to any damage
 20 or acceleration. So the acceleration or the forces that
 21 are generated on underground structures are much, much
 22 less than if they were to be overground.
 23 So these are one of the two main reasons that we
 24 have this thing.
 25 Next slide (3), please. Now I will explain on

Page 27

1 tunnelling construction and tunnelling in the context of
 2 the powerhouse.
 3 So can we go to slide number 4, please. Tunnelling
 4 is one of the most challenging parts of the hydropower
 5 construction in the Himalayas. We need tunnels because
 6 we have to convey water from the dam through the
 7 headrace, so that's the tunnel. Plus there are plenty
 8 of other tunnels, as you must have seen in many of the
 9 sketches and photos that have been shown.
 10 This is because (a) the geology is complex, so you
 11 have different types of rocks coming in. You have minor
 12 and major faults, which means these rocks are crushed.
 13 So they are not at the best of their strength. There
 14 are high rock stresses. Sometimes the rock cover is
 15 quite high. So then you have these squeezing ground
 16 conditions and you've got rock burst. These are
 17 technical terms, basically. Which means that at a given
 18 height, you will have rock actually bursting into your
 19 tunnel. And presence of water, which is always present
 20 there, almost.
 21 So all these things combined, they make tunnelling
 22 really challenging in these environments. And I'll
 23 explain a little bit.
 24 Many plants, you know, they use pressurised tunnels,
 25 headrace tunnels, to convey water over many kilometres.

Page 28

1 So the headrace -- and again, this pressure itself has
 2 to be managed, because it will go into the rock. And it
 3 may cause problems, especially (a) when you are
 4 energising and (b) sometimes then you have to empty the
 5 tunnels, and it has to be done gradually because
 6 otherwise all the pressure that has gone into the rock,
 7 when it starts coming back and you do it quickly, it can
 8 damage your tunnel.

9 So the other tunnelling works will include, of
 10 course, the surge tunnel and the tailrace tunnels, plus
 11 the excavation adits, the conveyance adits. Adits are
 12 basically tunnels but smaller diameter. When I say
 13 "smaller diameter", it doesn't mean like very small, but
 14 they are still like 4 or 5 metres. So we call them
 15 "adits" and the others are basically tunnels. So they
 16 are not small per se, but we call them "adits". Because
 17 we look at very large tunnels; the smaller ones, we say
 18 "adits".

19 So there are basically two methods that you can use
 20 to excavate the tunnels. And factors that will control
 21 are, again, the geology, the tectonic setup, the
 22 strength of rock, hydrogeological conditions, water, as
 23 I said, and geometry of the tunnel. Tunnel geometry
 24 could be totally circular, it could be a horseshoe, it
 25 could be a D-shape. So there are various types of

Page 29

1 so you spray it on the face.
 2 And you have seen -- you see even it here. So this
 3 is shotcrete, basically. So it is quick-setting, it
 4 just sort of sticks onto the surface, and it gives it
 5 that initial strength.

6 So normally in a day you do only one blast and muck
 7 at one phase. Therefore, if you have a long tunnel,
 8 progress is very slow. So how to overcome that problem:
 9 you have multiple faces that you attack. So you go from
 10 one side, you go from the other side, so now you have
 11 two faces. So now your progress from 3 plus 3, or you
 12 get to about 6-7 metres.

13 Then you also sometimes put in an adit in between.
 14 So now you have one, two, three, four faces that you can
 15 attack on. So then your daily progress goes to about
 16 15 metres a day.

17 So these are some of the techniques that you use
 18 when you are going for drill and blast.

19 And often we use specialised machinery which is
 20 called the tunnel boring machine, TBMs. And TBMs also
 21 come in various forms: there are open gripper, there are
 22 shield tunnels, there are earth pressure balance
 23 machines. And all these depend on the type of geology
 24 and stratigraphy that you have.

25 Here is a photograph of the cutter head of the

Page 31

1 sections that you can choose from for a tunnel,
 2 depending on your use and the geology.

3 So conventionally, tunnels are drilled by what we
 4 call a "drill and blast" method. So you have a -- let's
 5 say you have a full face of the tunnel, and in
 6 concentric circles you drill holes and you charge them
 7 with dynamite. Tonnes of dynamite -- hundreds and
 8 sometimes thousands of tonnes of dynamite is used in
 9 a typical construction.

10 So these concentric circles of holes are made and
 11 filled with explosive. So with certain delays. Delays
 12 are in milliseconds. So what you do is: the first --
 13 the innermost circle is blasted first. So that creates
 14 a space. And then the outer circle and then the
 15 outermost circle is blasted. So it all falls in, and
 16 then what we call is the mucking operation. So that is
 17 loaded into a truck or on a conveyor belt, and it is
 18 taken out of the tunnel.

19 Normally, because you have to drill and then you
 20 have to charge, so the length of the drilling is
 21 normally kept at about 3-3.5 metres. So this -- each
 22 cycle: drilling, charging, blasting, clearing out. And
 23 after that of course you have to put in the first
 24 support, which is normally shotcrete. So it's with
 25 a high-pressure nozzle. It's concrete that is flowable,

Page 30

1 tunnelling breaking through, basically. So this is
 2 basically a TBM in Albania. So here we also use two
 3 TBMs in Neelum-Jhelum Project. So it's a giant cutter
 4 head at the front. And the energy requirement to run
 5 these TBMs is in megawatts. And you need a specialised
 6 plant actually to feed these TBMs.

7 And so these cutter heads, they move in a rotating
 8 fashion, and they cut the rock, and while it has been
 9 thrust forward by pistons. That's the basic sort of
 10 mechanism with these TBMs work. And they normally take
 11 about 15 -- you can do 15 metres a day, on average.
 12 Some of the good TBMs have done 20, 30 metres even, in
 13 a day. So compared to one face, 3.5 metres with drill
 14 and blast, and you have to have multiple faces, here
 15 with one TBM you can do 15 metres, on average.

16 So as previously mentioned also, the tunnel network
 17 at this project is 68 kilometres through very difficult
 18 geology. Both drill and blast and tunnel boring
 19 machines were used in different parts.

20 Slide number 5, please. So I think Mr Arfan Miana
 21 has already explained the various tunnels that we have,
 22 and you have already seen this sketch a few times. But
 23 just as a recap, this is the main transformer hall --
 24 main generator hall, the transformer hall. These are
 25 the access tunnels/adits. This is the headrace tunnel.

Page 32

1 The headrace, manifold, penstocks. And because the
 2 pressure is high, these are steel-lined.
 3 There's a drainage gallery in here. And through
 4 this drainage gallery, we drill holes in all directions
 5 so that, if there is any water -- because the pressure
 6 is very high, some water will find its way through the
 7 rock joints towards the powerhouse. And we don't want
 8 any water coming because we have sensitive instruments
 9 and things and we don't want any water.
 10 So in addition to a lot of grouting and sealing
 11 those joints, we have this drainage gallery with all the
 12 drain holes, so any water that comes in, it is taken
 13 into this gallery and taken out, so it doesn't go
 14 towards the powerhouse.
 15 Then also, as Mr Arfan Miana and many others said,
 16 the size related to the Eiffel Tower and, you know, the
 17 surge shaft, you have seen that. So there is a lot of
 18 tunnels in this area. So we will look more closely at
 19 some of these features later on. So just a recap.
 20 Slide number 6, please. This is the headrace which
 21 conveys the water from the dam towards the powerhouse.
 22 In Neelum-Jhelum Project, this is about 28.6 kilometres,
 23 and it is made of single and twin circular and
 24 horseshoe-shaped tunnels. The tailrace tunnel removes
 25 water from the turbines back to the river. It's

Page 33

1 steel-lined. This is the lining in the tunnels.
 2 DR BLACKMORE: How much under Jhelum?
 3 MR MALIK: 732 metres, twin tunnels.
 4 DR HAYAT: Can you go slowly? Can you come in front here,
 5 please, and do this thing, so that everybody can see you
 6 and hear you better. (Pause) Slowly, one by one.
 7 MR MALIK: Okay. Single tunnel, 8 kilometres -- more than
 8 8 kilometres is concrete-lined. Twin tunnels, around
 9 9 kilometres is concrete-lined. And twin tunnel,
 10 732 metres under Jhelum crossing, steel-lined. And twin
 11 tunnel, 10 kilometres average is shotcrete-lined, which
 12 was excavated -- it's circular and excavated with a TBM.
 13 DR BLACKMORE: And the 10 kilometres is closest to the dam?
 14 MR MALIK: Yes, it starts 4.5 kilometres downstream of the
 15 dam.
 16 DR BLACKMORE: So the first 4.5 kilometres are unlined?
 17 MR MALIK: It's concrete-lined. First 4.5 is
 18 concrete-lined.
 19 DR BLACKMORE: Okay.
 20 MR MALIK: Which was excavated with a drill and blast.
 21 DR BLACKMORE: Yes.
 22 MR MALIK: And then we have the TBM tunnels.
 23 DR BLACKMORE: Yes.
 24 MR MALIK: They are then 10 kilometres which is
 25 shotcrete-lined.

Page 35

1 3.5 kilometres.
 2 So the project also consists of ten access adits.
 3 You know this, like adit this and adit that. This is
 4 the entrance and this is the cable adit. And total
 5 length is about 11 kilometres for all these adits.
 6 So between the headrace tunnel and the turbines, as
 7 I pointed out, we have the penstocks.
 8 THE CHAIRMAN: Just a question, I think, from Mr Blackmore.
 9 DR HAYAT: Sir.
 10 DR BLACKMORE: Just on the headrace, yesterday I understood
 11 that the headrace has three different sorts of tunnel
 12 lining: it has shotcrete, concrete, and down underneath
 13 the river I think it was steel-lined. Could you just
 14 give me an idea of what length each of those linings
 15 was, please?
 16 DR HAYAT: I will refer that question to Mr Ayub Malik, who
 17 will have a better answer on exact numbers. Can you
 18 answer that question, please, for me? I want to be
 19 precise.
 20 MR MALIK: The twin tunnels are 19 kilometres in length.
 21 Out of that, 10 kilometres is shotcrete-lined; it was
 22 excavated by the TBMs. Remaining is: 9 kilometres of
 23 the twin tunnel is concrete-lined, 8 kilometres of
 24 single tunnel is concrete-lined. And then we have got
 25 around 732 metres under Jhelum crossing which is

Page 34

1 DR BLACKMORE: Okay. Has the headrace tunnel been
 2 inspected?
 3 DR HAYAT: Not -- I mean, after being energised and after
 4 being full of water?
 5 DR BLACKMORE: Yes.
 6 MR MALIK: No, sir, but I think the plans are there now.
 7 Because you know better than I believe anybody else in
 8 the room that you have to do it slowly, and then that
 9 means losing generation for that amount of time, sir.
 10 Now they are planning that there are specialised
 11 firms with an ROV that go into the tunnels, and you can
 12 have inspection while the tunnel is running with water:
 13 you can put that submersible into the tunnel. So they
 14 are planning, and I think hopefully in the next few
 15 months they will have an inspection with that method.
 16 DR BLACKMORE: That was my next question, whether you are
 17 using some form of remote sensing, so well done.
 18 I think it's important, that's all.
 19 DR HAYAT: Thank you, sir.
 20 Slide number 7, please. So these are some of the
 21 photos of the tunnel excavation. I think you have seen
 22 this one before also. This is the start of the headrace
 23 tunnel. This is during construction. This is the
 24 collecting canal while it was being constructed. You
 25 can also see some formwork and reinforcement for the

Page 36

1 desander area that we were at. So this is during
 2 construction.
 3 Of course a lot of this hill had to be cut through,
 4 and this was basically conglomerate, this was not rock.
 5 And that is why you also saw that roller-compacted
 6 concrete on the upstream side to stabilise this area.
 7 You can imagine the excavating tunnel in this type
 8 of geology -- and this Murree formation especially, with
 9 its soft shales, silt stones, clay stones and sandstone
 10 inter-bedded -- it's a huge undertaking. I think it's
 11 one of the monumental projects in such a geology, to be
 12 building such a large and long headrace tunnel with such
 13 a high pressure. And we of course also encountered
 14 faults and falls, and one was very near Jhelum.
 15 Actually, when you are driving back to Islamabad,
 16 I would like you to have a look at both sides of the
 17 river, and you will see that the rocks here also are
 18 different on both -- like you saw on the dam site, here
 19 also the rocks are different on both sides of the
 20 River Jhelum. On one side you have the Murree
 21 formation, which are maroon-ish or reddish shales and
 22 sandstone, where the road is, on the left bank of the
 23 river. And on the right side, when you look, it is
 24 Hazara formation, which are shales and schists. And
 25 actually the river is running along the fault.

Page 37

1 So it took almost ten years to complete the
 2 Neelum-Jhelum Hydropower Project. The initial design
 3 for excavation was actually to use the conventional
 4 drill and blast method. But for a significant length,
 5 as Mr Ayub Malik also just told you, we used two tunnel
 6 boring machines, to increase the pace of work basically.
 7 The total length of the headrace tunnel is
 8 28.5 kilometres, just to repeat. Out of this,
 9 20 kilometres are twin tunnels, and that is 20 plus 20,
 10 so this means actually the tunnelling was 40 kilometres.
 11 The length is 20 kilometres, but you have 20 kilometres
 12 and 20 kilometres, so it makes a total of 40 kilometres.
 13 Out of this 40 kilometres, 20 kilometres was excavated
 14 by the two TBMs.
 15 Slide number 8, please.
 16 Now, this slide shows the cross-section of the
 17 penstock and inlet. So this is coming from the manifold
 18 or the part of the headrace, and this is the penstock.
 19 This is all steel-lined, very thick steel, and it is
 20 also grouted and encased in concrete.
 21 And here (indicating) you have the -- this is the
 22 main powerhouse or the generator hall. You have the
 23 main inlet valve, or "MIV", as we call it in short
 24 terms. And of course this is the turbine, the shaft and
 25 the generator (indicating). So just a cross-section of

Page 38

1 that.
 2 So design of the penstock must include not only
 3 basic hydraulics, like (inaudible), but also consider
 4 the high pressure, and the presence of pressure spikes
 5 caused by closing. So of course for that we have the
 6 safety mechanism of the third shaft, to take care of the
 7 effect of increased pressure.
 8 So these inlet valves actually act -- there are four
 9 inlet valves, because you have four units. So you can
 10 isolate any one of the units at any given time, not that
 11 you have to shut the whole plant.
 12 Slide number 9, please.
 13 DR BLACKMORE: Sorry, I'm just wondering: did you need to
 14 put any expansion joints in any of those penstocks?
 15 DR HAYAT: In this penstock, sir?
 16 DR BLACKMORE: Yes. I can see you --
 17 DR HAYAT: Not to my knowledge.
 18 DR BLACKMORE: I think you've got --
 19 DR HAYAT: But again, because Mr Ayub has been here: any
 20 expansion joint in any of these penstocks?
 21 DR BLACKMORE: I can see you've got thrust collars, I think,
 22 if I can read it correctly.
 23 MR MALIK: There is a small expansion joint between the MIV
 24 and the spiral case.
 25 DR BLACKMORE: Yes. Okay.

Page 39

1 MR MALIK: To cater for any movement in the powerhouse or in
 2 the MIV. Very small, I think it's in millimetres.
 3 DR BLACKMORE: Oh, is it?
 4 MR MALIK: That's all you require.
 5 DR BLACKMORE: Yes, yes. No, there's not much temperature
 6 change, so yes. Alright. Thank you.
 7 DR HAYAT: Thank you.
 8 Next one (slide 9), please.
 9 This is the inlet valve. I'm sure today you will --
 10 here you can't judge the scale maybe, and the 20-tonne
 11 counterweight that you have, but I'm sure you will be
 12 looking at it today when you are on a visit to the
 13 powerhouse, and it's a sight to see.
 14 So basically it's an on/off valve. During
 15 operations, the flow of water is controlled by the
 16 wicket gates along the periphery, which has been
 17 explained by Mr Arfan Miana in his presentation.
 18 So unless you have any questions for me at this
 19 stage, I will hand over to Mr Tariq.
 20 THE CHAIRMAN: Any questions?
 21 No, we have no questions, Dr Hayat. I take it
 22 we will see you again a little later in the
 23 presentation.
 24 DR HAYAT: A little later, sir.
 25 THE CHAIRMAN: Very good.

Page 40

1 DR HAYAT: I will take over from slide 25 later on, sir.
 2 THE CHAIRMAN: Okay. We look forward to having you back.
 3 MR TARIQ: Mr Chairman and members of the Court of
 4 Arbitration, I am very pleased to address you for the
 5 first time. My name is Mohammed Tariq and I am chief
 6 engineer at WAPDA ...
 7 THE CHAIRMAN: Let me just interrupt you for a moment.
 8 Is the audio okay on this?
 9 Okay, please proceed.
 10 MR TARIQ: Thank you.
 11 ... responsible for the operation and maintenance of
 12 Tarbela 4th Extension Hydropower Station.
 13 The next fundamental component of powerhouse
 14 structure is turbine. Turbine is rotating in
 15 a mechanical device that extracts the kinetic energy of
 16 moving fluid, which in our case is water, and converts
 17 it into the rotational energy, which is transferred to
 18 electrical generator by means of a coupled shaft to
 19 convert it into electrical energy.
 20 Before the invention of waterwheel, the water cycle
 21 was the same as it is today: rivers were flowing from
 22 glaciers to the sea, irrigating land in between. The
 23 kinetic energy of water was utterly wasted, contributing
 24 only to the erosion of land.
 25 After the invention of waterwheel, a small fraction

Page 41

1 can be transmitted to national grid through 500 kV,
 2 220 kV or 132 kV transmission lines. Hydroelectric
 3 power plants have the ability to quickly ramp up or
 4 down, therefore they are playing a crucial role in grid
 5 stability.
 6 Slide 12, please.
 7 This slide is a detailed view of internal
 8 cross-section of Francis turbine installed at
 9 Neelum-Jhelum and its associated structure for
 10 conversion of the kinetic energy of the water into
 11 electrical energy, which has already been explained in
 12 detail by Mr Arfan Miana in presentation 8, and its
 13 working in principle will be explained in upcoming slide
 14 number 15.
 15 Slide 13, please.
 16 We know that turbines are not one-size-fits-all.
 17 That is why we classify them on multiple design factors
 18 to meet our specific requirements. Some key design
 19 factors are: energy at inlet, direction of flow, head
 20 and revolutions per minute.
 21 There are two types of turbine, based on energy at
 22 inlet. These are impulse turbine and reaction turbine.
 23 They have already been explained in detail by
 24 Mr Ayub Malik in presentation no. 2.
 25 However, impulse turbine operates by converting the

Page 43

1 of the kinetic energy was utilised for different
 2 purposes, including milling grains and powering
 3 machinery. Later on, after Industrial Revolution and
 4 invention of AC generator in the 19th century, the
 5 output of waterwheel was not sufficient. This led to
 6 the development of initial turbines, which were not very
 7 efficient, but much better than waterwheels.
 8 They were preferred, due to their various shapes and
 9 design, for the use in the regions where the waterwheel
 10 could not be installed. Later on, they were customised
 11 for different locations, water flow and landscape,
 12 resulting in birth of modern turbines.
 13 Slide 11, please. This short video will describe
 14 operation of turbine in hydroelectric power plant.
 15 Please play.
 16 (Video played)
 17 Now we will play it again, and I will explain.
 18 Please pause. Please pause.
 19 Water flows from reservoir, passing through the
 20 penstock, and enters the spiral casing, where turbine is
 21 housed, and exits through draft tube into the tailrace.
 22 Please play.
 23 The coupled shaft imparts rotational energy to the
 24 electrical generator, resulting in production of cheap
 25 and environmentally friendly electrical energy, which

Page 42

1 kinetic energy of high-velocity jet of water into
 2 mechanical energy. Pelton wheel turbine falls in this
 3 category.
 4 However, in a reaction turbine, reaction turbine
 5 uses both potential energy of the water stored in the
 6 reservoir and the kinetic energy of the high-speed
 7 flowing water. Francis and Kaplan turbines fall in this
 8 category.
 9 We classify turbines in four categories with respect
 10 to the direction of flow. In tangential flow turbines,
 11 water flows tangentially to the turbines' runner blades.
 12 In radial flow turbines, water enters directly and exits
 13 tangentially. Pelton turbine falls in this category.
 14 In axial flow turbines, flow of water remains parallel
 15 to the axis of rotation. Francis and Kaplan turbines
 16 fall in this category. In cross-flow turbines, water
 17 passes across the turbine blades.
 18 There are three types of turbine with respect to the
 19 water head: high, medium and low. 300 metres and above
 20 is considered as high head. Pelton wheel turbines are
 21 installed to utilise this head. Head ranging from 30 to
 22 300 metres is called medium head, and Francis turbine
 23 falls in this category. However, in modern studies,
 24 medium head is defined up to 500 metres. Head below
 25 30 metres is considered as low head, and Kaplan turbines

Page 44

<p>1 fall in this category.</p> <p>2 There are three types of turbine with respect to the</p> <p>3 revolutions per minute: high, medium and low, for</p> <p>4 Pelton, Francis and Kaplan respectively.</p> <p>5 Slide 14, please.</p> <p>6 Let's discuss prominent types of the turbine. Their</p> <p>7 selection criteria depend upon head, flow rate and site</p> <p>8 conditions, which have already been explained by</p> <p>9 Mr Ayub Malik in presentation 2.</p> <p>10 Francis turbine is a type of a reaction turbine in</p> <p>11 which water enters in spiral casing and flows both</p> <p>12 axially and radially through turbine runner blades,</p> <p>13 changing direction and velocity. This change in</p> <p>14 momentum creates a reaction force that pushes the blade,</p> <p>15 causing a rotation. These turbines are suitable for</p> <p>16 medium head and variable flow rates.</p> <p>17 Francis turbines are used and are in operation in</p> <p>18 WAPDA. Pakistan's largest hydroelectric power plant,</p> <p>19 located at Tarbela on the River Indus, features</p> <p>20 17 Francis turbines with a rated installed capacity of</p> <p>21 4,888 MW. In WAPDA, Francis turbines are also used in</p> <p>22 many other hydroelectric power plants, like Mangla,</p> <p>23 Neelum-Jhelum, Ghazi Barotha and Warsak.</p> <p>24 Pelton turbine is a type of impulse turbine which</p> <p>25 uses kinetic energy of high-velocity water jet fired</p> <p style="text-align: center;">Page 45</p>	<p>1 dial accelerates the water flow for efficient energy</p> <p>2 transfer. Guide vanes regulate the flow of the water.</p> <p>3 Volume of the water can be controlled by adjusting the</p> <p>4 angle of the guide vanes.</p> <p>5 The runner is the heart of the turbine and directly</p> <p>6 interfaces with the water flow, capturing its kinetic</p> <p>7 energy and transmitting it to the turbine shaft.</p> <p>8 Bearing supports turbine shaft within the turbine</p> <p>9 housing and ensures proper alignment of the shaft to</p> <p>10 avoid wear and tear.</p> <p>11 Draft tube is located beneath the turbine runner and</p> <p>12 it provides the exit passage to the water for discharge</p> <p>13 into the tailrace. Its gradually increasing</p> <p>14 cross-section area acts as a diffuser.</p> <p>15 Slide 16.</p> <p>16 The performance and longevity of the turbine depends</p> <p>17 upon many factors, including head, flow rate and</p> <p>18 sedimentation. Head or height difference between the</p> <p>19 water source and the turbine directly affects the</p> <p>20 pressure and speed of the water entering the turbine.</p> <p>21 Similarly, flow rate or volume of the water passing</p> <p>22 through the turbine per unit time affects the output of</p> <p>23 the turbine. Therefore, matching of turbine type with</p> <p>24 site condition is crucial for determination of</p> <p>25 performance. That is why Pelton turbines are suitable</p> <p style="text-align: center;">Page 47</p>
<p>1 from nozzles at specific angles. These type of turbines</p> <p>2 are also in operation in WAPDA at high-head power</p> <p>3 plants, located at Duber Khwar, Allai Khwar and</p> <p>4 Khan Khwar power stations.</p> <p>5 Kaplan turbine is also a type of reaction turbine.</p> <p>6 These turbines are suitable for low head and large water</p> <p>7 volumes. These turbines are also in operation in WAPDA</p> <p>8 at small hydropower stations located at Rasul, Shadiwal,</p> <p>9 Nandipur and Chichoki.</p> <p>10 Slide 15, please.</p> <p>11 Now we will have a short video demonstrating</p> <p>12 fundamental working principles of Francis turbine in 3D.</p> <p>13 Please play.</p> <p>14 (Video played)</p> <p>15 (Indicating) Penstock. Transmission lines.</p> <p>16 Switchyard. Hydroelectric power plant. Machine hall of</p> <p>17 the power plant. Guide vanes, regulating rings.</p> <p>18 Runner. Guide vanes. Guide vanes. Turbine shaft.</p> <p>19 Spiral casing. Fixed vanes. Guide vanes. Runner with</p> <p>20 spiral casing -- draft tube.</p> <p>21 In this video we have seen penstock is a conduit to</p> <p>22 transport water from intake structure to turbine. Inlet</p> <p>23 wall is positioned at the entrance of the spiral casing.</p> <p>24 Spiral casing directs pressurised water from inlet wall</p> <p>25 to the turbines runner blades. Its gradually decreasing</p> <p style="text-align: center;">Page 46</p>	<p>1 for high heads and Kaplan turbines are suitable for low</p> <p>2 heads.</p> <p>3 Sedimentation is the deposition of particles carried</p> <p>4 by water. It has significant impact on performance and</p> <p>5 longevity of turbines. Accumulation of sediments can</p> <p>6 cause erosion, abrasion and damage to turbine blades</p> <p>7 over time. This phenomenon and its management</p> <p>8 strategies have [been] discussed in detail by Dr Abbas</p> <p>9 in presentation 6.</p> <p>10 This slide shows a close-up image of turbine</p> <p>11 abrasion on turbine blade profile. Rate of abrasion on</p> <p>12 the turbine increases with increase in head and size of</p> <p>13 grain. Sand particles larger than 0.2 to</p> <p>14 0.4 millimetres are particularly abrasive.</p> <p>15 Slide 17, please.</p> <p>16 Protective measures are essential for turbines to</p> <p>17 ensure their reliable operation, longevity and</p> <p>18 efficiency. These measures are necessary to mitigate</p> <p>19 various risk and threats that turbines may encounter</p> <p>20 during their operation.</p> <p>21 Protective measures include: inlet screens and trash</p> <p>22 rack; desander; surge tank; pressure relief valve;</p> <p>23 runner coating; and mechanical protection. In the</p> <p>24 following slides, I will quickly go through the measures</p> <p>25 which have already been explained by Dr Abbas in</p> <p style="text-align: center;">Page 48</p>

<p>1 presentation 6. 2 Slide 18. Inlet screens and trash racks are 3 installed at the intake of turbine to prevent entry of 4 debris, rocks and branches, to mitigate the risk of 5 blockage, abrasion, erosion and mechanical damage to 6 turbine components, therefore prolonging lifespan of 7 turbines. 8 Slide 19, please. Desanders. Desanders are 9 designed to remove sediments and abrasive particles from 10 water before it enters the turbine. They help to reduce 11 wear and tear on turbine components and prolong the 12 operational life of the turbine. 13 Slide 20. Surge tanks are installed between 14 penstock and turbine to absorb pressure surges caused by 15 sudden changes in water flow. They protect turbines 16 from water hammer effect. 17 Slide 21. Pressure relief valves are safety devices 18 installed in turbine hydraulic system to release excess 19 pressure and also to prevent pressure-related damages to 20 turbine during abnormal conditions in the power plant. 21 Slide 22. Runner coatings are applied to turbine 22 runners to enhance their resistance against abrasion, 23 corrosion and cavitation damages. These coatings 24 provide a protective barrier between turbine blades and 25 the abrasive elements to reduce wear and tear on turbine</p> <p style="text-align: center;">Page 49</p>	<p>1 DR HAYAT: A pleasure to be back, sir. I'll talk a little 2 bit now about generation and transmission. 3 Slide 25, please. 4 So this shows the photo of the generators inside the 5 powerhouse, 1, 2, 3, 4, in Neelum-Jhelum. As you know, 6 and as has been explained by Mr Tariq also and others, 7 the generators convert the mechanical energy produced by 8 the turbines into electrical energy, which is then 9 readied for transmission via the transformer hall and 10 the switchyard. 11 So the Neelum-Jhelum generator hall includes four 12 generators, each rated at 242 MW and expected to run at 13 300 RPM, revolutions per minute. 14 The vertical arrangement seen in this photo, the 15 generator is mounted on top of the turbines. You have 16 also seen other illustrations and videos. This is the 17 characteristic of large plants, while in smaller plants 18 the generators and the turbines could be in a horizontal 19 direction. So here they are vertical, and one vertical, 20 and in smaller plants there could be a horizontal 21 arrangement also. 22 As is in here, a hydroelectric plant would usually 23 have multiple generating units because this would allow 24 individual units to be removed from operation while the 25 others are kept running. So that is a desired design</p> <p style="text-align: center;">Page 51</p>
<p>1 blades, therefore extend operational lifespan of 2 turbines. 3 Slide 23. Mechanical protection. Various sensors 4 and monitoring systems are installed to detect 5 mechanical faults, such as: bearing oil level 6 monitoring; turbine overspeed protection; regular 7 inspection of inlet valve and pressure relief valve to 8 ensure their proper operation; vibration monitoring to 9 avoid wear and tear on the turbine shaft components; 10 shaft seal, to ensure as minimum as possible water 11 leakage between the turbine shaft and the head cover; 12 monitoring of bearing pad temperature, to avoid any 13 damage to the plant components with respect to the 14 turbine. 15 Alarm and automatic shutdown mechanisms are 16 triggered in response to abnormal conditions to prevent 17 the damage to the turbine components. 18 Thank you very much for your attention. Now 19 Dr Tahir Hayat will continue the remaining portion of 20 the presentation. 21 THE CHAIRMAN: Any questions? No. 22 MR TARIQ: Thank you, sirs. 23 THE CHAIRMAN: Okay, we have no questions for you Mr Tariq. 24 That was very clear. Thank you very much. 25 MR TARIQ: Thank you, sirs.</p> <p style="text-align: center;">Page 50</p>	<p>1 feature that we have, that we have more than one unit. 2 So multiple units also allow for power production to 3 track variations in available flows of water or changing 4 power demands during the day. So if you have less than 5 peak demand, so you can only run two generators, and as 6 the demand rises, then you can add on, or subtract as 7 the demand goes down. 8 For any turbine or generator, the energy conversion 9 efficiency is achieved by running a single unit at its 10 design optimal operating point, rather than running 11 multiple units at lower flow rates. So it is better to 12 be within the sweet spot, I would say, of the turbines 13 and generators, 50%, 70%, 80%, 90% efficiency, rather 14 than having all at 40%, 30% efficiency. So given that 15 the largest generating units produced by most of the 16 manufacturers are approximately 750 MW, larger plants 17 will need multiple such units to meet the plants' design 18 capacity. 19 Slide number 26, please. 20 Next, this is the transformer, photo of 21 a transformer, this one, and this is also a step-up 22 substation in the powerhouse. And it is located, in the 23 case of Neelum-Jhelum, underground also, and you will 24 see it today, only a few metres away from the generation 25 hall.</p> <p style="text-align: center;">Page 52</p>

1 The voltage that is produced at the generator in
 2 Neelum-Jhelum is 15.75 kV. As it is taken to the
 3 transformer, it is stepped up to 525 kV, and this is for
 4 efficient transmission.
 5 So a transformer, a step-up transformer -- there are
 6 two types of transformer, step-up and step-down. This
 7 is a step-up transformer: it increases from 15.75 to
 8 525. This is because this will allow generation of
 9 transmission of high voltage with less energy loss.
 10 So sometimes the transmission lines could be
 11 hundreds of kilometres. It's very normal, because they
 12 have to take these to a central grid station. In the
 13 case of Pakistan, it is distributed all over the
 14 country: it becomes part of the whole big basket of
 15 energy that you have.
 16 So modern turbines can convert about 94% of the
 17 potential energy theoretically available from water into
 18 mechanical energy, and generators can convert about
 19 98.5% of that mechanical energy into electricity, and
 20 about 1% will be lost in the process of transforming the
 21 low voltage of the generator. So at the transformer
 22 level there's 1% loss.
 23 So at the optimal operating point, over 90% -- to
 24 combine all the efficiencies and the losses, so from the
 25 total energy available in water we can produce

Page 53

1 electricity which is about 90% of that. This 10% is
 2 various losses that we have in the system.
 3 Next to the switchyard, please. Yes, 27.
 4 So this is a place where once the voltage has been
 5 stepped up, it is directed to the transmission line, and
 6 this plays a major role in the security of the power, or
 7 the security of the system. So it comprises a series of
 8 switches, breakers and other protective devices which
 9 can be either manually or remotely opened and controlled
 10 to energise or de-energise specific transmission
 11 circuits leaving the plant.
 12 To disconnect a transmission line leaving the plant,
 13 the breakers are opened, and to connect, they are again
 14 closed. So these are the breakers that we have, large
 15 ones. And basically to protect, if there are any surges
 16 or there are other problems, then you have these
 17 breakers to isolate the system, or multiple systems. So
 18 the Neelum-Jhelum switchyard is rated at 575 kV.
 19 Can we go to slide 28, please.
 20 So the transmission lines deliver the plant's
 21 electricity into electrical power grid at the designated
 22 point of connection. So that point has sufficient
 23 transmission capacity to accept the energy being
 24 produced at the plant and then to deliver it into lines
 25 serving the users, basically.

Page 54

1 So getting the hydropower to homes and businesses,
 2 it takes very careful planning, as transmission lines
 3 can carry the amount of electricity that will be
 4 consumed. To keep the right amount of power flowing,
 5 computers calculate how much electricity should be sent,
 6 when and where across the system, and power generation
 7 of various plants feeding the grid will be adjusted.
 8 So this is at the master control level. So all the
 9 plants, you know, they are at a master control level.
 10 They have a control which then decides which plant
 11 produces what and at what time, and where it has to be
 12 sent. So during the course of the day it will be
 13 adjusted so the correct amount of energy is flowing into
 14 the grid, and that will be used over the next whatever
 15 period it is required.
 16 Number 29, please. Okay.
 17 So beyond the transformer, there are multiple other
 18 types of substations in the power systems.
 19 There are step-down substations, which decrease the
 20 voltage for local distribution. Because the voltage
 21 that comes into your lines, for those living in America
 22 it is 110, for those living in this part of the world it
 23 is 220. So it has to be stepped down from that higher
 24 level to the distribution point for the ... So this is
 25 where we have the step-down substations.

Page 55

1 There are also distribution substations that supply
 2 electricity direct to the consumer, and switching
 3 substations. So multiple lines come into the switching
 4 substation, and if there's a problem with one, or
 5 there's less need, so that will decide -- these are the
 6 switches where you go from one place to the other place.
 7 So basically, switching stations can isolate, just
 8 like your main inlet valve or other safety devices:
 9 that's also another sort of a safety protection. If you
 10 need maintenance on one line, you will switch it off.
 11 If you need more energy in some, then you can give it to
 12 that.
 13 So next is, I think, the thank you. 30. Yes.
 14 So I'm at the end of my presentation. If you have,
 15 sir, any questions, I will be glad to take those, myself
 16 and Mr Tariq.
 17 Yes?
 18 THE CHAIRMAN: Mr Buytaert.
 19 PROFESSOR BUYTAERT: Would you know what is the percentage
 20 contribution of the Neelum-Jhelum plant compared to the
 21 total hydropower production in Pakistan? What share
 22 does the plant provide?
 23 DR HAYAT: So I would say it is about -- roughly 1 over 26,
 24 because the total -- please. To be precise.
 25 MR MIANA: For the hydropower station, we have about

Page 56

1 9,400 MW installation capacity. Out of that, 969 is
 2 the -- so almost 10%.
 3 DR HAYAT: But what about the total big -- that is 25,000?
 4 MR MIANA: Yes, they asked for the hydel.
 5 DR HAYAT: You're only asking about hydel?
 6 PROFESSOR BUYTAERT: Yes.
 7 DR HAYAT: Or total mix in the Pakistan ...
 8 PROFESSOR BUYTAERT: No, the percentage. So the 10% of the
 9 total hydropower energy --
 10 DR HAYAT: Total hydropower.
 11 PROFESSOR BUYTAERT: Yes. While we're at it, what is the
 12 percentage contribution of hydropower in general to the
 13 total electricity consumption; would you know?
 14 MR MIANA: About 25-30%.
 15 PROFESSOR BUYTAERT: Okay, yes. Thank you. And the rest?
 16 Would you happen to know the percentages of the other
 17 types of hydropower?
 18 MR MIANA: This is the nuclear, the thermal, and the way
 19 it --
 20 DR HAYAT: I think it will come in the next presentation.
 21 PROFESSOR BUYTAERT: Okay, perfect. No, no, I'll be happy
 22 to wait.
 23 DR HAYAT: So that will be answered in precise terms in the
 24 next presentation.
 25 PROFESSOR BUYTAERT: Great. Thank you.

Page 57

1 So I think then we have no further questions. So
 2 that concludes this presentation.
 3 If I understand correctly, Dr Hayat, you may need to
 4 leave at this point. Let me just, on behalf of the
 5 Court, say how much we appreciate all that you've done
 6 during the course of this visit. It's been very helpful
 7 to hear from you.
 8 DR HAYAT: It has been a pleasure, sir, to address you, and
 9 give you as much information as I could, sir. Thank you
 10 very much, sir, for listening to me.
 11 THE CHAIRMAN: Thank you very much.
 12 So I understand now is our lunch break, and then
 13 after that we'll resume with the next presentation. Is
 14 that correct?
 15 MR MIANA: We have now the next presentation, and after that
 16 we have the lunch break.
 17 THE CHAIRMAN: Okay. Next presentation and then lunch.
 18 (Pause)
 19 I think we are ready now for presentation no. 10.
 20 Presentation 10: Power Production
 21 MR KHAN: Honourable Mr Chairman, members of the Court,
 22 good afternoon.
 23 I am Hameedullah Khan. I am from WAPDA. I have
 24 a 31-year service length in WAPDA, mainly working as
 25 operation and maintenance engineer for powerhouses.

Page 59

1 DR HAYAT: If that's okay with you.
 2 PROFESSOR BUYTAERT: Absolutely.
 3 DR HAYAT: Thank you.
 4 THE CHAIRMAN: Just one question from me, Dr Hayat. You
 5 mentioned that there would be a sort of master person or
 6 place that would decide where the energy needs to go at
 7 what time. Is that located somewhere in Pakistan, and
 8 you receive instructions from them here as to where to
 9 send the energy? Is that how it works?
 10 DR HAYAT: That is how it works, sir. I think if I am not
 11 wrong, it is called NTDC, National ... NPCC.
 12 THE CHAIRMAN: NBCC?
 13 DR HAYAT: NPCC, National ...
 14 THE CHAIRMAN: NPCC.
 15 DR HAYAT: National Power Control Centre.
 16 THE CHAIRMAN: National Power Control Centre. Okay.
 17 DR HAYAT: So what happens is -- so he will also be talking
 18 about that in the next presentation, to give you more
 19 details. But I think there is a daily exchange of data
 20 between all the power plants. So it's a data coming
 21 out, so they will tell them what is the capacity that is
 22 available with them on a particular day, and they will
 23 tell them how to dispatch and what to do. But he will
 24 tell you more about it, sir.
 25 THE CHAIRMAN: Okay. Very good.

Page 58

1 Currently I am chief engineer, Warsak powerhouse.
 2 I have spent quite a time of my service at Tarbela
 3 Power Station, serving the first power station, the
 4 second power station and also the T4, where now my
 5 colleague Mr Tariq is chief engineer. I have spent more
 6 than 20 years out there.
 7 Currently I am looking [after] the north region
 8 powerhouses in the country, six of them, relatively
 9 small powerhouses. I am also looking after the
 10 rehabilitation work of Warsak powerhouse, which is one
 11 of the oldest powerhouses in the country, in fact the
 12 powerhouse which was commissioned back in 1960. It has
 13 a 242 MW installed capacity.
 14 So in our presentation -- along with me
 15 Mr Arshad Malik, co-presenter: he is also chief engineer
 16 in WAPDA -- we will be talking to you about the power
 17 systems. You have heard a lot about the hydropower, how
 18 the energy produced, and I consider that you are now the
 19 hydro experts, along with me. So it will be easy
 20 talking to you about the power production and the power
 21 systems now.
 22 We will be first discussing power system in general,
 23 then we will go to a simple power system, then we will
 24 be discussing it in more detail. Finally we will be
 25 discussing the role of Neelum-Jhelum, which my colleague

Page 60

1 will be presenting to you, in the current country's
 2 power system: how it fits and what is its contribution
 3 in the power system.
 4 Slide number 2, please. Hydropower.
 5 A lot has been said about the hydropower. It is the
 6 power extracted from the water, either from the falling
 7 water or the running water. And from the falling water
 8 we get the potential energy; from the running water, we
 9 get the kinetic energy. So either of them, or the
 10 combined effect of them, can generate a lot of
 11 mechanical power.
 12 Anciently, this mechanical power was used for
 13 mechanical purposes, like signboard or textiles, or
 14 maybe for grinding grains. After 1833, a modern hydro
 15 turbine was developed, and then this hydropower was
 16 started to be used as a source of electrical energy.
 17 As we know, water is about 800 times more dense than
 18 air. It has a density of 1,000 kg per metre cubed. In
 19 contrast, air has only 1.293 kg. So a little bit of
 20 water flowing with a smaller head can generate
 21 electricity. It is an equilibrium which we have to hit,
 22 where we stand or where we design our powerhouse,
 23 regarding the flow and the head.
 24 So, as I have told you, Mr Benoît Fourneyron was
 25 considered as the founder of the modern turbine in 1833.

Page 61

1 require some uranium or some fuel; for fossil fuel
 2 plants, it will require coal or some furnace oil, et
 3 cetera. But here the fuel is water.
 4 Water as known as the white gold. It doesn't
 5 generate any flue gases. In a hydropower station, you
 6 will not experience the extra high thermal losses
 7 because the temperatures are very low. And as these are
 8 built on the rivers, and the river has a flow around the
 9 year -- maybe it's less or high, maybe in wet season
 10 they are getting more water and in dry season they are
 11 getting less water, but the flow doesn't cease. It is
 12 not the case in the rivers, certainly, which are located
 13 in this part of the country, in the Himalayan region.
 14 So you have a minimum flow. And these hydel
 15 generators or hydropower plant can run in any part of
 16 the year. The production may vary. In wet season, they
 17 will be running as a baseload plant -- what is baseload?
 18 I will explain it in detail later -- or they may be used
 19 for peaking. But they will be kept running, owing to
 20 the property of the river, which doesn't cease: the
 21 minimum flow is there.
 22 Then the other advantage is: easy to maintain. And
 23 for this, we have to make the comparison. We have to
 24 make the comparison between the hydropower plant and
 25 a steam turbine.

Page 63

1 Then in 1882, as the slide suggests here, on River Fox
 2 in Wisconsin we have the first formal hydropower unit in
 3 the USA.
 4 The story doesn't stop over here regarding evolution
 5 of the turbines. In 1897, the first HEP was set up in
 6 Asia, at West Bengal, and it has an output of almost
 7 130 kW. Although it was a smaller one, as we are
 8 looking out to our powerhouses of the day, like
 9 Neelum-Jhelum is 969 MW.
 10 Slide number 3, please.
 11 Hydropower. Hydropower has three major advantages:
 12 it is clean, cheap and reliable. And by "clean" I mean
 13 that it doesn't generate any industrial waste: it
 14 doesn't have any chemical reactions going on while we
 15 are generating the hydropower. And it is
 16 environmentally friendly, in a broad spectrum.
 17 By "cheap" I mean that maybe the initial cost is
 18 very high for a hydropower station, but the running cost
 19 is minimal. It is almost perpetual, a perpetual machine
 20 having a generating efficiency of 98%. In fact, the
 21 tariff of the system is controlled by this cheap
 22 characteristic of hydropower.
 23 Then we have the reliability factor in it. As you
 24 know, the hydropower consumes water as its fuel. In
 25 contrast, if there is a nuclear power [plant], it will

Page 62

1 So the auxiliary equipment are the essential
 2 equipment in a powerhouse to run main equipment,
 3 i.e. generator and turbine. Turbines give you the
 4 mechanical energy; generator converts to the electrical
 5 energy, which is the theme over here.
 6 So the balance of the plant equipment which are
 7 essential for running these two major equipments is
 8 known as the auxiliary of the power plant. And this
 9 auxiliary in a hydropower plant is minimum as compared
 10 to a thermal power plant. Maybe a thermal power plant
 11 has so much auxiliary for one 600 MW unit, which is
 12 sufficient for a 2,000 or 3,000 MW hydro turbine.
 13 Less auxiliary means less maintenance, there is more
 14 reliability, and it's more economical also.
 15 The system doesn't run on the same load pattern
 16 throughout the day or throughout the season, so it must
 17 have a powerhouse, which can vary with the system
 18 requirements. And this property is mostly and reliably
 19 found in a hydropower unit.
 20 It can start up very quickly. Our turbines at
 21 Tarbela -- because I have worked a long time at
 22 Tarbela -- they can start in a matter of 3 minutes only,
 23 from zero to their rated speed of 136 RPM, and they can
 24 be synchronised in next 2 minutes. And the ramping of
 25 these turbines are so quick they can take a load of

Page 64

1 100 MW in a matter of few seconds: maybe 60 to
 2 70 seconds and they are running at 100 MW.
 3 So you see how they adapt to the changing load and
 4 how flexible they are. So for the reliability of
 5 a system, you cannot ignore the role of a hydropower
 6 plant.
 7 Ramping, as I have already explained, it is the
 8 ability of the turbine or a generator to go up quickly
 9 and to go down quickly in terms of loading, depending on
 10 the system requirement. So this ability has to be there
 11 if we are requiring a reliable system or if we want
 12 a system to be more reliable.
 13 Hydro turbines are also used as frequency
 14 regulators: they are put on auto mode and they will
 15 automatically regulate the frequency. The standard
 16 frequency in Pakistan is 50 Hz; as you already know, in
 17 America, it is 60 Hz. So due to quick ramping, they are
 18 used as frequency stabilisers.
 19 Slide 4, please.
 20 Sir, this is the map of Pakistan, showing the hydro
 21 potential of the country. All of these powerhouses
 22 which are shown over here are not operational. Some of
 23 them are operational; some of them are under
 24 construction; some of them are in feasibility stage,
 25 study stage.

Page 65

1 under construction or feasibility in the northern side
 2 of the country. Generally, the heads available are as
 3 per topography or terrain which Pakistan has. The north
 4 and west portion of the country has the heads, has the
 5 rivers. So all of the hydro generation is concentrated
 6 over here, in the north. In the south and in the
 7 central portion of the country, we have plain terrain,
 8 so thermal units, wind units and solar units are there.
 9 Next slide, please, slide number 5. Sir, now we
 10 will be talking about the power production and the power
 11 systems. So I will be explaining you first a simple
 12 power system.
 13 Next slide, please, slide number 6. Sir, this is
 14 a simple power system, and it is just for the sake of
 15 understanding, sir.
 16 So as you can see over here, sir, in the red we have
 17 the generation. We (indistinct) belong to this portion.
 18 Then we have the transmission, which is shown here as
 19 blue. Then we have distribution system, which is shown
 20 here as green. And then we have black, the essential
 21 part of a system: customers, from where we get the
 22 money.
 23 So, sir, explaining my portion first: the generating
 24 stations. These are designated as red. This generation
 25 station may be a hydel, in a power system -- and now

Page 67

1 So you can see the legend over here. And the
 2 powerhouses in green colour are in operation. The
 3 powerhouses in magenta colour, some of these are
 4 operational, some of these are under construction, but
 5 they are operated by a private owner and are controlled
 6 by PPIB, Private Power & Infrastructure Board. They are
 7 working under the umbrella of PPIB.
 8 Right now, sir, if I can show you, we are here
 9 (indicating), Neelum-Jhelum. You can see this is
 10 Neelum-Jhelum; this is a reservoir, and it is Mangla.
 11 So this Neelum-Jhelum, as you know, is a run-of-river
 12 plant. But what's coming to this reservoir is stored,
 13 and Mangla can operate as a reservoir-based plant
 14 throughout the year.
 15 If you are interested where I am working and coming
 16 here to brief you, I am working, sir, here (indicating).
 17 This is River Kabul and Warsak powerhouse. Right now
 18 I am performing my duty over here.
 19 Where I have spent a lot of time, 20 years, this is
 20 Tarbela (indicating). Tarbela 1, 1,750 MW; Tarbela 2,
 21 1,728 MW; Tarbela 4, where Mr Tariq is working,
 22 1,410 MW. And now we are in a process of developing
 23 another powerhouse, which is known as Tarbela 5, and it
 24 will be completed in a span of a few years.
 25 So we have a lot of other projects, sir, which are

Page 66

1 I am talking about a power system, sir. So this may be
 2 a hydel, it may be a nuclear power plant or it may be
 3 a thermal power plant, or wind or anything. So it is
 4 the first part of a power system.
 5 Then we have this generator step-up transformer.
 6 This is very important, sir. Because in powerhouses,
 7 whether it is a hydro or a thermal, the generation
 8 voltage, as Mr Hayat also explained, for Neelum-Jhelum
 9 it is 15.75 kV. But to transmit the power at this
 10 voltage level will ultimately result in a lot of losses,
 11 because -- as a simple technical discussion -- the
 12 losses depend on the amount of current.
 13 So the power we generate over here, 242 MW, and
 14 we have a 15 kV voltage at the generation. So the
 15 current will be obviously in kiloamperes. And for the
 16 losses you have to make square of the I and then
 17 multiply it with the resistance of the transmission
 18 line, and the result will be so much high losses.
 19 So to control these losses, we need a power
 20 transformer to step up the voltage to a level which is
 21 suitable for the transmission.
 22 So, as per engineering standards, the designer has
 23 suggested these levels, starting from 138 kV to
 24 extra-high voltage level of 765 kV. And the choice
 25 depends on: the distance you will be covering to the

Page 68

1 load centre; the topology of terrain of the area which
 2 you will be crossing during the transmission lines; the
 3 wind pressures, if the area gets snow, any snow loading,
 4 everything. There are so many factors. The designer
 5 knows about it.
 6 So, sir, here we will step up the voltage levels to
 7 the appropriate voltage level to reduce the current and
 8 control the losses. And then we will reach to
 9 a substation, which is the first step of the
 10 distribution network. So here we will reduce the
 11 voltage level again, and will bring it to an acceptable
 12 voltage level so that we can easily distribute the power
 13 which we have generated in a power station to the load
 14 consumers.
 15 So there are so many types of the load consumers.
 16 We have divided, for simple power system consumers over
 17 here, in three categories.
 18 First is the substation, consumers who like to buy
 19 the power in bulk. They will directly buy the power
 20 from you at a relatively high voltage level and they
 21 will distribute it in their system at their own will.
 22 So these are the first category. They purchase the
 23 power in bulk at a high voltage level.
 24 Then we have a primary customer, who needs the power
 25 at, in our country, only 11 kV, and just step down it to

Page 69

1 from the distribution network. This is called a concept
 2 of net metering. If you have a surplus, you give it to
 3 the system; if you have scarcity, you take it back.
 4 This is the first layer of the powerhouses, where we
 5 have the medium size. And these are at a little
 6 distance from the cities. So it may range from 150 MW
 7 to 350 MW. Most of the small thermals are designed like
 8 this.
 9 Then we have the main stabilisers of the system.
 10 The junk of the power is supplied from here
 11 (indicating). These are the large hydro and thermal
 12 power plants. So it can be as large as 22,500 MW like
 13 Three Gorges. In our country, it is Tarbela, 4,888 MW.
 14 It could be a coal plant, it could be a nuclear. We
 15 have one nuclear, 2,300 MW, at KANUPP.
 16 So this is the concept of an integrated power
 17 system, where the large power plants are available, the
 18 medium-sized power plants are available, relatively
 19 smaller power plants are available, windmills, solars
 20 are available, and the most important, consumers are
 21 available.
 22 Next slide, please, slide number 8.
 23 So now coming to the Pakistan power system, how the
 24 power is distributed. This is the map of Pakistan and
 25 these are the transmission lines, the hard lines are

Page 71

1 240 workable voltage and distribute it. These are the
 2 second: we call them primary customers.
 3 And then there are so many customers, like domestic,
 4 like markets, like hospitals, like railway stations, and
 5 so many customers who require the ready-made product,
 6 the finished product. So the finished product in our
 7 country is sold as 240 V; in America it is 120,
 8 I believe.
 9 So, sir, this is the simple power system. And now
 10 I will be moving, in slide number 7, to a little bit
 11 complex power system. Sir, this is the same power
 12 system, but here it is a little bit -- more things are
 13 added in it.
 14 These are again the consumers: rural consumers, then
 15 more denser city consumers; a farmhouse; distribution
 16 network; windmills; solar farms; small powerhouses
 17 located near the load centre, just to give the voltage
 18 boost and to control the peaking hours.
 19 Then we have the industrial consumers. These may be
 20 the sugar industry. They have their own powerhouses.
 21 So they will generate the energy, generate the power,
 22 consume it for their machinery, for their use; and which
 23 is surplus, they will give it to the distribution
 24 network. And if they have a fault on their generators,
 25 they can [do it] the other way round: they can take it

Page 70

1 actual transmission lines which exist in the country.
 2 The dotted transmission lines are the future
 3 transmission lines: their feasibility is complete and
 4 they are in a construction phase now, sir.
 5 Sir, for better understanding, I will request you to
 6 just concentrate on this legend. The red lines, all the
 7 red lines, these indicate 500 kV transmission lines.
 8 The green lines, these indicate 220 kV transmission
 9 lines. This magenta colour, this is the new addition in
 10 our system, the DC transmission lines. So far we have
 11 only one, starting from Matiari and ending at Lahore.
 12 Then for future, we are considering another DC line
 13 over here (indicating), to import power from Tajikistan
 14 in future. This is under consideration, sir.
 15 We have the powerhouses over here (indicating) also,
 16 sir. You can see these rectangles with a straight line:
 17 these show you the hydro powerhouses which are running
 18 in the system. And the rectangles with this cross, with
 19 this diagonal line, these show the thermal powerhouses.
 20 So, sir, for a wet season, when we have ample amount
 21 of water, the power flow in Pakistan is from north to
 22 south. And during the dry season, when the water is
 23 less in the rivers, to meet the country demand, the
 24 power flow is from south to the north, and most of the
 25 thermal units are running at that period of time.

Page 72

1 So it's quite a hectic planning. And as my earlier
 2 colleague Mr Hayat said, the NPCC, National Power
 3 Control Centre, is the system operator. They have the
 4 complete data and they are responsible for this
 5 planning. They will tell you when to start your unit.
 6 As an operator of this power plant where we are sitting
 7 right now, Neelum-Jhelum, its operator cannot start it,
 8 Mr Miana cannot start the unit at his own will. He will
 9 get the information and the instructions from NPCC, sir.
 10 So NPCC is the planner of the system.
 11 The transmission lines are controlled, maintained
 12 and erected by another company, sir, which is known as
 13 NTDC, National Transmission & Distribution Company, sir.
 14 This was once WAPDA: we were all brothers. But then
 15 we were disintegrated in 1998, obviously to improve the
 16 efficiencies. And WAPDA was given the mandate of
 17 developing and running the hydropower, and NTDC is
 18 looking after all the transmission lines, the grid
 19 systems, and developing the new transmission lines and
 20 studying the new transmission lines.
 21 Next slide, please, slide number 9.
 22 Sir, now coming to the energy mix of the country.
 23 Sir, this is the data from June 2023 and it will give
 24 you the idea what is the Pakistan total installed
 25 capacity and how it is generated, what is the energy

Page 73

1 mix.
 2 Sir, the country, as of last year, has an installed
 3 capacity of 46,035 MW. Out of this 46,035 MW, almost
 4 52-55% is generated through thermal powerhouses. Then
 5 we have the hydel. And its share is now shown over here
 6 as 23%, but as of now, in January 2024, it has risen up
 7 to almost 26%.
 8 Then we have nuclear, renewables and Karachi
 9 Electric. It is running independently from the rest of
 10 the system. It is obviously interconnected, but it is
 11 operating independently. This is an independent company
 12 responsible for supplying energy to Karachi, the
 13 mega-city of Pakistan.
 14 Next slide, slide number 10, please.
 15 THE CHAIRMAN: Before you move past this slide, just to
 16 clarify: the hydro component is which parts of the pie
 17 slice?
 18 MR KHAN: Sir, this is "WAPDA Hydel", the hydel powerhouses
 19 controlled by WAPDA. But as I explained in the previous
 20 slide, there are certain powerhouses which are run under
 21 the umbrella of PPIB, private power producers. So they
 22 are here, in yellow. Collectively, hydel is -- here it
 23 is shown as 23%, but as of today it is almost 26-27%,
 24 sir.
 25 THE CHAIRMAN: Okay, very good. Thank you.

Page 74

1 MR KHAN: Next slide, slide number 10.
 2 Sir, this is how we are utilising the powerhouses in
 3 our system. We have installed capacity of 46,035, as
 4 I have already told you, in megawatts. But it is not
 5 possible to run all these powerhouses on their full
 6 capacity all the time. Maybe the water is not available
 7 for a hydropower station, or maybe a nuclear power plant
 8 has some issues, or maybe the thermal power plant is
 9 under maintenance. So the planner has to decide how to
 10 use it most economically, in the economic merit order.
 11 So this is how, in previous year, 2022/23, we have
 12 utilised our thermal nuclear hydel/IPPs. This chart
 13 shows the energy in gigawatt hours, and this is the
 14 contribution of each power plant.
 15 So as from the previous slide, the thermal is almost
 16 more than 50%, sir. So if you can see over here, the
 17 contribution of the thermal in the power system is also
 18 around 50%, sir.
 19 And just in fact, sir, the nuclear is less in
 20 percentage [than] the energy mix we have seen in the
 21 last slide, and the hydro is more in the energy mix, in
 22 terms of percentage. But you can see over here there is
 23 very little difference between the energies of the hydel
 24 and the nuclear.
 25 It is because the hydel is seasonal: it depends on

Page 75

1 the flow of water. In dry, you have minimum water, so
 2 you cannot run Neelum-Jhelum at 969 MW all the time.
 3 But a nuclear will only require fuel -- if you have the
 4 fuel for the plant, you can run it 24/7, round the
 5 clock, throughout the year.
 6 The system operator and the planner have to consider
 7 these points as well while they are planning how to run
 8 the power plants.
 9 Next slide, please, slide 11.
 10 Sir, now we will be talking about how the HEPs, the
 11 hydropower plants and the power system, how they are
 12 interlinked, how a HEP fits in a power system.
 13 So next slide, slide number 12, sir.
 14 A lot has been said about this slide, sir, in
 15 previous presentations. And this is the HEP, and how
 16 HEP can be designed run-of-river with pondage and
 17 run-of-river without pondage, a reservoir or a pump
 18 storage. So I will not talk much about this. Then, as
 19 Mr Tariq explains, the turbines have low head, medium
 20 head and high head. This is the choice.
 21 So these two are the design parameters. And once
 22 the powerhouse is established, then the operator has to
 23 look to it from the load perspective.
 24 Now he has to decide, for an HEP, whether to operate
 25 it as a baseload plant, intermediate-load plant or

Page 76

1 a peaking-load plant. And what are these terms? I will
 2 be explaining to you in the next slides, sir.
 3 Next slide, 13.
 4 Sir, before going to that, a very simple formula,
 5 just for understanding how the P, the watts, the power,
 6 which factors it depends [on].
 7 So obviously it depends on the quantity of water and
 8 the head of water. You already know I consider you,
 9 sir, as hydro experts now.
 10 So the other things are: the gravity, acceleration
 11 due to gravity, a fixed quantity, 9.8 metres per second
 12 squared.
 13 This is the density of water, 1,000 kg per metre
 14 cubed.
 15 This is, sir, the efficiency of a turbine. The
 16 efficiency of a turbine theoretically can vary from 0 to
 17 100, but for a modern turbine, it is always above 90%.
 18 So even if we considered it as 0.9, which is 90%, we can
 19 easily calculate the watts from a given quantity and
 20 head of water.
 21 This is how the HEP output is derived, and this is
 22 the main theme in the minds of the planners during the
 23 wet and dry season.
 24 Next slide, please, slide 14.
 25 Sir, now this is the daily plant loading. I was

Page 77

1 Then during the evening, when most of the people
 2 return to their homes, they are cooking, they are doing
 3 their works, markets are on, everything, then we get
 4 another peak. Lighting load is there. And this peak,
 5 as you can see, is a little bit prolonged. In our
 6 country, this lasts 4 to 5 hours. Morning peak lasts
 7 from 1.5 hours to 2 hours. So in general, in 24 hours
 8 you get 8 hours of the peaking, or maybe less than this.
 9 Then, sir, concentrate on this portion (indicating).
 10 This is the amount of power -- in this graph, almost
 11 12 MW -- which is consistently required, which has
 12 a straight line, which is consistently required from
 13 midnight until 12.00 [noon]. And then the power or the
 14 load which is consistently required by the system is
 15 known as the "baseload" for that system.
 16 So if I am talking of -- if I have a multiplier of
 17 1,000 over here for a system of 25,000 MW, so it means
 18 that I will require 12,000 MW as a baseload. And now
 19 I have a data to give it to the planner, or the planner
 20 has a data to think about how they will use plants in
 21 this baseload, the plants which are most reliable and
 22 cheaper in their production.
 23 The varying load of the system, sir, but which
 24 doesn't vary much, is called the "intermediate load".
 25 It lasts some 14/15 hours a day in 24 hours, or maybe

Page 79

1 talking to you about the baseload, intermediate load and
 2 peak load. So let us first understand what I mean by
 3 baseload, intermediate load and peak load, sir.
 4 Sir, obviously this load requirement is from humans.
 5 Humans are pretty predictable: all of them sleep during
 6 the night. After midnight, everybody feels sleepy and
 7 they sleep.
 8 So if you can see over here, this is the time
 9 starting from midnight up to 12.00 [noon], and this is
 10 the power requirement or the load requirement.
 11 So you can see the minimum requirement is around
 12 12.00 midnight. All of us are sleeping. We don't
 13 require any lights in our rooms, we don't require TV, we
 14 are not interested in going to the restaurants, so the
 15 power requirement is minimum. So this point, we are
 16 achieving this point, sir, indicating lowest point.
 17 Sir, then when the people are rising in the morning,
 18 around 6.00 am, they are switching [on] the lights; the
 19 industrial load is about to come. So we get a minor
 20 peak over here, and this is called the morning peak of
 21 the system. This is for a relatively smaller duration,
 22 maybe 2 hours. And then when the people settle down in
 23 their offices and their workplaces, then the demand goes
 24 down a little bit, but it doesn't touch here because we
 25 are not sleeping; we are still working.

Page 78

1 18 hours. And the peaks, which are the abnormal high
 2 load requirements, last about 8 hours.
 3 So if we multiply this time with these megawatts,
 4 we will get the energy, the base energy required, the
 5 intermediate energy required and the peak energy
 6 required. And now we have arrived to a point where the
 7 planner can, in terms of gigawatt hours, can decide
 8 which plant is best for baseload and which plant is best
 9 for the peak load.
 10 Next slide, please, slide 15.
 11 Sir, again the same: baseload is 24 hours a day;
 12 intermediate load, [8] to 14 hours, depending on the
 13 power system; and peak load, less than 8 hours a day.
 14 Next slide, please, 16.
 15 Sir, this is another view, another way of looking to
 16 the power system. Now we are moving ahead. I have
 17 explained you the daily load curve. Now I will be
 18 talking in broader spectrum: weekly load curve. We can
 19 make this as monthly load curve; we can make it for
 20 a full year load curve. And then we can effectively
 21 plan our power system and the power plants which we have
 22 available to adjust in this system.
 23 So, sir, looking at this graph, now it is days of
 24 the week, starting from Saturday and ending on Sunday.
 25 So you can see peaks are there, everywhere. But on the

Page 80

1 weekends it is relatively less because people are not
 2 working, and on the other days these are quite high.
 3 So this we can get from our daily load curve. And
 4 then we can multiply the time with this load, and we
 5 will be representing it in the percentage of time and
 6 the load requirement, and we will arrive to a graph
 7 which in our power system is called as the "load
 8 duration curve". So now we have arrived to a point
 9 where the planner can easily decide, sir.
 10 This is 100% of the time, sir. This is the baseload
 11 of this power system. Then this (indicating) is the
 12 time where the load requirement is quite high, but it is
 13 quite less in time; and this (indicating) is the peak of
 14 this power system. And the rest is the intermediate
 15 load.
 16 So, slide number 17, sir.
 17 Sir, now in Pakistan we have more than 150 power
 18 plants, different: coal, nuclear, hydel, wind. And now
 19 the system operator has to decide, having this load
 20 curve and the choice of the available power plants, how
 21 he will use to run this power system most reliably and
 22 most economically.
 23 So I will start from the right. This is, sir, my
 24 interest portion, because it is for wet season, where
 25 hydro is baseload. As I am from hydro, I will explain

Page 81

1 starting from here.
 2 Sir, we have a lot of water in the wet season. So
 3 a big hydro like Tarbela, even the Neelum-Jhelum, can
 4 run on baseload. Because a large amount of water is
 5 available, and it is better to operate the power plant
 6 at its optimum level. Variability will be less because
 7 there will be no changing in the load. And obviously
 8 we will get good energy from this power plant, which is
 9 cheap and reliable, sir.
 10 Then nuclear power plants, which are less in
 11 ramping, and which have hazards if they are changing
 12 loads abruptly because of this nuclear uranium present
 13 and variations presented there. So they are preferred,
 14 globally preferred, as a baseload. So nuclear will be
 15 the second choice in this load duration curve.
 16 Then the big coal, the steam power plants. Steam
 17 has a low ramping, sir. If you compare it with a normal
 18 hydro, it has 100 times lower ramping. So it will be
 19 again preferred as a baseload where no major variation
 20 is required.
 21 Then we have the gas turbines, which is quick in
 22 ramping, in the thermal family.
 23 Then the peak, we have -- we may have the combustion
 24 turbines. They are put over here because they are
 25 expensive. They have low efficiency, sir.

Page 82

1 Finally on top the reserve capacity; and by "reserve
 2 capacity", I mean for make up the deficiency, sir. All
 3 these power plants are machinery-based and they can
 4 develop faults. So if one of the power plants develops
 5 a fault and reduces its load, so this reserve capacity
 6 must be there to cover it. Hot reserve capacity must be
 7 there to cater [for] this. This is essential for the
 8 stabilising, stability of the power system, sir.
 9 We can look at the other scenario, sir, which is the
 10 dry season for hydro. You see hydro is missing over
 11 here base, and it is here. The run-of-river plants can
 12 no longer now run as a baseload. It will be used as
 13 a peaking load. But by using it as a peaking load, we
 14 will avoid the combustion turbines, and now we have
 15 a cheaper energy at the top. So we have the advantage.
 16 And the others are in the same economic order as I have
 17 already explained, and the reserve is still from the
 18 combustion chambers.
 19 So that's all, sir, from my side. Now for
 20 Neelum-Jhelum in the power system, this will be
 21 explained and presented to you by Mr Malik, my
 22 co-presenter, chief engineer in WAPDA.
 23 So, thanking you, sir. I am waiting, sir.
 24 THE CHAIRMAN: Thank you very much, Mr Khan. Let me just
 25 check to be sure we don't have any questions.

Page 83

1 No. It was very helpful, Mr Khan.
 2 MR KHAN: Thank you.
 3 THE CHAIRMAN: We appreciate you coming all the way from
 4 across the country to be with us for this.
 5 MR KHAN: My pleasure, sir. Thank you.
 6 THE CHAIRMAN: Thank you very much.
 7 MR KHAN: Thank you, sir.
 8 (Pause)
 9 THE CHAIRMAN: Okay, Mr Malik, we're ready.
 10 MR MALIK: Thank you. Honourable Mr Chairman and Honourable
 11 members of the Arbitration Court, I'm Arshad Malik,
 12 presently working as chief engineer, hydel operation in
 13 head office, Lahore. I have got 31 years of experience
 14 working at different positions of WAPDA, thermal and
 15 hydro projects, and a major part of my service is at
 16 Ghazi Barotha Project, another run-of-river project on
 17 the downstream of Tarbela.
 18 I will be elaborating the concepts given by
 19 Mr Hameedullah in a very good presentation, and will
 20 explain the things, particularly by taking the example
 21 of Neelum-Jhelum Hydro Project, where we are sitting:
 22 how it fits in Pakistan's power system.
 23 So please go to slide 19. Now definitely you are
 24 becoming somewhat expert, and know well that
 25 Neelum-Jhelum Hydro Project is a 969 MW run-of-river

Page 84

1 project, having a small pondage.
 2 And in the region where it's operating, there are
 3 three other projects, hydro run-of-river projects: for
 4 Patrind, having a capacity of 150 MW; and another hydro
 5 project of Karot that is 720 MW; while there is also the
 6 Mangla Project at the River Jhelum, which is a storage
 7 project having a capacity of 1,000 MW.
 8 These projects, as we can expect from the hydro
 9 projects, that in the dry season they're operating as
 10 the combination of the baseload and the peaking load,
 11 depending upon the water and the head available; whereas
 12 the Neelum-Jhelum project specifically, in the wet
 13 season also it is working, like the other conventional
 14 hydro run-of-river projects, as a baseload plant. This
 15 we expect from this plant.
 16 On the left side, this is the switchyard of this
 17 Neelum-Jhelum Project, from where two 500 kV lines are
 18 efficiently transporting the power at the voltage level
 19 of 525 kV to a distance of 285 kilometres in total.
 20 And another interesting thing is that at the
 21 distance of about 80 kilometres, another powerhouse has
 22 been added and connected to these lines. That is the
 23 Karot power station.
 24 Slide 20. Now, this slide, this gives then the
 25 overall view of the power system expansion in the region

Page 85

1 as the total system generation fit with each other. It
 2 has been made on 31 July 2023, which is, you can see,
 3 the peak of the wet season. We expect that water flow
 4 is maximum in this part of the year, and therefore you
 5 can see Neelum-Jhelum is running almost flat throughout
 6 the day, 24 hours, on the baseload of 969 MW.
 7 Same pattern is reflected, with small variations,
 8 with the other hydro projects of WAPDA. You can see
 9 that they are almost running flat, serving the baseload
 10 requirements with some little variations, delivering
 11 about 7,500 MW.
 12 And the big portion you can see, the thermal, it
 13 has -- the total system generation, not only thermal --
 14 this is the total system generation. It has available
 15 peaks which are significantly changing because of the
 16 thermal mix, because in this period of the year we are
 17 having the maximum hydro potential, so we run them as
 18 the baseload, and thermals are just to, you can say,
 19 meet the remaining requirements and serving the peaks in
 20 addition with the hydro systems.
 21 In this part of the year, we are also having the
 22 maximum load requirement; see this figure. In the
 23 coming slides this will be important to see. You see
 24 that the maximum load for the system generation is about
 25 20,000 MW in this period of the year. This is natural

Page 87

1 where the Neelum-Jhelum Project is lying. In this
 2 slide, you are seeing triangles of different colours.
 3 And to understand these, you can see the legend, please.
 4 The green ones, these are the projects which are in
 5 operation. And number 2, this is our Neelum-Jhelum
 6 Project. In its vicinity, number 4, is the Patrind
 7 Project. While coming down, it's the Karot Project at
 8 the River Jhelum. And this is the Mangla Power Project
 9 in the green colour.
 10 While the red colour triangles, these are the plants
 11 which are under construction. And these violet-coloured
 12 triangles, these are showing the plants which are in the
 13 planning phase, and they are going through that.
 14 All these plants are planned in such a manner,
 15 including the Neelum-Jhelum Project, not to [only] serve
 16 the present needs of the country and the system, but
 17 also the future requirements. So availability of these
 18 plants gives the system operator the flexibility to
 19 harness the benefits of cheap hydroelectricity which is
 20 available, as well as it can fit well to the system
 21 requirements, especially in the role of adapting to the
 22 load changes and coping with emergencies.
 23 Slide 21, please. Now come to see this slide. This
 24 shows the generation curve of the whole system, and how
 25 the Neelum-Jhelum and the WAPDA hydro projects as well

Page 86

1 because in July we are having hard temperatures, so the
 2 loads like air conditioners and similar things, these
 3 are definitely in extensive use. So that's why the
 4 generation required is also maximum in this period of
 5 the year.
 6 Slide 22, please. Now, this is the other side of
 7 the picture. Look at this date. This is almost the
 8 peak of the dry season: 23 December 2023 this generation
 9 graph has been taken. It reflects also the
 10 Neelum-Jhelum, the WAPDA hydro and the total system
 11 generation.
 12 Look to interesting behaviour of Neelum-Jhelum in
 13 this period on this day specifically. You see that it's
 14 operating very below its peak for about 10 hours, when
 15 it is switched off then so that some water is stored.
 16 And later on in the peak time, it started again to feed
 17 the peak load, but definitely at very low capacity
 18 beyond its installed capacity.
 19 Why it is so? It's already explained that all the
 20 hydro projects are highly dependent on two variables
 21 which are in the hydro generation. One is the available
 22 flow; and the other one, the available head. If these
 23 are available, definitely system operators prefer them
 24 to operate. And if it is normal, then these sources,
 25 they are to be utilised.

Page 88

1 You can see now the behaviour of the other hydros.
 2 It's quite different from the Neelum. They are running
 3 from these hours to drop up to these hours also up to
 4 the base, and observing some peaks, some peak time from
 5 here and here. But they're running almost throughout
 6 the day and run at the base and peak combination, and
 7 fitting in the overall generation of the system with the
 8 available hydro capacity.
 9 The interesting thing which I have pointed out
 10 before, look here: that the total demand is below
 11 12,000 MW in this period of the year, which was above or
 12 near about 20,000 MW in the summer seasons; naturally,
 13 because the temperature is low, so the big load of
 14 air conditioners and similar items is shut off.
 15 Please go to slide 23. Now, this is the period of
 16 the intermediate generation which is reflected. And you
 17 can see this is March 2024 this year.
 18 Neelum-Jhelum is an early riser: water comes early.
 19 And because of the arrival of the water, you see the
 20 behaviour in the operation of Neelum-Jhelum in this
 21 brown colour; it has also changed. It is now running
 22 throughout the day for 24 hours, with the combination of
 23 the base and peak loads as per availability of the water
 24 in the head, and the system fitting into the system
 25 requirements along with the other hydro plants of WAPDA,

Page 89

1 up to near 400 MW; whereas, correspondingly, the peaking
 2 load is also, with some spikes and with increase in the
 3 water flow, it also has a similar trend in gradually
 4 increasing. And ultimately it goes up to near 700 MW
 5 during the month of February.
 6 So this is the period of the intermediate
 7 generation, where we have both the baseload and the peak
 8 loads because of, you can say, the feature of the early
 9 riser of Neelum-Jhelum, which gets the water earlier
 10 than Tarbela.
 11 Slide 25, please. This slide, here we have taken
 12 the turbine discharge in this brown colour, and the
 13 corresponding power generation in this colour, the red
 14 one. You can see starting from July, which is the peak
 15 period, or we can say the wet season, where we have the
 16 maximum flow.
 17 In this period of time, the required discharge for
 18 Neelum-Jhelum to have the maximum generation is
 19 available throughout: nearly you can say 280 cumecs are
 20 required for running four units on full load. We had
 21 almost the maximum generation in this period of time,
 22 running them at the baseload, as I have already
 23 described.
 24 Then when the water inflow reduces, correspondingly
 25 the turbine discharge, which is used for the generation

Page 91

1 which are following always the same pattern for the
 2 baseload, the peaks, and fitting into overall generation
 3 pattern depending upon the availability and the system
 4 requirements.
 5 And also see that with this change in the season and
 6 the temperature or the weather, the generation demand is
 7 also changing: from 12,000, it has reached almost to
 8 14,000. So this is a scenario which is reflecting that
 9 how the behaviour of the system, the load demands and
 10 the operations of the plants, they are changing with the
 11 passage of time; and how the system operator makes the
 12 decision depending upon the available powerhouses, the
 13 storage capacity and things like that. He makes the
 14 decision keeping in view all these things.
 15 Let's go to, please, slide 24. This is taking only
 16 for isolated behaviour of Neelum-Jhelum Project in the
 17 month of February. And the whole month of February is
 18 covered here. Water has started coming, and with the
 19 increase in the water flow, there is also gradual load
 20 rise with some spikes increase in the generation of the
 21 Neelum-Jhelum. This is the baseload and this is the
 22 peak load, only for Neelum-Jhelum. As you can see,
 23 after some flat period it is gradually increasing, some
 24 spikes, and then increasing.
 25 And ultimately it goes to near flat in the baseload,

Page 90

1 reduces, and the power generation also reduces. And
 2 where we come here, you can see in the period here of
 3 December and January, you can see the generation is
 4 almost stopped, and it's zero. And in these months'
 5 period if time we have only the environmental discharge,
 6 there's no generation.
 7 This behaviour then continues till the water
 8 arrives. And with that arrival, there's some little
 9 generation, which continues to increase with the
 10 increase in the water, you can say the inflow,
 11 accordingly the discharge, and then the power
 12 generation.
 13 Ultimately, in March we are able to have the maximum
 14 installed capacity generation of 969 MW, which then
 15 continues. And the best periods of the generation are
 16 here from almost up till, let's say, September we are
 17 having the maximum generation in that period of time.
 18 Slide 26, please. Now, here comes the interesting
 19 slide, the production plans. How the operator plans his
 20 generations, these are based on the requirements of the
 21 system as well as the capacity of the hydro plant. But
 22 capacity means both the machines are available, because
 23 particularly the machines are also shut down and some
 24 maintenance work has to be done, it depends on that; how
 25 the plant planned that. And sometimes the machines are

Page 92

1 having a preventive maintenance; they are usually done
 2 over a period of a year. But depending upon conditions
 3 the system operator decides when to give the shutdown to
 4 any machine, and when to make off: the system operator
 5 makes these decisions.
 6 However, if the plant is unconstrained, even then,
 7 depending upon its own particular conditions it will
 8 operate in a different manner. So this is very
 9 important to describe here. Although the Neelum-Jhelum
 10 and Ghazi Barotha Projects are fundamentally having the
 11 same design, but they are operating in a different
 12 manner.
 13 The actual reason for this difference of operation
 14 of Neelum-Jhelum and Ghazi Barotha is that for
 15 Neelum-Jhelum we are not having a big storage otherwise,
 16 unlike Ghazi Barotha, which has, on its upstream,
 17 Tarbela. Tarbela has a large storage, and Ghazi Barotha
 18 is immediately downstream of this Tarbela power project.
 19 The other thing which makes the difference in the
 20 operation for Neelum-Jhelum and Ghazi Barotha is that
 21 Ghazi Barotha has got some more pondage at site itself
 22 Barotha station is lying, as well as at barrage. And
 23 whereas Neelum-Jhelum has got a little pondage, only of
 24 itself, which you have seen during your visit at C1
 25 site.

Page 93

1 So accordingly, Ghazi Barotha is used more
 2 aggressively during the peaking hours in the dry season
 3 because of the reason which I have already told you,
 4 that it has a big reservoir only upstream, in the form
 5 of Tarbela, and there is some pondage. So this makes
 6 the big difference in the operation of Neelum-Jhelum and
 7 Ghazi Barotha: Neelum-Jhelum is totally dependent upon
 8 the water inflows.
 9 Next slide, please, slide 27. So the concept which
 10 I've already given is reflected in these slides and the
 11 coming slide. The Ghazi Barotha project off-peak
 12 production is reflected here over a period of a year.
 13 This in red colour shows the off-peak generation of the
 14 Ghazi Barotha, whereas this green colour is reflecting
 15 the generation from the Neelum-Jhelum. And for the
 16 reason which I have described, you can see behaviour in
 17 this off-peak production from Ghazi Barotha, as well as
 18 the peak you will see later on.
 19 Here, you will see that both are following the same
 20 pattern till here, and both are operating at the maximum
 21 load, supplying the grid you can say from this period
 22 onwards, the peak season for the water inflow, and the
 23 period of the months of July and August. And then
 24 there's a steep decline gradually in the production from
 25 the Neelum-Jhelum for these off-peak hours, subject to

Page 94

1 the water availability; whereas the Ghazi Barotha, it
 2 drops and follows the pattern of the Neelum-Jhelum by
 3 December for a short period of time only.
 4 And then later on, the Ghazi Barotha again rises and
 5 gives much more generation than the Neelum-Jhelum
 6 because of the factors that I have explained whereas
 7 Neelum-Jhelum starts performing and generating more near
 8 its capacity by March, which is when it is able to
 9 generate at its installed capacity, already described.
 10 Okay?
 11 THE CHAIRMAN: A question for you, Mr Malik. So looking at
 12 the comparison of these two hydroelectric plants, it
 13 does seem that there's great value in having a larger
 14 pondage so that you can generate power throughout the
 15 year. Why would it be that at Neelum-Jhelum the dam
 16 wasn't designed perhaps to have a higher dam so that you
 17 could have more pondage to achieve a comparable result
 18 of what you got at Ghazi Barotha? Is it a cost issue or
 19 is it other issues?
 20 MR MALIK: These things have been explained by my friends
 21 also. And what I remember -- tell if I'm wrong, I will
 22 take help from Mr Ayub -- you can say that before it has
 23 been explained that the geological conditions, they have
 24 prevented to make a big reservoir there. The
 25 excavations in that dam area were difficult.

Page 95

1 And the other thing was that what advantage has been
 2 taken, that having this tunnelling of 28 kilometres, the
 3 high head has been depleted by covering in terms of
 4 distance. And through that, we have been enabled to
 5 use, with very small quantity of water, the generation
 6 near to Ghazi Barotha. One unit of Ghazi Barotha, it
 7 generates 290 MW. But for that 290 MW, it requires
 8 468 cumecs of water because the head there is only
 9 69 metres. Whereas for this project, the head is
 10 420 metres, and that's why it requires only 70 cumecs
 11 instead of 468 cumecs.
 12 So these are different things which have been in the
 13 minds of the designers.
 14 THE CHAIRMAN: Okay, thank you.
 15 MR MALIK: Slide 28, please. Now, this is the behaviour of
 16 the Ghazi Barotha project for the peak production. You
 17 can see that it is aggressively used almost throughout
 18 the year, as compared to the Neelum which is in the
 19 green colour. And only for a small period of time the
 20 peak production is less, and which restores much earlier
 21 than the Neelum-Jhelum. And it follows almost then the
 22 pattern after the months December, January, from
 23 February onwards, the Neelum-Jhelum, whenever it starts,
 24 from March onwards, to serve the peaks at par with the
 25 Ghazi Barotha station.

Page 96

1 So these are the things and the concepts I think
 2 I have been able to clear you. And if there are still
 3 any questions, you are welcome, please.
 4 THE CHAIRMAN: Thank you, Mr Malik. Let me just check to
 5 see if we have a question. Professor Wouter.
 6 PROFESSOR BUYTAERT: Yes, thank you.
 7 Would you be able to go back to slide 25, please.
 8 Two questions on that slide.
 9 First, a quick technical question. You see those
 10 big drop-downs during the wet season, where I assume the
 11 turbines were switched off. Is that because of
 12 maintenance? So you see during the wet season,
 13 occasional peaks down to zero. Is that because of
 14 maintenance or is that because of a lack of need to
 15 produce electricity?
 16 MR MALIK: Yes, what I remember: that in this period of time
 17 we were having some maintenance activities.
 18 PROFESSOR BUYTAERT: Maintenance, okay.
 19 MR MALIK: Yes.
 20 PROFESSOR BUYTAERT: Thank you.
 21 And then looking curve this is of course for
 22 2021-2022 and looking at about the time of year we are
 23 now, the end of April, at least in this year it seems to
 24 be already at maximum capacity and high flows, which
 25 seems to be much higher than what we have at the moment.

Page 97

1 operation and maintenance.
 2 THE CHAIRMAN: Sean Murphy. Nice to meet you.
 3 MR MIANA: This is project director for the Neelum-Jhelum
 4 Project.
 5 THE CHAIRMAN: Good to see you again.
 6 MR MIANA: He's the resident engineer, mechanical.
 7 THE CHAIRMAN: Nice to meet you. Sean Murphy.
 8 MR MIANA: The resident engineer, electrical.
 9 THE CHAIRMAN: A pleasure.
 10 MR MIANA: He's the senior engineer, operation.
 11 THE CHAIRMAN: Nice to meet you.
 12 MR MIANA: And the senior engineer, electrical.
 13 THE CHAIRMAN: Wonderful. Nice to meet you, sir.
 14 MR MIANA: So we'll start with looking at the switchyard
 15 because we have the opportunity that there's no rain
 16 over there.
 17 THE CHAIRMAN: Okay.
 18 MR MIANA: So it's fine, we can take that opportunity.
 19 So at the left-hand side is the powerhouse which we
 20 have already seen is on the ground side. So here is the
 21 power coming from the inside. We have the two adits
 22 over there. We call it adit A5 -- tunnel A5 and tunnel
 23 A6. So this tunnel is going that we have shown in the
 24 pink and the green colour in our slides, over there.
 25 So the power coming from the A6 side, which is

Page 99

1 Does that mean that we are currently in relatively
 2 dry conditions, or is that just an impression?
 3 MR MALIK: I have already described that all these decisions
 4 regarding the running and loading, these are to be made
 5 by the system operator. How he fits the things in his
 6 system primarily depends on him.
 7 And if the summer works are to be done by the local
 8 plant operator locally, then they make their requests to
 9 have some works to be done, and accordingly it's
 10 registered. So it's a matter of the decision merely
 11 because of the system operator, how he fits any plant in
 12 the generation plan. It depends mainly on him.
 13 PROFESSOR BUYTAERT: Yes, okay, thank you.
 14 THE CHAIRMAN: Okay, Mr Malik, I think we have no further
 15 questions, but thank you very much for your
 16 presentation. It was quite helpful.
 17 MR MALIK: Thank you. My pleasure.
 18 Presentation 11: Powerhouse Inspection
 19 MR MIANA: Mr Chairman and members of the Court, good
 20 afternoon and welcome to the powerhouse site. We are at
 21 the entrance to the control building for the powerhouse.
 22 First of all, I would like to introduce my operation
 23 and maintenance team.
 24 THE CHAIRMAN: Very good.
 25 MR MIANA: So that is headed by the chief engineer of

Page 98

1 a cable tunnel as well, and that cable is terminating in
 2 the switchyard over here.
 3 THE CHAIRMAN: I see.
 4 MR MIANA: And from this switchyard, we have the
 5 transmission line going outside, we can see over there.
 6 This one. The tower at the top is taking the power
 7 evacuation from this powerhouse.
 8 THE CHAIRMAN: Can we walk over a little bit?
 9 MR MIANA: Sure, sure. (Pause)
 10 So this switchyard consists of all the equipment,
 11 like the equipment which isolate and circuit-breakers:
 12 the current transformer, the protection transformer for
 13 metering, for instrumentation and for the protection
 14 system and for the electrical instrumentation. So
 15 everything is in there.
 16 Now, at the moment they are taking power to the
 17 national grid over there. This is a double busbar
 18 one-and-a-half-breaker scheme. One-and-a-half-breaker
 19 scheme has the advantage that it takes less space, but
 20 it works like a double-breaker scheme. So at the
 21 moment, two units are -- one going outline and one unit
 22 can be put in one-and-a-half-breaker scheme. So if one
 23 breaker is under maintenance, so we will not have any
 24 problem for the operation of the power.
 25 THE CHAIRMAN: All of the power is going out through those

Page 100

1 lines up there?
 2 MR MIANA: These are the lines to the national grid over
 3 there.
 4 THE CHAIRMAN: So you're not taking us into the ...?
 5 MR MIANA: No, we can, we can.
 6 THE CHAIRMAN: No, no, no.
 7 MR MIANA: That's providing the (indistinct), because there
 8 is the corona effect, you can hear the noise. This is
 9 the corona effect.
 10 THE CHAIRMAN: Ah, okay.
 11 MR MIANA: This is the high tension, the high voltage is
 12 there. So that creates the ionisation of the air, and
 13 that creates that noise over there.
 14 THE CHAIRMAN: Interesting.
 15 MR MINEAR: What is the current electric production at this
 16 moment?
 17 MR MIANA: Actually production power or electricity?
 18 We explain in the -- we are going there, okay.
 19 MR MINEAR: Okay, great.
 20 THE CHAIRMAN: Good. Wonderful, thank you. (Pause)
 21 MR MIANA: So the same safety rules are mostly given
 22 already. We will come down over here after visiting
 23 there. Maybe we have to check Professor Wouter over
 24 there, just the height, the head.
 25 So here comes the main control room for the power

Page 101

1 the HRT, so we have restricted the load to 530 MW with
 2 the consultation with the consultants.
 3 We are working on that one, first to have the ROV
 4 inspection and then to see what has happened inside.
 5 Why 530; why not 500 or why not 600? We have calculated
 6 the velocity, and this velocity is within the
 7 permissible limit of the velocity within the HRT. So we
 8 are working on that limit.
 9 At the moment, all four units are in operation. The
 10 unit no. 4 is generating 125 MW; unit no. 3 is
 11 generating 150 MW; third one, unit no. 2, is generating
 12 130 MW; and unit no. 1 is generating 124 MW. So
 13 altogether -- can we switch it to the other picture?
 14 So this indicates the electrical parameters. So the
 15 green lines are showing the active power, the megawatt
 16 generation from each of the units. You can see it. And
 17 there are all the parameters, starting from the
 18 megawatts: megawatts, generation voltage, generation of
 19 electricity, the frequency, and the available head over
 20 there, and the servo motor position. This is the wicket
 21 gate position that we have been talking about.
 22 So you can see this is at 51% and this is 49%,
 23 because load is 125 on that one, and there the load is
 24 130, so slightly above that one. Similarly, the load at
 25 unit no. 3 is 150. So it's 55% opening. So as soon as

Page 103

1 transmission, everything. These are the two shift
 2 engineers -- please take your seats and do your work.
 3 These are the shift engineers responsible for the smooth
 4 operation of the powerhouse. And in case of any fault
 5 or any indication coming, so they have to take action
 6 immediately. So all the time, 24-hour, their shifts are
 7 there to be covered in the shifts, and they are
 8 responsible for all these things.
 9 I will explain over there, starting from the
 10 switchyard from there. I can go there, just to give you
 11 more information.
 12 So here we have the four generator units: 1, 2 3 and
 13 4. And I have already explained the double busbar. We
 14 have two busbars over here, and one-and-a-half-breaker
 15 scheme. We call one-and-a-half-breaker scheme because
 16 we have three breakers over there: 1, 2 and 3.
 17 So these three breakers are for the dual operation.
 18 Like, in this bay we have one transmission line and one
 19 generator is coming. So in case of fault or maintenance
 20 of any of the circuit-breakers, we'll be able to have
 21 connection with both of these busbars.
 22 So this is our generation side. And at the moment
 23 we are operating all four units, but with restricted
 24 load of 530 MW. The water is available, but during the
 25 first week of April we find the pressure fluctuation in

Page 102

1 we open the wicket gates, the generation exceeds this
 2 one. So this is what happens. And altogether we have
 3 530 MW over here, generating this one.
 4 DR BLACKMORE: So who's controlling the wicket gates? Are
 5 they controlled from here, or is that automatic?
 6 MR MIANA: At the moment they are automatically controlled
 7 with the frequency and the output that we have given as
 8 a set point to the generators. But if the system
 9 operator asks to reduce the load due to any outage at
 10 this one, then our shift are responsible to adjust the
 11 load.
 12 THE CHAIRMAN: Does the step-up get recorded here?
 13 MR MIANA: Step-up is not ... (Confers in Urdu)
 14 This diagram. So our generation at this one here,
 15 we are generating at this one at 15.5, 15.75, and we are
 16 stepping up from this transformer to the 525. So these
 17 are actually the common nomenclature and the
 18 identification for presenting in their drawings for the
 19 step-up and step-down for this one.
 20 So we already also have the CCTV all around the
 21 powerhouse. We can see all these three screens are
 22 showing the different locations inside the powerhouse
 23 and outside the powerhouse.
 24 That's this control room. But if you have any
 25 questions about the control room or this one; otherwise

Page 104

1 we will proceed.
 2 THE CHAIRMAN: So when you receive the instructions from the
 3 National Power ...
 4 MR MIANA: Control Centre.
 5 THE CHAIRMAN: ... Control Centre, do they come to this
 6 room, and you then adjust to provide them with the power
 7 that they seek?
 8 MR MIANA: Yes. This is a communication through the telecom
 9 system.
 10 DR BLACKMORE: Are those communications verbal or over the
 11 computer?
 12 MR MIANA: Both.
 13 DR BLACKMORE: Both?
 14 MR MIANA: If it is the immediate action, it's verbal --
 15 DR BLACKMORE: Yes.
 16 MR MIANA: -- but that would also be documented.
 17 DR BLACKMORE: Okay.
 18 MR MIANA: And also our shift operator -- let me show you
 19 one thing. (Confers in Urdu) He records every event in
 20 this one. (Confers in Urdu)
 21 So then the shift in charge takes over the shift.
 22 Then the shift changes. So they record the shift charge
 23 taken over by these engineers, and then they start
 24 writing every event over there. You can see the time:
 25 9.30, then 10.04, and even 10.21 and 11.40. Every event

Page 105

1 is it taken up there?
 2 MR MIANA: That person responsible for the inflows and the
 3 safety of the dam.
 4 THE CHAIRMAN: Yes.
 5 MR MIANA: So altogether, when he changes the inflow, the
 6 outflow regulates. So he immediately informs that, he
 7 gives the message. They also give the message in case
 8 of the increasing flow to the local administration
 9 downstream, so that everybody should be ready for the
 10 increase in flow.
 11 THE CHAIRMAN: Very good. Questions?
 12 PROFESSOR BUYTAERT: I saw that on the previous screen you
 13 also had the other two power plants on there.
 14 MR MIANA: (Confers in Urdu)
 15 PROFESSOR BUYTAERT: So at the top you've got (indistinct)
 16 power plants?
 17 MR MIANA: No, these are not the power plants; these are the
 18 outgoing lines.
 19 PROFESSOR BUYTAERT: Okay.
 20 MR MIANA: One is going to the Karot hydropower plant and
 21 the other is going to the Ghakkar grid station.
 22 PROFESSOR BUYTAERT: Okay, yes. And from there then they go
 23 on to the national grid?
 24 MR MIANA: Basically -- you already know about that -- we
 25 have downstream the Karot hydropower.

Page 107

1 is recorded on this one. So it's a permanent document
 2 over there.
 3 At the end of this, the shift engineer also signs
 4 and dates it over there, just to make that he has
 5 returned all these things.
 6 THE CHAIRMAN: Is there any particular communication between
 7 the powerhouse and the dam site?
 8 MR MIANA: Yes, we have three kinds of the communication
 9 with the powerhouse and dam site. (Confers in Urdu)
 10 So we have this one data coming from the dam site to
 11 the satellite, and then we have the communication
 12 through Thuraya satellite telephone, and the third one
 13 is the local communication system.
 14 DR BLACKMORE: Okay. All three are closed?
 15 MR MIANA: All three are closed, yes.
 16 We are also getting that inflow data. (Confers in
 17 Urdu) This one. So now we can see the intake level is
 18 this one. It's coming from that one. And this is the
 19 TRT pressure over there, and this is the HRT pressure
 20 that we are observing. We are putting the yellow colour
 21 different, just for observation. And these are
 22 megawatts and this is frequency. So we are getting
 23 online data, this one.
 24 THE CHAIRMAN: Would you say that the instructions as to
 25 where to place the gates and so on comes from here, or

Page 106

1 PROFESSOR BUYTAERT: Ah, okay. That's the --
 2 MR MIANA: So one circuit goes, terminates there, and then
 3 out from there.
 4 PROFESSOR BUYTAERT: Yes. So --
 5 MR MIANA: So one is directly going to this one, the Ghakkar
 6 grid station 2.
 7 PROFESSOR BUYTAERT: Yes. So from here you've got two lines
 8 going --
 9 MR MIANA: Two lines and one pole.
 10 PROFESSOR BUYTAERT: Okay.
 11 MR MIANA: Each side. Double circuit.
 12 PROFESSOR BUYTAERT: Thank you.
 13 THE CHAIRMAN: Very good. Very interesting. Thank you.
 14 MR MIANA: So we'll move to the downstairs again. (Pause)
 15 So I will show you some instrumentation and
 16 switchgear installed there.
 17 THE CHAIRMAN: Very good.
 18 MR MIANA: So here we have the --
 19 THE CHAIRMAN: Let's wait for the ...
 20 MR MIANA: Sorry, sorry. But it's already going here.
 21 THE CHAIRMAN: I know. But I like to have the other members
 22 here so they can see you pointing.
 23 MR MIANA: Okay. Sure, sure.
 24 So this is with the busbar protection schemes for
 25 the switchyard. I already mentioned busbar 1 and

Page 108

1 busbar 2. So there are two busbars over there,
 2 different breakers: middle breaker, side breaker and the
 3 other breaker. So everything is coming over here and
 4 switching from there. They are controlling and
 5 protecting all these things from this one.
 6 THE CHAIRMAN: So this is taking the power that's coming out
 7 of the turbines and moving it into the switch --
 8 MR MIANA: Yard.
 9 THE CHAIRMAN: Before it gets stepped up, or has it already
 10 been stepped up?
 11 MR MIANA: Already stepped up.
 12 THE CHAIRMAN: Okay.
 13 MR MIANA: The step-up is inside the powerhouse.
 14 THE CHAIRMAN: Ah.
 15 MR MIANA: Yes. We will see the transformer inside.
 16 THE CHAIRMAN: Okay.
 17 MR MIANA: We will go to where the transformer is.
 18 Actually this is only the protection system. So
 19 there everything -- we cannot work all that well there,
 20 just to have an indication of any fault, taking some
 21 reading. Metering, all instrumentation, everything is
 22 done from this panel.
 23 MR MINEAR: These are basically your circuit-breakers,
 24 you said?
 25 MR MIANA: Circuit-breakers and all the other -- all

Page 109

1 equipment. So we have data up there coming.
 2 This is our private exchange used for the local
 3 control over there. This is the administrator for
 4 private exchange for the communication between the
 5 control building and with the powerhouse, and even with
 6 the (indistinct) meters. So this is a private exchange,
 7 with automatic exchange installed over there.
 8 THE CHAIRMAN: Very good. (Pause)
 9 MR MIANA: So this is the battery room. So we have two sets
 10 of the battery level: one is a 48V, the other is a 220V.
 11 The 48 is also sometimes stepped down for the different
 12 protection relays and the metering. And each cell is
 13 2V. And these are the 220V batteries over here. Just
 14 in case of the emergency, everything is switched off,
 15 the battery will take the load to the -- for the
 16 essential load and for the emergency loads.
 17 PROFESSOR BUYTAERT: Are those lead acid batteries?
 18 MR MIANA: Sorry?
 19 PROFESSOR BUYTAERT: Are those lead acid batteries?
 20 MR MIANA: Lead acid batteries.
 21 DR BLACKMORE: These are exactly the same batteries I have
 22 for my solar!
 23 MR MIANA: But these are dry batteries. They are dry
 24 batteries.
 25 THE CHAIRMAN: Very interesting.

Page 110

1 MR MIANA: Thank you. (Pause)
 2 So now we'll move to the powerhouse inside the
 3 tunnel. So I think they have to close this one, or
 4 I don't know whether they will continue with this one.
 5 (Pause)
 6 MR MIANA: So welcome to the powerhouse. We are at the
 7 entrance gate of the Neelum-Jhelum Hydroelectric
 8 Project, 969 MW. We will go in a small group, so that
 9 I can communicate with you more clearly.
 10 I will also request, as I mentioned in my briefing,
 11 that all the panels are energised, so try not to touch
 12 them. And I would also request all the guests who are
 13 travelling with us inside the room, they should take all
 14 the safety PPEs, personal protective equipment, and
 15 please do not touch anything. If you want to have some
 16 clarification, you can ask the operation people, they
 17 can clarify to [you].
 18 Okay, so just moving inside.
 19 THE CHAIRMAN: Thank you. (Pause)
 20 MR MIANA: If you like, you can also have the earmuffs. If
 21 you like the earmuffs, it will feel more nice your ears.
 22 It will feel more nice over there. (Pause)
 23 So let me start with the two cranes that I have
 24 mentioned in most of our presentations over there. We
 25 have two cranes, 275 tonnes each, so altogether we have

Page 111

1 550 tonnes capacity for the lifting of the heaviest part
 2 in this powerhouse.
 3 The heaviest part is the rotor, as I mentioned in my
 4 presentation number 8. The heaviest part is the rotor,
 5 which is about 450-460 tonnes. So the tandem operation
 6 with (inaudible) the crane and electrically it is
 7 operated by one operator. So that is called the tandem
 8 operation.
 9 THE CHAIRMAN: And these can go down the galley to the
 10 location they're needed?
 11 MR MIANA: Yes, they can go up to this one, along all this
 12 rail over there they will travel to.
 13 So we'll just go to this one, and we'll see the
 14 other things over there. (Pause)
 15 We have already seen this when we were on the dam
 16 site from the upstairs. The same photograph there, just
 17 for the presentation, when some delegates come,
 18 we present them directly on this floor.
 19 With this we have the tunnelling system over here,
 20 we have already seen this one, and at the moment we are
 21 here in this powerhouse site.
 22 If we look at the salient features, we have the
 23 composite dam, gravity plus rockfill, and its length is
 24 160 metres. The rest is the earth-filled dam,
 25 65-70 metres. This is the length of single tunnel,

Page 112

1 length of TRT, the total head for this one, the total
 2 discharge for the operation of all four units, and this
 3 is the output of the four units over there.
 4 This is the annual energy generation of 4.6 billion.
 5 And this is the (indistinct) of the powerhouse plant
 6 that we have [been] involved in construction of this
 7 one.
 8 This is the installed data of this one. And up till
 9 now, we have generation up to -- they have put down the
 10 latest figure, 19.9. I only show at 19.6 in my
 11 presentation, but that was a couple of days ago. So now
 12 they put today this figure over there.
 13 THE CHAIRMAN: Very good.
 14 MR MIANA: So at the moment we are just here, inside this
 15 one (indicating).
 16 This is the cavern, the powerhouse cavern or the big
 17 cavern. We'll also go to the other side in the
 18 transformer room, where the small cavern, we'll see over
 19 that. Before going to that, we'll just go around this
 20 powerhouse and I will try to explain over there.
 21 Here is the unit number 4 in front of us and this is
 22 the excitation system for that one. I already mentioned
 23 during the presentation that the exciter gives the DC
 24 current to the poles, and then when the pole generates
 25 the electricity, which is collected at the rotor. So

Page 113

1 generator. The inside is red, is the rotation rotor,
 2 and outside yellow is the stationary parts. So these
 3 are all parameters. We can see from here the maximum
 4 upper limit air gap is coming over there, round the
 5 variation to all the parameters (inaudible) which been
 6 installed and other protection and the effective
 7 operation of the plant.
 8 Then we can see the similar -- the upgrade, this
 9 one. This is the generator. From there we are
 10 generating 15.75 kV. At the moment it's 15.78 over
 11 there, we can see on the top of this one. And from this
 12 one, we can also see the unit speed, 99.9. It means
 13 300 RPM is 100%; slight variation because of the
 14 frequency changes.
 15 And then the servo motor, the wicket gate opening
 16 over there, 48%. And the flow at the moment is
 17 36 cumecs over there. And the field voltage for the
 18 excitation, 159 V, and the field current is 1,026.
 19 So do we have generation? The power is okay, but do
 20 we have the generation connection for this one?
 21 Okay, sir. So then we have there breakers, earth
 22 switch, and here is the transformer with this one.
 23 There we'll step up the transformer. Just before
 24 reaching the 525 kV switchyard that is showing on the
 25 top one.

Page 115

1 this is the excitation system; beneath this one is the
 2 generator.
 3 So let's have a look on this one downstairs. There
 4 we can see the main inlet power over there. That's what
 5 we're talking about. Just upstream of this one, this
 6 one is the penstock, and downstream to this one is the
 7 spiral case. And inside the spiral case we have the
 8 stationary vanes, then the wicket gates and then the
 9 runner. So we'll go there; that's just to describe from
 10 here.
 11 THE CHAIRMAN: And that is the counterweight there?
 12 MR MIANA: These are the counterweights. They are holding
 13 MIV in balance (inaudible). And the other one is there
 14 in case of emergency, power failure of the complete
 15 powerhouse, then they can move by their weight, close
 16 the unit to avoid any damage.
 17 MR MINEAR: How do you actuate the counterweights?
 18 MR MIANA: How?
 19 MR MINEAR: How do you begin them? What do you do to
 20 trigger them?
 21 MR MIANA: We have the hydraulic system to operate them.
 22 We will see that hydraulic system when we go down there.
 23 (Pause)
 24 So this is the online monitoring panel number 4, for
 25 unit number 4. Here we can see the picture of the

Page 114

1 THE CHAIRMAN: And this is just for this turbine?
 2 MR MIANA: Yes, panel number 4. So each unit has a separate
 3 control panel over there. So we'll go around there.
 4 These are different switches: the generator
 5 construction panel, overall unit control panel, and this
 6 is extra (indistinct). This you can supply over there.
 7 So here we can see the unit number 3 in operation.
 8 The red light indicates that unit is in operation. When
 9 the unit is shut down, this light will not be glowing;
 10 it will be switched off. (Pause)
 11 Here we will see the whole picture and the
 12 cross-section of the Francis turbine. The lower part is
 13 showing the runner and the wicket gate and the spiral
 14 case, the middle is to the shaft over there, and this is
 15 the generator over there. So we have all the parameters
 16 which are required, which has been given the
 17 instrumentation it's displaying over there.
 18 Similarly, this one, number 3, is generating power
 19 149-150 MW at the moment. (Pause)
 20 Just for the record, just to show you, this is our
 21 turbine operator over here. They also work in the
 22 shifts. And they take all the parameters which are
 23 displaying overhead just for the record. You can see
 24 the parameters that are displaying on those panels, they
 25 also record hourly readings over there, and we have that

Page 116

1 record for the years.
 2 So since the start of 2018 we have all the records,
 3 all these are available with us. So whenever we want to
 4 analyse some fault at this one and we want to compare
 5 the old parameters, so we can just take the sheets out
 6 and we can compare it.
 7 Similarly, this is the unit number 2 over there.
 8 And finally, the unit number 1 over here. And the
 9 same panel also installed for these units. So all the
 10 units have their separate operational panel and their
 11 instrumentation panel, so they are operating separately,
 12 independently.
 13 THE CHAIRMAN: And right now all four are operating?
 14 MR MIANA: Four are operational, yes. Because all the red
 15 lights are on.
 16 DR BLACKMORE: I notice that the chamber is very dry. So
 17 just looking at your drainage, you have a lot of
 18 drainage around to keep it dry?
 19 MR MIANA: Yes, we already mentioned that there is upstream
 20 drainage gallery over there.
 21 DR BLACKMORE: Yes, it's on that side. Okay.
 22 THE CHAIRMAN: And the reason for the cavern to be so high
 23 is so the cranes can operate?
 24 MR MIANA: Yes, because we have to take the lower part and
 25 this height maximise, and then the height of the shaft.

Page 117

1 THE CHAIRMAN: Okay. So how far down are we underneath the
 2 mountain?
 3 MR MIANA: At this place, I think about 300 metres. I will
 4 check, but it's around 300 metres.
 5 THE CHAIRMAN: Okay.
 6 MR MIANA: But that varies from the C one to this one,
 7 starting from 200 metres and the maximum that we have
 8 are 2,000 metres. So maybe here 300, plus/minus. Maybe
 9 I have to check the exact figure. But it's around
 10 300-350 over there.
 11 MR MALIK: This is 600. Overburden is about 300-plus,
 12 300 metres-plus.
 13 MR MIANA: We will go down, then come up.
 14 THE CHAIRMAN: Perhaps we'll do a group photo of the Court
 15 on this side.
 16 MR MIANA: Okay. Okay, you can take now, because we have
 17 plans to go down as well.
 18 THE CHAIRMAN: We could do one down there too.
 19 MR MIANA: Yes, yes.
 20 THE CHAIRMAN: But this is a wonderful space, so ...
 21 MR MIANA: I think better if you stand with the unit
 22 number 4, then the whole picture is shown there.
 23 THE CHAIRMAN: Okay, perfect.
 24 MR MIANA: We have that place for the photographs.
 25 THE CHAIRMAN: Okay. (Pause)

Page 118

1 MR MIANA: So by standing over here, you can (inaudible)
 2 over here. (Pause)
 3 So we'll go by stair. I will come to the elevator.
 4 (Pause)
 5 So we are at the basement number 1 of (inaudible)
 6 this one, and the elevation at this point is 594. The
 7 elevation at generator floor was 600 metres. And also
 8 I forgot to mention that from the portal of the tunnel
 9 to the generator, we were 14 metres lower than that one.
 10 So that outlet is 614 metres. So at the moment we are
 11 594 over here.
 12 So these are the different panels, we can look at
 13 this one, the production and the instrumentation panel.
 14 This is the circuit-breaker inside the powerhouse for
 15 different equipment, like the motor and the compressor
 16 and everything. So all these panels have different
 17 readings.
 18 We have also some spare over here. In case of the
 19 faulty breaker overhead, we can change the (inaudible).
 20 So here we can see the panel indoor lighting. This
 21 is for the lighting system. Similarly we can see the
 22 main transformer on this one, main transformer. So main
 23 transformer means that supply to the main transformer,
 24 not the main transformer load.
 25 And similarly, these are all the switchgear, the

Page 119

1 400 V switchgear for the different electricity supplies.
 2 (Pause)
 3 Here we can also see this is the bonneted gate, we
 4 call it, and this is at the outlet of the draft tube.
 5 So whenever we want to have the maintenance inside the
 6 unit, we have to shut down the main inlet valve and
 7 close this one, then we can dewater the unit up to the
 8 draft.
 9 And this is the crane for the maintenance of this
 10 draft.
 11 We will go up to there, just to show around the
 12 upstairs. (Pause)
 13 These are different switchgear and the panels.
 14 I will not go into detail because they are a similar
 15 kind of panel.
 16 So this is the output from the generator, going to
 17 the transformer, the main transformer. Here the voltage
 18 is 15.75 kV, but the current is in thousands.
 19 I will check with -- what is the total current?
 20 10,800 is the total ampere generated from there.
 21 With the step-up transformer, we enhance the voltage but
 22 lower the current. Advantage is there because the
 23 current has to be transported on the outer conductor.
 24 So if we have thousands of ampere, we cannot have the
 25 big cable like this one. So reducing the size of the

Page 120

1 cable will increase the voltage level.
 2 THE CHAIRMAN: I see.
 3 PROFESSOR BUYTAERT: So inside these pipes are the electric
 4 cables?
 5 MR MIANA: Yes.
 6 PROFESSOR BUYTAERT: What diameter? (Pause)
 7 MR MIANA: We will check diameter.
 8 But these are basically insulated. If they are not
 9 insulated, we cannot stand here!
 10 PROFESSOR BUYTAERT: We would be fried here, yes!
 11 MR MIANA: If the outer diameter is, say, 1 metre, it will
 12 be around 0.4 metre.
 13 PROFESSOR BUYTAERT: Yes, something like that.
 14 MR MINEAR: Is it copper cable?
 15 MR MIANA: Yes, copper, all of it.
 16 Similarly the other unit monitor gauge over here, as
 17 we've seen for the first one.
 18 We can look round from this, the opposite side.
 19 So this is the main inlet valve. We are getting
 20 closer to the main inlet valve. The main inlet valve,
 21 over here.
 22 And this is bank of CO2 cylinders for the generator
 23 protection in case of fire.
 24 DR BLACKMORE: CO2, ah. (Pause)
 25 MR MIANA: So that ends the powerhouse system. And we have

Page 121

1 also the fire alarm system over there. If there's
 2 a fire, it will generate the signal and the operator
 3 will know about the location of the fire in this one.
 4 And this is the CCTV network that I showed you in
 5 the control room.
 6 THE CHAIRMAN: Yes.
 7 MR MIANA: The signal is coming all around us from these
 8 panels. (Pause)
 9 So here we can see inside. (Pause)
 10 So here we have the transformer oil used for this
 11 one, and we have a spare. So for the transformer oil
 12 bank we have a separate protection system with the CO2
 13 in case of fire.
 14 THE CHAIRMAN: So the step-up occurs through this
 15 transformer?
 16 MR MIANA: No, no, no, the transformer oil only. This is
 17 the oil being used in the transformer. We will go [to
 18 the] transformer, we will see, we will touch that.
 19 THE CHAIRMAN: I'm not sure I want to touch it, but ...!
 20 MR MIANA: No, we will touch it, because we have a spare
 21 without generation.
 22 THE CHAIRMAN: Okay.
 23 MR MIANA: And this is used for cleaning of the transformer
 24 oil. (Pause)
 25 So please, please take care. We have another one as

Page 122

1 well downstairs. These are okay, but downstairs one
 2 step more we have another one.
 3 So here we have the air system for the brake system,
 4 for the braking of the generator, the air brake, and the
 5 station supply for the different purposes. So we have
 6 two different systems over there: small for the braking
 7 system, and these bigger for other systems of
 8 powerhouse. (Pause)
 9 THE CHAIRMAN: So we've seen these on several levels. So
 10 are these to be removed when you need to ...?
 11 MR MIANA: Yes, when we need to lower the material
 12 downstairs, we cannot take down through the stairs.
 13 THE CHAIRMAN: Yes.
 14 MR MIANA: So we have to take it out, and then lower the
 15 material and then place it back. This side and the
 16 other side as well, on both sides of the powerhouse.
 17 So here is again battery power system, battery
 18 system. So we have four banks of 220 V over there, for
 19 the station supply in case of emergency: bank 1, bank 2,
 20 bank 3 and bank 4.
 21 THE CHAIRMAN: That's a lot of batteries!
 22 MR MIANA: Yes. It's essential, because the tripping is
 23 a common phenomenon that can happen any time. So if
 24 there's no supply, then the batteries take electrical
 25 load, and the powerhouse also is underground, so more

Page 123

1 dangerous for this one. So there are a lot of batteries
 2 over there, just to make it more safe.
 3 THE CHAIRMAN: And why don't you use a generator, a gas
 4 generator?
 5 MR MIANA: I'm sorry, I forgot to show you. When we go
 6 back, I will show you that we have in the beginning.
 7 But starting a generator takes some time. These
 8 generators are just like (indistinct) power supply.
 9 DR BLACKMORE: How long do you expect the battery to last?
 10 MR MIANA: I think they have not yet replaced any of the
 11 batteries, this one. Not replaced yet any of these
 12 ones.
 13 Similar to that on the dam site with the control
 14 building we have the generator, and similar to that
 15 control building we have another generator over here.
 16 So that capacity, this is sufficient to operate the
 17 first unit. (Pause)
 18 So here, different cooling waters. You see
 19 closed-loop cooling water system for the cooling of the
 20 different equipment over there. So this inlet has the
 21 open-loop and we also have a closed-loop output. So
 22 normally in the old power station we have only the
 23 open-loop cooling water system, but in the modern one
 24 that has been changed and we have both the open loop and
 25 the closed loop.

Page 124

1 Advantage is that because the heads are high, and if
 2 we are using the open loop then we have to take the
 3 water from upstream of the inlet valve, main inlet
 4 valve. So if you take the water from upstream of the
 5 main inlet valve, the pressure is too high. We will
 6 normally use the pressure-reducing valve over there.
 7 But in case of rupture of any pressure this side, it
 8 will flood the powerhouse.
 9 So the concept has been changed. Instead of one
 10 cooling, there are two cooling systems, but the water is
 11 taken from the downstream instead of taking from the
 12 upstream. So the more waters they are coming, but the
 13 danger of the flooding has been mitigated.
 14 DR BLACKMORE: Yes, that's a very sensible move.
 15 MR MIANA: Yes. (Pause)
 16 For each unit, a separate system. (Pause)
 17 So here is the closed loop.
 18 So we can see we are very much near to this one
 19 again. So the (inaudible). We are getting closer to
 20 this point.
 21 THE CHAIRMAN: Yes, we certainly are! (Pause)
 22 MR MIANA: Similarly, we close and open for the last. And
 23 these are the heat exchangers, so they're -- not the
 24 heat exchangers; these are the cleaners. So they take
 25 mud over there, they rotate and take the mud inside, and

Page 125

1 THE CHAIRMAN: Okay.
 2 MR MIANA: Here we have the shaft, the shaft over here,
 3 300 RPM. 300 RPM. And wicket gates are outside this
 4 one.
 5 And you can see over there the shaft. Going up to
 6 the generator. (Pause)
 7 THE CHAIRMAN: That's the generator up there. (Pause)
 8 MR MIANA: So here we can bend the water at the gate. So
 9 we need this one here.
 10 So when we want to operate it, we have the separate
 11 hydraulic system for the operation of this one. We just
 12 lower (inaudible) inside that cylinder and they've got
 13 the operation over there. We can have the isolation
 14 from the downstream side, the other side, and the
 15 isolation from the HRT, upstream side, is (inaudible).
 16 DR BLACKMORE: Did you have to activate these when you had
 17 the tunnel cave in? Were these gates activated when you
 18 had your tunnel cave in and you had to --
 19 MR MIANA: We just opened this one because that's for air
 20 ventilation --
 21 DR BLACKMORE: Ah, you let it go through. Okay. That'll
 22 work. (Pause)
 23 MR MIANA: So these are the pipes. Damaged pipes, if we
 24 have the water from the pump, due to the rain or
 25 anything, the water comes down over here. As we can

Page 127

1 the oil is then taken out for the cleaning purposes.
 2 A very different (inaudible). These are the control
 3 panels for this one.
 4 THE CHAIRMAN: So it cleans the oil?
 5 MR MIANA: Yes.
 6 THE CHAIRMAN: Wow.
 7 MR MIANA: Yes, basically this is the heat exchanger for the
 8 closed loop and the open loop. So the heat exchanger is
 9 this one. These are channel plates, like different
 10 plates over one, then the other.
 11 THE CHAIRMAN: I see.
 12 MR MIANA: So move to the lower one. (Pause)
 13 So again, please take ... Be careful, please. And
 14 this one is the most dangerous. It's the most
 15 dangerous. The rest is comfortable. (Pause)
 16 So this is the (inaudible) system, the hydraulic
 17 system for operation of the wicket gates. So we then
 18 want to operate the wicket gates because they're under
 19 the pressure, and hydraulic pressure is required for
 20 that. I think -- how much is the total pressure?
 21 350 bar is the pressure for this one to operate that
 22 we can gauge inside the running water.
 23 We'll have the chance to see the rotating shaft over
 24 there. We will not go inside, but then we will see it
 25 from the outside.

Page 126

1 see, very small water is coming. (Pause)
 2 We are going there just to see a valve which is used
 3 for the dewatering of HRT. We have not yet used that
 4 one, but we're just showing there.
 5 So you can see over here, the similar one over here.
 6 When we want to put the things down this one, we have to
 7 take it out and put it over there. But not up to the
 8 (inaudible) maybe this is only for the -- maybe this is
 9 only for this floor and the down floor.
 10 So this is the MIV. We have reached the MIV over
 11 here. We can now see the counterweights over there.
 12 This is the needle valve. When the unit is shut
 13 down, this valve is closed. So when the valve is
 14 closed, there is always leakage in the wicket gates,
 15 small leakage. So spiral casing gets empty to some
 16 extent. So in the beginning we just open this one, this
 17 automatic system, and the water is filled from the
 18 upstream side to downstream side. And when the pressure
 19 is balanced, then we can open this one. If the upstream
 20 and downstream pressure are not balanced, we cannot open
 21 MIV.
 22 And this is our HRT, headrace dewatering, this one.
 23 If we want to dewater the headrace tunnel, then we have
 24 to operate this one.
 25 THE CHAIRMAN: The penstock comes in here?

Page 128

1 MR MIANA: Yes, the penstock starts from here.
 2 THE CHAIRMAN: Right there?
 3 MR MIANA: Yes, going there. This is the end of the MIV,
 4 this big bolt over there. And the penstock you can see
 5 is on the pedestal, and this was it.
 6 DR BLACKMORE: Where is the expansion valve?
 7 MR MIANA: I was expecting this question! I will ask
 8 Ayub Malik. (Pause)
 9 MR MALIK: We'll invite them, because I was not there at
 10 that time. So we can ask the consultant who is the
 11 oldest person over there. 16 years (inaudible) over
 12 here.
 13 THE CHAIRMAN: Okay.
 14 MR MALIK: So 32 years is half of it. (Pause)
 15 So this is the expansion valve.
 16 DR BLACKMORE: What's the expansion valve packed with?
 17 What's inside of it?
 18 MR MIANA: What is the inside? Inside is rubber. What is
 19 the inside in the expansion valve?
 20 DR BLACKMORE: What's it packed with inside?
 21 UNIDENTIFEID WORKER: Inside, rubber (inaudible).
 22 DR BLACKMORE: Ah, okay.
 23 THE CHAIRMAN: And that's the hydraulic that operates the
 24 counterweight?
 25 MR MIANA: Yes. Yes, this is hydraulic, and they have

Page 129

1 up?
 2 MR MIANA: They slide it and they take it out, yes. Because
 3 the runner is small in diameter. It's weighing about
 4 40 tonnes. 40 tonnes is not a big weight.
 5 THE CHAIRMAN: Any other questions?
 6 MR MIANA: Then we'll move to the transformer room, cavern.
 7 THE CHAIRMAN: Sure, yes. (Pause)
 8 MR MIANA: So this is a big cavern, and now we are moving to
 9 a small cavern.
 10 So here we have entered the transformer cavern. We
 11 have seen two caverns on each drawing and photograph.
 12 So earlier we were in the big cavern; now it's the small
 13 cavern over there.
 14 These are the pipes taking the current and the
 15 voltage from the generation side.
 16 We'll just go to see the transformer, which is
 17 energised, and then we'll come back to one which is not
 18 energised.
 19 Yes, please come in, gentlemen.
 20 So this is the power, the transformer is energised.
 21 They step up 15.75 kV to the 525 kV. These are
 22 different equipment, the protection system, everything,
 23 installed for the transformer.
 24 THE CHAIRMAN: Is the power coming in from ...?
 25 MR MIANA: This side.

Page 131

1 separate system for this one. This is the hydraulic
 2 system for the MIV.
 3 THE CHAIRMAN: Okay, very good. Wow.
 4 MR MIANA: And all these are the metering pipes, metering
 5 and some other things. The pressure and the
 6 different -- there are different locations over there.
 7 And this is the air vent valve. Whenever you want
 8 to -- I mean, after the annual maintenance, when we are
 9 filling this one, the air has to take out from that
 10 area, because the air has to be taken from this one.
 11 Air vent valve. (Pause)
 12 So we will go in parts, because the elevator is
 13 small: maybe 6/7 persons can go at a time.
 14 So in the first instance, with us the cameraman and
 15 we can go, and Mr Pomper can also join us. Please, join
 16 us. Come in, come in. 13 persons. (Pause)
 17 We have the opening over there just to lower the
 18 weights, the heavy equipment down there.
 19 DR BLACKMORE: Okay. Where do you bring the runners up to
 20 this level?
 21 MR MIANA: I think this is the place. We can even take them
 22 from there.
 23 DR BLACKMORE: Oh, okay, move away.
 24 MR MIANA: Because the runner position is over there.
 25 DR BLACKMORE: Okay. So you slide it that way and bring it

Page 130

1 THE CHAIRMAN: Up there?
 2 MR MIANA: Yes.
 3 THE CHAIRMAN: Oh, okay.
 4 MR MIANA: You have seen that --
 5 THE CHAIRMAN: We saw the tubes, yes.
 6 MR MIANA: We saw the tubes from outside.
 7 THE CHAIRMAN: Okay. Wow.
 8 MR MIANA: This we can touch. This we can touch.
 9 THE CHAIRMAN: Because it's --
 10 MR MIANA: Because it is not energised.
 11 THE CHAIRMAN: -- it's not working right now?
 12 MR MIANA: No, it's spare. In case of failure of any other
 13 transformer, we have to take it out. The rails have
 14 already been provided over there just to drag it out.
 15 And first drag out the faulty one, take it outside, and
 16 then drag it out this one and then place there, it is
 17 required.
 18 THE CHAIRMAN: Spare transformer?
 19 MR MIANA: Yes, spare transformer. Because without the
 20 transformer, we cannot generate the unit.
 21 THE CHAIRMAN: Yes.
 22 MR MIANA: There is always one spare at every power station.
 23 THE CHAIRMAN: And is the single transformer for all four?
 24 MR MIANA: No.
 25 THE CHAIRMAN: There's --

Page 132

1 MR MIANA: Each unit has three transformers.
 2 THE CHAIRMAN: Three transformers?
 3 MR MIANA: Yes. So this one is 13 number. For the four
 4 units we have 12, and this is the spare one. So the
 5 power is 242, so divided by three will give the power
 6 for this one.
 7 THE CHAIRMAN: It's unlucky to have 13!
 8 MR MIANA: So 98.7 kVA (sic) is the transformer capacity of
 9 each one.
 10 DR BLACKMORE: Very good. Seems like a very nice place to
 11 be on a hot day!
 12 THE CHAIRMAN: Good. Okay. (Pause)
 13 MR MIANA: Maybe they want to see.
 14 THE CHAIRMAN: We were looking at the spare transformer.
 15 MR MIANA: We were just looking at the second cavern there.
 16 That was the big cavern we have seen in the sheets and
 17 the slides. So this is the small cavern for the
 18 transformer.
 19 DR BLACKMORE: They have 13, [12] plus a spare.
 20 MR MIANA: Total transformers are 13, 12 for the four units.
 21 Each unit required three transformers and one is spare.
 22 And the capacity of one transformer is 98.7 MVA.
 23 THE CHAIRMAN: And those big tubes are bringing the power in
 24 from the generator ...
 25 MR MIANA: Yes, from the generator to the transformer.

Page 133

1 electromechanical equipment over there.
 2 THE CHAIRMAN: Any questions?
 3 No, this has been a very interesting walkaround for
 4 us. We saw them in pictures before; now we see the real
 5 thing. So thank you very much. That's wonderful.
 6 MR MIANA: You are welcome.
 7 So now we are going back to the same welcome
 8 building in the (inaudible). Okay?
 9 THE CHAIRMAN: Very good.
 10 MR MIANA: So in the back we can see that there are two
 11 generators over there. We can see the outlet pipes are
 12 (inaudible). So in case of the power failure from the
 13 public or from the powerhouse, we can immediately
 14 operate the diesel set, in addition to the batteries.
 15 So now we are at the entrance of our A6 tunnel,
 16 which we call the cable tunnel as well. And on both
 17 sides of this tunnel we have the cables coming out from
 18 the four units. Each side contains the cable for the
 19 two units over there. So there are six cables in each
 20 one: red, yellow, blue. Red, yellow, blue, unit 1,
 21 unit 2, unit 3 and unit 4. And this is going out, this
 22 one, and also that is going to the TRT. We have shown
 23 you this is going to downstream-side tunnel over there.
 24 So these are different cables for the lighting system,
 25 the instrumentation and everything over there.

Page 135

1 THE CHAIRMAN: ... to the transformers.
 2 Good.
 3 MR MIANA: Good. Sorry, one thing remaining.
 4 Above this, we have also the GIS system over there,
 5 gas insulated switchgear over there, inside the
 6 powerhouse. And we have some connection of this
 7 powerhouse with the other tunnel which we have seen
 8 outside there, which was closed. We'll just see, go
 9 over there. So we have that connection as well over
 10 there.
 11 So please, take water.
 12 THE CHAIRMAN: Thank you. (Pause)
 13 MR MIANA: We'll leave all these PPEs over here, inside, and
 14 then we'll go back to that same place.
 15 THE CHAIRMAN: Okay.
 16 MR MIANA: But before going there, I will show you the
 17 transformer, the diesel generator room outside.
 18 THE CHAIRMAN: On the outside.
 19 MR MIANA: Yes.
 20 THE CHAIRMAN: Okay. Where would you like us to put these?
 21 MR MIANA: Over here. (Pause)
 22 Let's go. Everybody outside.
 23 So if you have any question or clarification.
 24 I think I have explained in a very detailed [way], so
 25 that you should become familiarised with all the

Page 134

1 THE CHAIRMAN: So on each of these, there are cables?
 2 MR MIANA: Yes, these are cables we can see over here.
 3 THE CHAIRMAN: Yes.
 4 MR MIANA: Different -- the CCTV cables, the power cables.
 5 And also we have a connection from -- when we go
 6 downstairs, we can see the connection going into the
 7 powerhouse. So we also use this as a second route for
 8 when we are rehabilitating the TRT over there.
 9 So these pipes, you can see we've just left these
 10 pipes over here. We use these pipes to dewater the
 11 tunnel from the upstream side. It's a mechanical system
 12 that we have to dewater from the upstream side from
 13 these pipes.
 14 THE CHAIRMAN: And you can stop and have a snack too!
 15 MR MIANA: These are for the security people. They can sit
 16 over here.
 17 PROFESSOR BUYTAERT: When the downstream tunnel collapsed,
 18 did the water pass through or filter through by itself,
 19 or did you have to evacuate the water from the upstream
 20 part of the collapse?
 21 MR MIANA: So I already mentioned collapse started from 251
 22 to 293.
 23 PROFESSOR BUYTAERT: Yes.
 24 MR MIANA: So downstream of 293, it was dewatered through
 25 the pumps that we installed permanently inside the TRT.

Page 136

1 Upstream, we could not do that. So we put these pipes
 2 specially for dewatering on the upstream side.
 3 PROFESSOR BUYTAERT: Okay. Yes, that was then ... okay.
 4 MR MIANA: And we have one bulkhead at the end of this
 5 tunnel, before entering to the downstream-side tunnel.
 6 PROFESSOR BUYTAERT: Okay.
 7 MR MIANA: But that is permanent -- that is closed, and when
 8 required we open that one.
 9 PROFESSOR BUYTAERT: Okay. Thank you.
 10 (Pause)
 11 Final Remarks
 12 THE CHAIRMAN: Well, I think I will stand up here, so that
 13 I'm not looking at a blank wall.
 14 So the court has met and discussed whether there are
 15 any follow-on questions that we have, and we really
 16 don't have many. But we do have one, and it's actually
 17 a question we asked you, Mr Miana, during the power
 18 station visit, which you answered, but some of us did
 19 not hear the answer, and so we were hoping you could
 20 just answer it again.
 21 The question was: to the extent that the turbines,
 22 generators, are not doing full power today, what was the
 23 reason for that?
 24 MR MIANA: I explained that there was some pressure
 25 fluctuation in the headrace tunnel that we observed

Page 137

1 during the first week of April this year. So we have
 2 reduced the generation to the extent that the velocity
 3 inside the HRT is within the permissible limit.
 4 THE CHAIRMAN: I see.
 5 MR MIANA: So as and when the matter is resolved, then we go
 6 for the 969.
 7 THE CHAIRMAN: Okay, yes.
 8 Okay, very good. So we have no further questions
 9 for you today, and we don't expect to have any, say,
 10 tomorrow morning or anything, so I think basically we
 11 are done. We don't need to return to the dam site or to
 12 the power station site.
 13 The reason why we don't need to do those things is
 14 that we've been relatively active in asking our
 15 questions throughout the site visit and feel that we've
 16 received the answers that we need to understand as best
 17 as possible the information that you've been providing
 18 to us. And I think that's in part because you've had
 19 a wonderful number of slides that you've been providing
 20 to us, even a video today, some hands-on materials with
 21 the rocks and the sediments. So we really feel we
 22 received quite a bit of information that was extremely
 23 helpful for us in understanding the issues that are
 24 before us.
 25 I also want to note how the Court felt that you

Page 138

1 brought an enormous number of talent to this site visit,
 2 an extraordinary breadth of individuals who are experts
 3 in different areas, some coming from here, some coming
 4 from afar, and we're really very grateful for that. It
 5 allowed us to understand the situation as the water is
 6 approaching the dam and as the electricity is arriving
 7 at the customers, all the way through that life-cycle.
 8 So we're very grateful for that.
 9 I do want to reiterate what I said at the outset,
 10 which is that I do regret that representatives from
 11 India were not here for this site visit. I think we
 12 would have benefited from any observations they may have
 13 wished to make with respect to the information we were
 14 receiving. And of course also it would have been of
 15 great benefit to do a site visit in India as well, so
 16 that we could see their facilities and hear from their
 17 experts. In any event, we do welcome the possibility of
 18 India joining in this proceeding at some point, so that
 19 we could benefit from them.
 20 Maybe in this regard I will just note that because
 21 of India's absence, we've tried to maintain a pretty
 22 sharp division between us and all of you who have been
 23 presenting to us. That has felt awkward at times, but
 24 it was something we felt we had to do in order to ensure
 25 the integrity of the visit as best we could.

Page 139

1 So just a few thanks at the end of the visit here.
 2 Mr Miana, I particularly want to thank you.
 3 I understood and I said yesterday that you were the
 4 boss. I found out today that there's a thing called the
 5 NPCC which is the real boss standing behind you! But of
 6 course I joke. We are all very grateful for your
 7 assistance throughout this visit, to you and your staff.
 8 You've really allowed us to not only hear from people we
 9 needed to hear from, but this ability to walk through
 10 the various facilities was extremely helpful.
 11 I mentioned yesterday that the dam site was your
 12 home. I now see you have a second home here at the
 13 power station, and you were very generous to allow us to
 14 come and see it.
 15 I also want to thank, of course, the Government of
 16 Pakistan generally. I won't list out the various
 17 ministries that I did on the first day, but the Court is
 18 well aware that this was a project that required
 19 individuals from across the government to assist.
 20 External counsel, of course; experts assisting
 21 external counsel. The Court imagines that all of you
 22 were deeply involved in helping to make the site visit
 23 move forward, and we're very grateful for that.
 24 I would be remiss in not also saying thanks to the
 25 Permanent Court of Arbitration, which also was

Page 140

<p>1 instrumental in making this possible, and our 2 videographer, who did yeoman's work in chasing us around 3 and being sure that we recorded everything that happened 4 here. 5 Let me just finish by saying that we do have next 6 steps in our process, which I won't go into any detail, 7 but we will be contacting the deputy agent and external 8 counsel in relatively short order to discuss where 9 things go from here. 10 So with that, I think I'll bring to a close our site 11 visit. Again, tremendous thanks to all those involved. 12 You've made us feel very comfortable here; you've 13 educated us on the issues we wanted to learn about. And 14 from all of you here in the room and all of those 15 outside the room -- the security staff, the 16 transportation people -- it's really been a remarkable 17 opportunity for us that you made very seamless, so we're 18 very grateful for it. Thank you very much. 19 MR MIANA: I would like to say a few words. 20 Mr Chairman and the Court of the members, I really 21 feel pleasure and honour that your stay at the 22 Neelum-Jhelum was quite comfortable, that you mentioned 23 over there. And I'm also thankful to you for your keen 24 interest during all the presentations; and not only the 25 interest, but you are aware of asking the questions that</p> <p style="text-align: center;">Page 141</p>	
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<p>1 encourage all the presenters to respond very effectively 2 throughout this one. 3 I'm also thankful to all my presenters who were 4 joining with me in the whole visit starting from the 5 presentation no. 1 till the presentation no. 11. They 6 have all done very well. And I'm especially thankful to 7 all of them that are coming from very far away from this 8 site. 9 I hope that this visit, the presentations that we 10 tried to make were very informative, knowledgeable for 11 you people to understand the operation, maintenance, 12 design, and almost starting from the pre-feasibility 13 study of a run-of-the-river HEP. I'm again thankful to 14 all of you, and wish you a very safe journey back to 15 your homes. So thank you very much. 16 THE CHAIRMAN: Thank you very much, Mr Miana. 17 (The site visit concluded) 18 19 20 21 22 23 24 25</p> <p style="text-align: center;">Page 142</p>	
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ARBITRATION PURSUANT TO ARTICLE IX AND ANNEXURE G OF THE INDUS WATERS TREATY 1960

Day 5 -- Site Visit

Saturday, 27 April 2024

<p>A</p> <p>Abbas 2:19 48:8,25 ability 43:3 65:8,10 140:9 able 20:15 21:10 23:4 92:13 95:8 97:2,7 102:20 abnormal 49:20 50:16 80:1 about 2:16,18,22 3:4 3:21,23,23 4:10,17 4:19,20,25 5:16 6:8 6:9 7:6,14,24 9:12 9:14 10:3 11:6,6 15:24 16:1 17:3,4 18:23 21:18 22:17 25:12 30:21 31:12 31:15 32:11 33:22 34:5 51:2 53:16,18 53:20 54:1 56:23,25 57:3,5,14 58:18,24 60:16,17,20 61:5,17 67:10 68:1 69:5 76:10,14,18 78:1,19 79:20 80:2 85:21 87:11,24 88:14 89:12 97:22 103:21 104:25 107:24 112:5 114:5 118:3 118:11 122:3 131:3 141:13 above 17:3,20 24:22 44:19 77:17 89:11 103:24 134:4 abrasion 25:14,19,22 48:6,11,11 49:5,22 abrasion-resistant 25:16 abrasive 48:14 49:9 49:25 abruptly 82:12 absence 139:21 Absolutely 58:2 absorb 49:14 AC 42:4 accelerates 47:1 acceleration 27:20,20 77:10 accept 54:23 acceptable 69:11 access 8:1,4,7,10,23 9:16 32:25 34:2 accident 18:6,8 21:15 accordingly 92:11 94:1 98:9 Accumulation 48:5 achieve 95:17 achieved 52:9 achieving 78:16 acid 110:17,19,20 across 44:17 55:6 84:4 140:19 act 39:8 action 102:5 105:14 activate 127:16 activated 127:17 active 103:15 138:14 activities 97:17</p>	<p>activity 15:1 acts 47:14 actual 26:22 72:1 93:13 actually 8:22 25:23 26:10,11 27:19 28:18 32:6 37:15,25 38:3,10 39:8 101:17 104:17 109:18 137:16 actuate 114:17 adapt 65:3 adapting 86:21 add 52:6 added 70:13 85:22 adding 7:8 addition 33:10 72:9 87:20 135:14 Additional 2:14 additions 21:20 address 23:20 41:4 59:8 addressed 18:11 adit 8:2,11 31:13 34:3 34:3,4 99:22 adits 29:11,11,11,15 29:16,18 34:2,5 99:21 adjust 80:22 104:10 105:6 adjusted 55:7,13 adjusting 47:3 administration 107:8 administrator 110:3 advantage 12:1 63:22 83:15 96:1 100:19 120:22 125:1 advantages 62:11 advice 17:7 Advisor 2:8,9 afar 139:4 Affairs 2:5 affects 47:19,22 after 1:21 3:7 4:5 6:21 9:7 12:5,11 14:18 17:17 18:19 20:5 25:13,22 27:1 30:23 36:3,3 41:25 42:3 59:13,15 60:7,9 61:14 73:18 78:6 90:23 96:22 101:22 130:8 afternoon 22:21 59:22 98:20 again 1:7,8 3:8 10:7 18:1 23:21 24:10 29:1,21 39:19 40:22 42:17 54:13 69:11 70:14 80:11 82:19 88:16 95:4 99:5 108:14 123:17 125:19 126:13 137:20 141:11 142:13 against 49:22 agent 141:7 aggressively 94:2 96:17</p>	<p>ago 23:2 113:11 ah 101:10 108:1 109:14 121:24 127:21 129:22 ahead 19:25 80:16 air 19:3,4,8 22:2 61:18 61:19 88:2 89:14 101:12 115:4 123:3 123:4 127:19 130:7 130:9,10,11 AKBAR 2:3 alarm 50:15 122:1 ALAUDDIN 2:16 Albania 32:2 ALI 2:4,4 alignment 47:9 Allai 46:3 allow 51:23 52:2 53:8 140:13 allowed 139:5 140:8 almost 3:3 4:15 28:20 38:1 57:2 62:6,19 74:3,7,23 75:15 79:10 87:5,9 88:7 89:5 90:7 91:21 92:4,16 96:17,21 142:12 along 10:13 11:12 16:16 17:16 26:5 37:25 40:16 60:14 60:19 89:25 112:11 Alongside 23:21 already 1:8,24 2:20 3:12 4:19,24 12:14 15:19 16:1 18:15 20:18 21:13 23:25 24:15,25 32:21,22 43:11,23 45:8 48:25 65:7,16 75:4 77:8 83:17 88:19 91:22 94:3,10 95:9 97:24 98:3 99:20 101:22 102:13 104:20 107:24 108:20,25 109:9,11 112:15,20 113:22 117:19 132:14 136:21 Alright 40:6 Although 62:7 93:9 altogether 13:4 103:13 104:2 107:5 111:25 always 28:19 77:17 90:1 128:14 132:22 America 55:21 65:17 70:7 amount 36:9 55:3,4,13 68:12 72:20 79:10 82:4 ampere 120:20,24 ample 72:20 analyse 117:4 Anciently 61:12 angle 27:7 47:4 angles 46:1 Annexure 1:1 Anne-Marie 1:21 annual 3:19 15:1</p>	<p>113:4 130:8 annually 14:20 another 15:8,17 56:9 66:23 72:12 73:12 79:4 80:15,15 84:16 85:4,20,21 122:25 123:2 124:15 answer 22:22 34:17 34:18 137:19,20 answered 57:23 137:18 answers 138:16 anybody 36:7 anything 14:5 68:3 111:15 127:25 138:10 apartment 26:19 APPEARANCES 2:1 applied 18:21 25:21 49:21 appreciate 59:5 84:3 approaching 14:20 139:6 appropriate 69:7 approximately 52:16 April 1:6 1:1 97:23 102:25 138:1 Arbitration 1:1 2:21 1:6 23:20 41:4 84:11 140:25 area 4:18 16:6 17:2,15 17:22 18:4,23 19:14 19:17,20,20,22 27:18 33:18 37:1,6 47:14 69:1,3 95:25 130:10 areas 8:24 139:3 Arfan 2:15 1:8 24:1 32:20 33:15 40:17 43:12 around 6:25 9:19 22:14 34:25 35:8 63:8 75:18 78:11,18 104:20 113:19 116:3 117:18 118:4 118:9 120:11 121:12 127:7 141:2 arrangement 51:14,21 arrangements 25:8 arrival 89:19 92:8 arrive 81:6 arrived 80:6 81:8 arrives 92:8 arriving 139:6 arrow 26:23 Arshad 2:18 60:15 84:11 Article 1:1 Asia 62:6 asked 2:3 57:4 137:17 asking 57:5 138:14 141:25 asks 104:9 assist 140:19 assistance 140:7 Assistant 2:23 Assistant 140:20 associated 11:8 43:9</p>	<p>assume 14:16 97:10 attack 31:9,15 attention 22:19 50:18 Attorney 2:6 audio 41:8 August 4:5 16:10 21:6 94:23 authority 2:13 2:6,7 auto 65:14 automatic 50:15 104:5 110:7 128:17 automatically 12:3 65:15 104:6 auxiliary 6:20 64:1,8 64:9,11,13 availability 3:20 86:17 89:23 90:3 95:1 available 4:4,7,8 7:9 13:13 22:22 52:3 53:17,25 58:22 67:2 71:17,18,19,20,21 75:6 80:22 81:20 82:5 85:11 86:20 87:14 88:21,22,23 89:8 90:12 91:19 92:22 102:24 103:19 117:3 average 32:11,15 35:11 avoid 12:3 13:13 20:9 22:9 47:10 50:9,12 83:14 114:16 avoided 21:14 aware 140:18 141:25 away 52:24 130:23 142:7 awkward 139:23 axes 26:5 axial 44:14 axially 45:12 axis 11:13 44:15 Ayub 2:16 34:16 38:5 39:19 43:24 45:9 95:22 129:8 AZAM 2:13 A5 8:2 99:22,22 A6 8:11 99:23,25 135:15</p>	<p>93:10,14,16,17,20 93:21,22 94:1,7,11 94:14,17 95:1,4,18 96:6,6,16,25 barrage 93:22 barrier 49:24 bars 18:17,17 base 80:4 83:11 89:4,6 89:23 based 15:6 43:21 92:20 baseload 63:17,17 76:25 78:1,3 79:15 79:18,21 80:8,11 81:10,25 82:4,14,19 83:12 85:10,14 87:6 87:9,18 90:2,21,25 91:7,22 basement 119:5 Basha 2:14 basic 32:9 39:3 basically 5:4,24 25:11 28:17 29:12,15,19 31:3 32:1,2 37:4 38:6 40:14 54:15,25 56:7 107:24 109:23 121:8 126:7 138:10 Basics 3:9 23:18 basket 53:14 batteries 110:13,17,19 110:20,21,23,24 123:21,24 124:1,11 135:14 battery 110:9,10,15 123:17,17 124:9 bay 102:18 bearing 13:18,18,19 13:19 47:8 50:5,12 become 134:19 becomes 53:14 becoming 84:24 before 1:8 1:25 10:14 12:7 13:24 14:6 17:15 20:12 36:22 41:20 49:10 74:15 77:4 89:10 95:22 109:9 113:19 115:23 134:16 135:4 137:5 138:24 begin 1:2 114:19 beginning 124:6 128:16 behalf 59:4 behaviour 88:12 89:1 89:20 90:9,16 92:7 94:16 96:15 behind 1:16 140:5 being 36:3,4,24 54:23 122:17 141:3 believe 22:13 36:7 70:8 belong 67:17 below 16:7 26:8,10,12 26:14 44:24 88:14 89:10 belt 30:17 bend 127:8 beneath 47:11 114:1</p>
--	--	--	--	--	--

<p>benefit 139:15,19 benefited 139:12 benefits 27:9 86:19 Bengal 62:6 Benoît 61:24 beside 3:9 4:23 20:25 best 28:13 80:8,8 92:15 138:16 139:25 BETHLEHEM 2:7 better 22:7 34:17 35:6 36:7 42:7 52:11 72:5 82:5 118:21 between 1:14 31:13 34:6 39:23 41:22 47:18 49:13,24 50:11 58:20 63:24 75:23 106:6 110:4 139:22 beyond 26:2 55:17 88:18 big 9:17 10:1,2 12:7 14:23 16:13 17:5 53:14 57:3 82:3,16 87:12 89:13 93:15 94:4,6 95:24 97:10 113:16 120:25 129:4 131:4,8,12 133:16,23 bigger 123:7 billion 3:20,22,23 113:4 birth 42:12 bit 21:23 28:23 51:2 61:19 70:10,12 78:24 79:5 100:8 138:22 black 67:20 Blackmore 1:11 34:8 34:10 35:2,13,16,19 35:21,23 36:1,5,16 39:13,16,18,21,25 40:3,5 104:4 105:10 105:13,15,17 106:14 110:21 117:16,21 121:24 124:9 125:14 127:16,21 129:6,16 129:20,22 130:19 130:23,25 133:10 133:19 blade 10:19 25:21 45:14 48:11 blades 10:18 12:10 44:11,17 45:12 46:25 48:6 49:24 50:1 blank 137:13 blast 30:4 31:6,18 32:14,18 35:20 38:4 blasted 30:13,15 blasting 30:22 block 20:14 blockage 21:11 49:5 blocked 20:18,20,22 blue 26:23 67:19 135:20,20 Board 66:6</p>	<p>bolt 129:4 bonneted 14:22 120:3 boost 70:18 bores 18:18,19 boring 31:20 32:18 38:6 boss 140:4,5 both 6:13 27:11 32:18 37:16,18,19 44:5 45:11 91:7 92:22 94:19,20 102:21 105:12,13 123:16 124:24 135:16 bottom 14:9 25:10 26:18 boulders 16:13 brake 123:3,4 braking 123:4,6 branches 49:4 breadth 139:2 break 1:19,21 23:11 59:12,16 breaker 100:23 109:2 109:2,3 119:19 breakers 54:8,13,14 54:17 102:16,17 109:2 115:21 breaking 32:1 breakthrough 18:4 brief 1:12 2:21 24:4 66:16 briefing 1:13 20:13 21:18 111:10 briefly 7:13 9:12 15:24 16:1 bring 69:11 130:19,25 141:10 bringing 133:23 broad 62:16 broader 80:18 brothers 73:14 brought 139:1 brown 89:21 91:12 BRYCE 2:23 building 7:13 26:19 37:12 98:21 110:5 124:9 125:14 124:14,15 135:8 Buildings 2:8 built 63:8 bulk 69:19,23 bulkhead 137:4 burst 28:16 bursting 28:18 busbar 100:17 102:13 108:24,25 109:1 busbars 102:14,21 109:1 businesses 55:1 buy 69:18,19 Buytaert 1:10 23:2,9 56:18,19 57:6,8,11 57:15,21,25 58:2 97:6,18,20 98:13 107:12,15,19,22 108:1,4,7,10,12 110:17,19 121:3,6 121:10,13 136:17 136:23 137:3,6,9</p>	<p style="text-align: center;">C</p> <p>C 118:6 cabin 10:4 cable 8:11,12,16,17 34:4 100:1,1 120:25 121:1,14 135:16,18 cables 121:4 135:17 135:19,24 136:1,2,4 136:4 calculate 27:13 55:5 77:19 calculated 103:5 calendar 4:2 call 8:2,11,11 11:17 12:8 14:13 20:21 29:14,16 30:4,16 38:23 70:2 99:22 102:15 120:4 135:16 called 2:6 5:6,7 31:20 44:22 58:11 71:1 78:20 79:24 81:7 112:7 140:4 calls 23:4 cameraman 130:14 CAMERON 2:8 canal 36:24 capacity 6:8,9 7:3 45:20 52:18 54:23 57:1 58:21 60:13 73:25 74:3 75:3,6 83:1,2,5,6 85:4,7 88:17,18 89:8 90:13 92:14,21,22 95:8,9 97:24 112:1 124:16 133:8,22 capturing 47:6 care 21:23 39:6 122:25 careful 55:2 126:13 carried 48:3 carry 55:3 carrying 3:6 case 10:13,13 11:7,22 12:1,5,6 20:7 25:6 39:24 41:16 52:23 53:13 63:12 102:4 102:19 107:7 110:14 114:7,7,14 116:14 119:18 121:23 122:13 123:19 125:7 132:12 135:12 casing 10:23 25:9 42:20 45:11 46:19 46:20,23,24 128:15 categories 44:9 69:17 category 44:3,8,13,16 44:23 45:1 69:22 cater 40:1 83:7 cause 10:20 29:3 48:6 caused 39:5 49:14 causing 45:15 cave 127:17,18 cavern 4:23,24 5:16 113:16,16,17,18 117:22 131:6,8,9,10 131:12,13 133:15</p>	<p>133:16,17 caverns 131:11 cavitation 49:23 cavity 17:3,6 CCTV 104:20 122:4 136:4 cease 63:11,20 ceiling 17:15,20,22,23 cell 110:12 centimetre 27:13 central 53:12 67:7 centre 58:15,16 69:1 70:17 73:3 105:4,5 century 42:4 certain 30:11 74:20 certainly 63:12 125:21 cetera 63:3 chainage 16:8 challenging 28:4,22 chamber 117:16 chambers 83:18 chance 5:19 10:6 126:23 change 13:6 40:6 45:13 90:5 119:19 changed 89:21 124:24 125:9 changes 49:15 86:22 105:22 107:5 115:14 changing 11:14 16:17 45:13 52:3 65:3 82:7,11 87:15 90:7 90:10 channel 126:9 characteristic 51:17 62:22 charge 30:6,20 105:21 105:22 charging 30:22 chart 75:12 chasing 141:2 cheap 42:24 62:12,17 62:21 82:9 86:19 cheaper 79:22 83:15 check 83:25 97:4 101:23 118:4,9 120:19 121:7 chemical 62:14 Chichoki 46:9 chief 1:9 23:24 41:5 60:1,5,15 83:22 84:12 98:25 choice 68:24 76:20 81:20 82:15 choose 30:1 circle 30:13,14,15 circles 30:6,10 circuit 108:2,11 circuits 54:11 circuit-breaker 119:14 circuit-breakers 100:11 102:20 109:23,25 circular 29:24 33:23 35:12 cities 71:6</p>	<p>city 3:4 70:15 civil 2:16 4:21 clarification 25:15 111:16 134:23 clarify 74:16 111:17 classify 43:17 44:9 clay 37:9 clean 62:12,12 cleaners 125:24 cleaning 122:23 126:1 cleans 126:4 clear 15:9 19:15 50:24 97:2 clearance 21:4 clearing 30:22 clearly 111:9 clock 76:5 close 12:3 14:21 111:3 114:15 120:7 125:22 141:10 closed 16:21 54:14 106:14,15 124:25 125:17 126:8 128:13,14 134:8 137:7 closed-loop 124:19,21 closely 33:18 closer 121:20 125:19 closest 35:13 close-up 48:10 closing 39:5 coal 63:2 71:14 81:18 82:16 coaster 23:3 coated 15:19 25:19 coating 25:16,20,25 48:23 coatings 49:21,23 coffee 1:19 collapse 9:12 15:25 16:3,4,6,7,20,21,25 17:2,4,9,15 18:6 19:14,17,22 20:13 20:16 21:8 136:20 136:21 collapsed 16:8 18:4 136:17 collars 39:21 colleague 23:3 60:5,25 73:2 colleagues 2:13 collected 5:13 12:25 113:25 collecting 36:24 Collectively 74:22 colour 26:14 66:2,3 72:9 86:9,10 89:21 91:12,13 94:13,14 96:19 99:24 106:20 colours 86:2 combination 85:10 89:6,22 combine 53:24 combined 1:12 9:8 28:21 61:10 combines 9:24 combustion 82:23 83:14,18</p>	<p>come 9:20,25 23:12 24:10 31:21 35:4 56:3 57:20 78:19 86:23 92:2 101:22 105:5 112:17 118:13 119:3 130:16,16 131:17 131:19 140:14 comes 3:23 6:24 9:7 26:24 33:12 55:21 89:18 92:18 101:25 106:25 127:25 128:25 comfortable 126:15 141:12,22 coming 2:23 3:5,12 7:15 8:17 11:11 15:14,15 27:8 28:11 29:7 33:8 38:17 58:20 66:12,15 71:23 73:22 84:3 86:7 87:23 90:18 94:11 99:21,25 102:5,19 106:10,18 109:3,6 110:1 115:4 122:7 125:12 128:1 131:24 135:17 139:3,3 142:7 comments 24:4 commissioned 3:17 60:12 Commissioner 2:4,14 common 17:9 104:17 123:23 communicate 111:9 communication 105:8 106:6,8,11,13 110:4 communications 105:10 company 2:15 1:10 73:12,13 74:11 comparable 95:17 compare 82:17 117:4 117:6 compared 32:13 56:20 64:9 96:18 comparing 7:17 comparison 63:23,24 95:12 complete 38:1 72:3 73:4 114:14 completed 3:17 66:24 completely 20:14,18 20:19,22 complex 7:11 10:3 16:14,17 28:10 70:11 complexity 26:8,10,21 component 41:13 74:16 components 10:6 49:6 49:11 50:9,13,17 composite 112:23 compressor 119:15 comprises 54:7 computer 105:11 computers 55:5 concentrate 72:6 79:9</p>
---	---	---	---	--	---

<p>concentrated 67:5 concentric 30:6,10 concept 71:1,16 94:9 125:9 concepts 84:18 97:1 conclude 22:18 concluded 142:17 concludes 59:2 concrete 19:20 20:6,6 20:8 30:25 34:12 37:6 38:20 concrete-lined 34:23 34:24 35:8,9,17,18 concreting 20:3 condition 14:17 15:3,6 47:24 conditioners 88:2 89:14 conditions 28:16 29:22 45:8 49:20 50:16 93:2,7 95:23 98:2 conductor 8:17 120:23 conduit 46:21 cone 14:13,13 Confers 104:13 105:19,20 106:9,16 107:14 configuration 23:5 24:16 configured 23:6 conglomerate 37:4 connect 54:13 connected 2:14 7:21 8:18 11:5,18,19 12:18 85:22 connection 54:22 102:21 115:20 134:6,9 136:5,6 connects 26:15,24 consider 39:3 60:18 76:6 77:8 considerable 24:21 consideration 72:14 considered 44:20,25 61:25 77:18 considering 72:12 consistently 79:11,12 79:14 consists 5:4 34:2 100:10 constant 10:16 construct 6:2,5 constructed 5:25 36:24 construction 3:16 4:22 5:8,22 6:3,4,15 11:9 24:3,7 26:21 28:1,5 30:9 36:23 37:2 65:24 66:4 67:1 72:4 86:11 113:6 116:5 construction/fabric... 5:2 consultant 17:8 129:10 consultants 2:14</p>	<p>103:2 consultation 103:2 consume 70:22 consumed 55:4 consumer 56:2 consumers 69:14,15 69:16,18 70:14,14 70:15,19 71:20 consumes 62:24 consumption 57:13 contacting 141:7 contains 135:18 context 28:1 continue 50:19 111:4 continues 92:7,9,15 continuous 13:1 contrast 61:19 62:25 contributing 41:23 contribution 56:20 57:12 61:2 75:14,17 control 1:22 7:13 21:21 26:7 29:20 55:8,9,10 58:15,16 68:19 69:8 70:18 73:3 98:21 101:25 104:24,25 105:4,5 110:3,5 116:3,5 122:5 124:13,15 126:2 controlled 40:15 47:3 54:9 62:21 66:5 73:11 74:19 104:5,6 controlling 104:4 109:4 controls 2:8 conventional 38:3 85:13 conventionally 30:3 conversion 43:10 52:8 convert 14:14 41:19 51:7 53:16,18 converting 3:24 43:25 converts 41:16 64:4 convey 28:6,25 conveyance 29:11 conveyor 30:17 conveys 33:21 cooking 79:2 cooling 124:18,19,19 124:23 125:10,10 coping 86:22 copper 121:14,15 corona 101:8,9 correct 14:1 19:2,10 55:13 59:14 correctly 5:23 23:11 39:22 59:3 corresponding 91:13 correspondingly 91:1 91:24 corrosion 49:23 cost 62:17,18 95:18 counsel 2:23,23 140:20,21 141:8 counterweight 12:1,2 40:11 114:11 129:24 counterweights 11:25</p>	<p>114:12,17 128:11 country 53:14 60:8,11 63:13 65:21 67:2,4 67:7 69:25 70:7 71:13 72:1,23 73:22 74:2 79:6 84:4 86:16 country's 61:1 couple 113:11 coupled 6:11 41:18 42:23 course 27:1 29:10 30:23 37:3,13 38:24 39:5 55:12 59:6 97:21 139:14 140:6 140:15,20 court 2:21 3:3,4,5,6,7 3:8,11,12,13,16,19 3:21,22 1:6 2:4 23:20 41:3 59:5,21 84:11 98:19 118:14 137:14 138:25 140:17,21,25 141:20 cover 9:17 24:6 28:14 50:11 83:6 covered 13:7 90:18 102:7 covering 2:11 68:25 96:3 co-presenter 60:15 83:22 CO2 121:22,24 122:12 crane 112:6 120:9 cranes 6:7,8,11,11,13 24:24 111:23,25 117:23 created 17:19 creates 30:13 45:14 101:12,13 criteria 45:7 cross 18:3 72:18 crossing 34:25 35:10 69:2 cross-flow 44:16 cross-section 11:15 24:14,18 38:16,25 43:8 47:14 116:12 crown 20:20 crucial 4:13 43:4 47:24 crushed 28:12 cubed 61:18 77:14 cumecks 7:4 91:19 96:8 96:10,11 115:17 current 5:11 15:6 61:1 68:12,15 69:7 100:12 101:15 113:24 115:18 120:18,19,22,23 131:14 currently 60:1,7 98:1 curve 80:17,18,19,20 81:3,8,20 82:15 86:24 97:21 customer 69:24 customers 67:21 70:2 70:3,5 139:7</p>	<p>customised 42:10 cut 9:18 32:8 37:3 cutaway 24:16 cutter 31:25 32:3,7 cycle 30:22 41:20 cylinder 127:12 cylinders 121:22 C1 93:24</p> <hr/> <p style="text-align: center;">D</p> <hr/> <p>D 1:9 DAAN 2:24 daily 31:15 58:19 77:25 80:17 81:3 dam 3:9 1:25 3:5 7:15 23:18 28:6 33:21 35:13,15 37:18 95:15,16,25 106:7,9 106:10 107:3 112:15,23,24 124:13 138:11 139:6 140:11 damage 13:13 21:14 21:15 27:19 29:8 48:6 49:5 50:13,17 114:16 Damaged 127:23 damages 12:4 18:22 49:19,23 dams 2:16 danger 125:13 dangerous 124:1 126:14,15 DANIEL 2:7 data 58:19,20 73:4,23 79:19,20 106:10,16 106:23 110:1 113:8 date 88:7 dates 106:4 day 1:6 1:25 31:6,16 32:11,13 52:4 55:12 58:22 62:8 64:16 79:25 80:11,13 87:6 88:13 89:6,22 133:11 140:17 days 20:24 23:2 80:23 81:2 113:11 DC 5:11 72:10,12 113:23 debris 49:4 December 4:6 88:8 92:3 95:3 96:22 decide 56:5 58:6 75:9 76:24 80:7 81:9,19 decides 55:10 93:3 decision 90:12,14 98:10 decisions 93:5 98:3 decline 94:24 decrease 55:19 decreasing 46:25 deeply 140:22 deficiency 83:2 defined 44:24 definitely 84:23 88:3 88:17,23 delays 30:11,11 delegates 112:17</p>	<p>delighted 1:10 deliver 54:20,24 delivering 87:10 demand 52:5,6,7 72:23 78:23 89:10 90:6 demands 52:4 90:9 demonstrates 25:24 demonstrating 46:11 dense 61:17 denser 70:15 density 61:18 77:13 depend 31:23 45:7 68:12 dependent 88:20 94:7 depending 3:19 30:2 65:9 80:12 85:11 90:3,12 93:2,7 depends 15:14 47:16 68:25 75:25 77:6,7 92:24 98:6,12 depleted 96:3 deposition 48:3 deputy 2:22 141:7 derived 77:21 desander 25:25 37:1 48:22 Desanders 49:8,8 describe 42:13 93:9 114:9 described 12:14 91:23 94:16 95:9 98:3 describing 9:13 design 24:2,3 38:2 39:2 42:9 43:17,18 51:25 52:10,17 61:22 76:21 93:11 142:12 designated 54:21 67:24 designed 49:9 71:7 76:16 95:16 designer 68:22 69:4 designers 96:13 desired 51:25 detail 12:14 43:12,23 48:8 60:24 63:18 120:14 141:6 detailed 43:7 134:24 details 58:19 detect 50:4 determination 47:24 develop 83:4 developed 2:12 24:5 61:15 developing 66:22 73:17,19 development 2:13 42:6 develops 83:4 device 41:15 devices 49:17 54:8 56:8 dewater 14:23 120:7 128:23 136:10,12 dewatered 136:24 dewatering 128:3,22 137:2</p>	<p>de-energise 54:10 diagonal 72:19 diagram 7:11 12:15 104:14 dial 10:23,24,25 12:6 12:7 47:1 Diameter 2:14 diameter 29:12,13 121:6,7,11 131:3 diesel 134:17 135:14 difference 27:14,15 47:18 75:23 93:13 93:19 94:6 different 12:16 14:7,8 18:12,21 24:9,11 28:11 32:19 34:11 37:18,19 42:1,11 81:18 84:14 86:2 89:2 93:8,11 96:12 104:22 106:21 109:2 110:11 116:4 119:12,15,16 120:1 120:13 123:5,6 124:18,20 126:2,9 130:6,6 131:22 135:24 136:4 139:3 difficult 32:17 95:25 diffuser 47:14 direct 56:2 directed 54:5 direction 11:11 43:19 44:10 45:13 51:19 directions 33:4 directly 8:13 12:10 44:12 47:5,19 69:19 108:5 112:18 director 1:15 99:3 directs 46:24 dirty 22:4 discharge 47:12 91:12 91:17,25 92:5,11 113:2 disconnect 54:12 discuss 45:6 141:8 discussed 23:2 48:8 137:14 discussing 2:15,18 4:20 60:22,24,25 discussion 22:5 68:11 disintegrated 73:15 dispatch 58:23 displaying 116:17,23 116:24 distance 6:25 22:12 68:25 71:6 85:19,21 96:4 distribute 69:12,21 70:1 distributed 53:13 71:24 distribution 55:20,24 56:1 67:19 69:10 70:15,23 71:1 73:13 divided 69:16 133:5 division 139:22 document 106:1 documented 105:16 doing 79:2 137:22</p>
--	---	---	---	---	--

<p>domestic 70:3 DON 1:11 done 6:3 19:14 23:10 29:5 32:12 36:17 59:5 92:24 93:1 98:7,9 109:22 138:11 142:6 dotted 72:2 double 100:17 102:13 108:11 double-breaker 100:20 down 10:9 11:21 14:10 16:22 21:13 34:12 43:4 52:7 55:23 65:9 69:25 78:22,24 86:7 92:23 97:13 101:22 110:11 112:9 113:9 114:22 116:9 118:1 118:13,17,18 120:6 123:12 127:25 128:6,9,13 130:18 downstairs 108:14 114:3 123:1,1,12 136:6 downstream 9:16 10:11 17:11 35:14 84:17 93:18 107:9 107:25 114:6 125:11 127:14 128:18,20 136:17 136:24 downstream-side 135:23 137:5 Dr 1:11 2:8,8,14,19 3:10,15 23:16,19 27:6,11 34:9,10,16 35:2,4,13,16,19,21 35:23 36:1,3,5,16 36:19 39:13,15,16 39:17,18,19,21,25 40:3,5,7,21,24 41:1 48:8,25 50:19 51:1 56:23 57:3,5,7,10 57:20,23 58:1,3,4 58:10,13,15,17 59:3 59:8 104:4 105:10 105:13,15,17 106:14 110:21 117:16,21 121:24 124:9 125:14 127:16,21 129:6,16 129:20,22 130:19 130:23,25 133:10 133:19 draft 9:6,7,8 12:12,13 27:2 42:21 46:20 47:11 120:4,8,10 drafted 14:13 drag 132:14,15,16 drain 33:12 drainage 8:6 20:4 33:3,4,11 117:17,18 117:20 drains 20:5 drawing 131:11 drawings 4:24 104:18</p>	<p>drill 30:4,6,19 31:18 32:13,18 33:4 35:20 38:4 drilled 30:3 drilling 30:20,22 drives 27:1 driving 37:15 drop 89:3 drops 95:2 drop-downs 97:10 dry 22:1 63:10 72:22 76:1 77:23 83:10 85:9 88:8 94:2 98:2 110:23,23 117:16 117:18 dual 102:17 Duber 46:3 duct 19:3,4,8 due 42:8 65:17 77:11 104:9 127:24 duration 78:21 81:8 82:15 during 2:3 3:18 4:15 4:22 9:21 11:8,14 15:1 16:15 18:5 36:23 37:1 40:14 48:20 49:20 52:4 55:12 59:6 69:2 72:22 77:22 78:5 79:1 91:5 93:24 94:2 97:10,12 102:24 113:23 137:17 138:1 141:24 duty 66:18 dynamite 30:7,7,8 D-shape 29:25</p> <hr/> <p style="text-align: center;">E</p> <p>each 2:14 4:15 7:3,7 7:22 10:19 11:4 15:2 17:21 30:21 34:14 51:12 75:14 87:1 103:16 108:11 110:12 111:25 116:2 125:16 131:11 133:1,9,21 135:18,19 136:1 earlier 73:1 91:9 96:20 131:12 early 89:18,18 91:8 earmuffs 111:20,21 earning 3:22 ears 111:21 earth 31:22 115:21 earth-filled 112:24 easily 15:13 69:12 77:19 81:9 easy 17:24 60:19 63:22 economic 75:10 83:16 economical 64:14 economically 75:10 81:22 edge 25:21 educated 141:13 effect 39:7 49:16 61:10 101:8,9</p>	<p>effective 115:6 effectively 80:20 142:1 effectiveness 25:24,25 efficiencies 53:24 73:16 efficiency 48:18 52:9 52:13,14 62:20 77:15,16 82:25 efficient 42:7 47:1 53:4 efficiently 85:18 Eiffel 7:18 33:16 either 21:2 54:9 61:6,9 elaborating 84:18 electric 74:9 101:15 121:3 electrical 2:7 13:9,11 13:11 21:21 22:9 41:18,19 42:24,25 43:11 51:8 54:21 61:16 64:4 99:8,12 100:14 103:14 123:24 electrically 112:6 electricity 4:9,10 5:12 5:13 7:5,8 12:2,24 13:2 53:19 54:1,21 55:3,5 56:2 57:13 61:21 97:15 101:17 103:19 113:25 120:1 139:6 electromechanical 2:19 4:20 135:1 elements 24:11 49:25 elevation 119:6,7 elevator 119:3 130:12 embedded 13:16 emergencies 86:22 emergency 12:2 110:14,16 114:14 123:19 empty 29:4 128:15 enabled 96:4 encased 38:20 encompassed 7:25 encounter 48:19 encountered 37:13 encourage 142:1 end 56:14 97:23 106:3 129:3 137:4 140:1 ending 72:11 80:24 ends 10:25 121:25 energies 75:23 energise 54:10 energised 21:21,22 22:10,12 36:3 27:16 32:4 41:15,17 41:19,23 42:1,23,25 43:10,11,19,21 44:1 44:2,5,6 45:25 47:1 47:7 51:7,8 52:8 53:9,15,17,18,19,25</p>	<p>54:23 55:13 56:11 57:9 58:6,9 60:18 61:8,9,16 64:4,5 70:21 73:22,25 74:12 75:13,20,21 80:4,4,5,5 82:8 83:15 113:4 engine 11:16 engineer 23:24 41:6 59:25 60:1,5,15 83:22 84:12 98:25 99:6,8,10,12 106:3 engineering 2:17 68:22 engineers 102:2,3 105:23 enhance 49:22 120:21 enormous 139:1 enough 4:17 ensure 24:9 48:17 50:8,10 139:24 ensures 47:9 ensuring 22:15 entered 131:10 entering 10:14,24 47:20 137:5 enters 42:20 44:12 45:11 49:10 entire 19:9,11 27:4 entrance 10:19 12:8 34:4 46:23 98:21 111:7 135:15 entry 49:3 environmental 92:5 environmentally 42:25 62:16 environments 28:22 equilibrium 61:21 equipment 2:19 13:20 13:20 22:4,9 24:17 24:17,25 64:1,2,2,6 100:10,11 110:1 111:14 119:15 124:20 130:18 131:22 135:1 equipments 64:7 erected 73:12 erosion 41:24 48:6 49:5 especially 29:3 37:8 86:21 142:6 essential 48:16 64:1,7 67:20 83:7 110:16 123:22 Essex 2:7,7 established 76:22 estimated 4:11 estimation 4:1 et 63:2 evacuate 136:19 evacuation 8:16 100:7 even 15:8 20:6 27:13 31:2 32:12 77:18 82:3 93:6 105:25 110:5 130:21 138:20 evening 79:1 event 105:19,24,25</p>	<p>139:17 every 105:19,24,25 132:22 everybody 35:5 78:6 107:9 134:22 everything 7:25 10:5 69:4 79:3 100:15 102:1 109:3,19,21 110:14 119:16 131:22 135:25 141:3 everywhere 22:11 80:25 evolution 62:4 exact 34:17 118:9 exactly 26:11 110:21 example 84:20 excavate 17:2,24,25 29:20 excavated 24:14 34:22 35:12,12,20 38:13 excavating 37:7 excavation 18:8 24:18 29:11 36:21 38:3 excavations 95:25 exceeds 104:1 excellent 22:1 except 7:12 21:19 excess 49:18 exchange 3:24 58:19 110:2,4,6,7 exchanger 126:7,8 exchangers 125:23,24 excitation 5:12 13:2 113:22 114:1 115:18 excite 13:1 excited 5:11 exciter 113:23 executive 1:9 exist 72:1 exit 9:22 47:12 exits 9:22 27:2 42:21 44:12 expansion 39:14,20,23 85:25 129:6,15,16 129:19 expect 85:8,15 87:3 124:9 138:9 expected 3:19,25 51:12 expecting 129:7 expensive 82:25 experience 63:6 84:13 expert 84:24 experts 2:12 60:19 77:9 139:2,17 140:20 explain 7:14 11:5 12:17 16:24 24:10 27:25 28:23 42:17 63:18 81:25 84:20 101:18 102:9 113:20 explained 9:11 16:1 16:15 32:21 40:17 43:11,13,23 45:8 48:25 51:6 65:7</p>	<p>68:8 74:19 80:17 83:17,21 88:19 95:6 95:20,23 102:13 134:24 137:24 explaining 67:11,23 77:2 explains 76:19 explanation 2:22 explosive 30:11 extend 50:1 extended 19:24 extends 26:11 Extension 2:18,19 23:24 41:12 extensive 88:3 extent 128:16 137:21 138:2 external 140:20,21 141:7 extra 21:23 63:6 116:6 extracted 61:6 extracts 41:15 extraordinary 139:2 extra-high 68:24 extremely 138:22 140:10</p> <hr/> <p style="text-align: center;">F</p> <p>face 30:5 31:1 32:13 faces 31:9,11,14 32:14 facilities 7:12 139:16 140:10 facility 26:3 27:8 fact 19:3 27:12 60:11 62:20 75:19 factor 62:23 factors 29:20 43:17,19 47:17 69:4 77:6 95:6 failure 12:1 114:14 132:12 135:12 fall 44:7,16 45:1 falling 61:6,7 falls 30:15 37:14 44:2 44:13,23 false 17:19,22 familiar 24:15 familiarised 134:25 family 82:22 far 15:2 72:10 118:1 142:7 farmhouse 70:15 farms 70:16 FAROOQ 2:17 fashion 32:8 fault 37:25 70:24 83:5 102:4,19 109:20 117:4 faults 28:12 37:14 50:5 83:4 faulty 119:19 132:15 feasibility 65:24 67:1 72:3 feature 52:1 91:8 features 2:12 24:7 26:2 33:19 45:19 112:22 February 4:3 90:17</p>
---	--	---	--	--	--

<p>90:17 91:5 96:23 feed 32:6 88:16 feeding 55:7 feel 1:23 15:2 111:21 111:22 138:15,21 141:12,21 feels 78:6 fellow 23:21 felt 138:25 139:23,24 few 15:4,12 21:19 25:13 32:22 36:14 52:24 65:1 66:24 140:1 141:19 Fiaz 2:18 16:15 field 115:17,18 figure 87:22 113:10 113:12 118:9 filled 30:11 128:17 filling 130:9 film 15:20 filter 136:18 Final 3:25 137:11 finally 60:24 83:1 117:8 find 18:11 33:6 102:25 fine 8:21 99:18 finish 141:5 finished 6:19 19:8,22 70:6,6 fire 121:23 122:1,2,3 122:13 fired 45:25 firms 36:11 first 1:19 14:21 17:13 22:13 24:6 30:12,13 30:23 35:16,17 41:5 60:3,22 62:2,5 67:11,23 68:4 69:9 69:18,22 71:4 78:2 97:9 98:22 102:25 103:3 121:17 124:17 130:14 132:15 138:1 140:17 fit 26:18 86:20 87:1 fits 61:2 76:12 84:22 98:5,11 fitting 89:7,24 90:2 five 4:7,11,13 15:8 five/ten 15:11 fixed 46:19 77:11 flat 87:5,9 90:23,25 flexibility 86:18 flexible 65:4 flood 125:8 flooding 125:13 floor 10:10 24:22 26:9 26:11 112:18 119:7 128:9,9 floors 5:19 flow 4:3 40:15 42:11 43:19 44:10,10,12 44:14,14 45:7,16 47:1,2,6,17,21 49:15 52:11 61:23 63:8,11,14,21 72:21 72:24 76:1 87:3 88:22 90:19 91:3,16</p>	<p>107:8,10 115:16 flowable 30:25 flowing 19:1 21:2 41:21 44:7 55:4,13 61:20 flows 19:9 20:25 42:19 44:11 45:11 52:3 97:24 fluctuation 102:25 137:25 flue 63:5 fluid 41:16 focus 24:8 followed 1:20 following 48:24 90:1 94:19 follows 95:2 96:21 follow-on 137:15 force 45:14 forced 16:22 forces 27:20 Foreign 2:5 forepole 17:21 18:2,2 forepoles 17:16 forepoling 17:8,9 forgot 119:8 124:5 form 36:17 94:4 formal 62:2 formation 37:8,21,24 forms 31:21 formula 77:4 formwork 36:25 forward 1:4 32:9 41:2 140:23 fossil 63:1 found 64:19 140:4 founder 61:25 four 3:18 5:23 6:18,22 7:8,20,21 8:20 9:6 10:8,11 15:13 25:22 26:11 31:14 39:8,9 44:9 51:11 91:20 102:12,23 103:9 113:2,3 117:13,14 123:18 132:23 133:3,20 135:18 Fourneyron 61:24 Fox 62:1 fraction 41:25 Francis 25:4,9 43:8 44:7,15,22 45:4,10 45:17,20,21 46:12 116:12 frequency 65:13,15,16 65:18 103:19 104:7 106:22 115:14 fried 121:10 friendly 42:25 62:16 friends 95:20 front 32:4 35:4 113:21 fuel 15:20 62:24 63:1 63:1,3 76:3,4 full 16:21 30:5 36:4 75:5 80:20 91:20 137:22 function 13:4 fundamental 41:13 46:12</p>	<p>fundamentally 93:10 furnace 63:2 further 2:12 7:1 20:7 22:23 24:5 59:1 98:14 138:8 future 20:7 72:2,12,14 86:17</p> <hr/> <p style="text-align: center;">G</p> <hr/> <p>G 1:1 gallery 8:6,8,12 33:3,4 33:11,13 117:20 galley 112:9 gap 115:4 GARTH 2:22 gas 82:21 124:3 134:5 gases 63:5 gate 14:22 23:8 103:21 111:7 115:15 116:13 120:3 127:8 gates 23:3,3,6 40:16 104:1,4 106:25 114:8 126:17,18 127:3,17 128:14 gauge 121:16 126:22 general 2:6,22 23:25 25:5 57:12 60:22 79:7 generally 25:2,2 67:2 140:16 generate 4:9,15 5:12 7:5 61:10,20 62:13 63:5 68:13 70:21,21 95:9,14 122:2 132:20 generated 3:21 4:12 27:16,21 69:13 73:25 74:4 120:20 generates 96:7 113:24 generating 3:7 7:3 51:23 52:15 62:15 62:20 67:23 95:7 103:10,11,11,12 104:3,15 115:10 116:18 generation 2:18 3:6 3:19 4:1,4,7,11,14 7:7,9 11:14 13:2 24:4,11 36:9 51:2 52:24 53:8 55:6 67:5,17,24 68:7,14 86:24 87:1,13,14,24 88:4,8,11,21 89:7 89:16 90:2,6,20 91:7,13,18,21,25 92:1,3,6,9,12,14,15 92:17 94:13,15 95:5 96:5 98:12 102:22 103:16,18,18 104:1 104:14 113:4,9 115:19,20 122:21 131:15 138:2 generations 3:16 92:20 generator 5:3,4,17 6:14 7:23 12:19,20 12:24 13:3,19 14:5</p>	<p>21:9 22:14 24:22 25:3 26:4,7,10,13 26:16 32:24 38:22 38:25 41:18 42:4,24 51:11,15 52:8 53:1 53:21 64:3,4 65:8 68:5 102:12,19 114:2 115:1,9 116:4 116:15 119:7,9 120:16 121:22 123:4 124:3,4,7,14 124:15 127:6,7 133:24,25 134:17 generators 5:24 14:1 51:4,7,12,18 52:5 52:13 53:18 63:15 70:24 104:8 124:8 135:11 137:22 generous 140:13 gentlemen 131:19 geological 95:23 geology 16:14,17 17:4 28:10 29:21 30:2 31:23 32:18 37:8,11 geometry 29:23,23 Georgina 1:21 gets 69:3 91:9 109:9 128:15 getting 19:19 55:1 63:10,11 106:16,22 121:19 125:19 Ghakkar 107:21 108:5 Ghazi 45:23 84:16 93:10,14,16,17,20 93:21 94:1,7,11,14 94:17 95:1,4,18 96:6,6,16,25 giant 32:3 gigawatt 75:13 80:7 girder 17:13 18:16 GIS 134:4 give 1:11 2:21 13:1 18:20 19:14 20:7 21:4 24:19 26:17 34:14 56:11 58:18 59:9 64:3 70:17,23 71:2 73:23 79:19 93:3 102:10 107:7 133:5 given 23:25 28:17 39:10 52:14 73:16 77:19 84:18 94:10 101:21 104:7 116:16 gives 24:16 26:20 31:4 85:24 86:18 95:5 107:7 113:23 giving 12:11 glaciers 41:22 glad 56:15 globally 82:14 gloves 22:3 glowing 116:9 go 1:21 2:24 5:19 6:10 6:25 8:2,12,14,23 9:1,4,19 10:2 14:25 16:2 17:3 20:15</p>	<p>22:7,10 25:4 28:3 29:2 31:9,10 33:13 35:4 36:11 48:24 54:19 56:6 58:6 60:23 65:8,9 84:23 89:15 90:15 97:7 102:10 107:22 109:17 111:8 112:9 112:11,13 113:17 113:19 114:9,22 116:3 118:13,17 119:3 120:11,14 122:17 124:5 126:24 127:21 130:12,13,15 131:16 134:8,14,22 136:5 138:5 141:6,9 goes 9:24 12:13 31:15 52:7 78:23 90:25 91:4 108:2 goggles 22:6,8 going 9:23 13:14 17:5 19:16,23 20:14 22:13,14 31:18 62:14 77:4 78:14 86:13 99:23 100:5 100:21,25 101:18 107:20,21 108:5,8 108:20 113:19 120:16 127:5 128:2 129:3 134:16 135:7 135:21,22,23 136:6 gold 63:4 gone 29:6 good 1:7 15:3,3 20:17 27:11 32:12 40:25 58:25 59:22 74:25 82:8 84:19 98:19,24 99:5 101:20 107:11 108:13,17 110:8 113:13 130:3 133:10,12 134:2,3 135:9 138:8 Gorges 71:13 government 140:15 140:19 gradual 90:19 gradually 29:5 46:25 47:13 90:23 91:3 94:24 grain 48:13 grains 42:2 61:14 graph 79:10 80:23 81:6 88:9 grateful 139:4,8 140:6 140:23 141:18 gravity 77:10,11 112:23 great 23:9 57:25 95:13 101:19 139:15 green 7:16 66:2 67:20 72:8 86:4,9 94:14 96:19 99:24 103:15 greenish 26:14 GREGORY 2:8 grey 13:15 grid 5:14 43:1,4 53:12 54:21 55:7,14 73:18</p>	<p>94:21 100:17 101:2 107:21,23 108:6 griping 61:14 gripper 31:21 ground 28:15 99:20 group 2:14 22:10 111:8 118:14 grout 17:19 grouted 17:18 38:20 grouting 20:6 33:10 guests 111:12 guide 1:24 12:9 13:18 13:19 46:17,18,18 46:19 47:2,4 guided 1:24 Gulland 1:21 GWh 4:15,16</p> <hr/> <p style="text-align: center;">H</p> <hr/> <p>half 129:14 hall 5:17 7:23 22:14 22:14 26:4,7,10 32:23,24,24 38:22 46:16 51:9,11 52:25 Hameedullah 2:20 59:23 84:19 hammer 49:16 hand 1:17 22:3 23:23 40:19 handle 16:23 21:11 hands-on 138:20 hanging 14:12 HANIF 2:18 happen 57:16 123:23 happened 9:13 103:4 141:3 happens 20:8 58:17 104:2 happy 57:21 hard 71:25 88:1 harm 21:9 harness 86:19 hassle 25:11 having 11:3 18:9 27:9 27:18 41:2 52:14 62:20 81:19 85:1,4 85:7 87:17,21 88:1 92:17 93:1,10,15 95:13 96:2 97:17 Hayat 2:14 3:10,15 23:16,19 27:6,11 34:9,16 35:4 36:3 36:19 39:15,17,19 40:7,21,24 41:1 50:19 51:1 56:23 57:3,5,7,10,20,23 58:1,3,4,10,13,15 58:17 59:3,8 68:8 73:2 Hazara 37:24 hazards 82:11 head 7:5 27:12 31:25 32:4 43:19 44:19,20 44:21,21,22,24,24 44:25 45:7,16 46:6 47:17,18 48:12 50:11 61:20,23 76:19,20,20 77:8,20</p>
---	---	---	--	---	---

<p>84:13 85:11 88:22 89:24 96:3,8,9 101:24 103:19 113:1 headed 98:25 headrace 3:5 7:15 8:4 8:5 11:20 28:7,25 29:1 32:25 33:1,20 34:6,10,11 36:1,22 37:12 38:7,18 128:22,23 137:25 heads 32:7 48:1,2 67:2 67:4 125:1 hear 23:15 35:6 59:7 101:8 137:19 139:16 140:8,9 heard 60:17 hearing 1:4 heart 47:5 heat 125:23,24 126:7 126:8 heaviest 6:6 112:1,3,4 heavy 24:25 130:18 hectic 73:1 height 5:18 24:21 26:5 27:14 28:18 47:18 101:24 117:25,25 helmets 22:2 help 49:10 95:22 helpful 59:6 84:1 98:16 138:23 140:10 helping 140:22 HEP 62:5 76:12,15,16 76:24 77:21 142:13 HEPs 76:10 high 7:6 28:14,15 33:2 33:6 37:13 39:4 44:19,20 45:3 48:1 53:9 62:18 63:6,9 68:18 69:20,23 76:20 80:1 81:2,12 96:3 97:24 101:11 101:11 117:22 125:1,5 higher 55:23 95:16 97:25 highly 88:20 high-flow 4:16 high-head 46:2 high-pressure 17:19 30:25 high-speed 44:6 high-velocity 15:19 44:1 45:25 hill 37:3 him 98:6,12 Himalayan 27:17 63:13 Himalayas 28:5 hit 61:21 hi-vis 22:2 hold 17:14 holding 114:12 holes 14:23,24 30:6,10 33:4,12 home 140:12,12 homes 4:18 55:1 79:2</p>	<p>142:15 honour 141:21 Honourable 59:21 84:10,10 hope 22:20 142:9 hopefully 36:14 hoping 137:19 horizontal 51:18,20 horseshoe 29:24 horseshoe-shaped 33:24 hospitals 70:4 hosting 1:3 hot 83:6 133:11 hourly 116:25 hours 70:18 75:13 78:22 79:6,7,7,7,8 79:25,25 80:1,2,7 80:11,12,13 87:6 88:14 89:3,3,22 94:2,25 housed 42:21 housing 47:9 HRT 16:16 103:1,7 106:19 127:15 128:3,22 138:3 hub 5:8 huge 37:10 human 24:19 humans 8:23,25 78:4 78:5 hundreds 30:7 53:11 hydel 57:4,5 63:14 67:25 68:2 74:5,18 74:18,22 75:23,25 81:18 84:12 hydel/IPPs 75:12 hydraulic 49:18 114:21,22 126:16 126:19 127:11 129:23,25 130:1 hydraulics 39:3 hydro 60:19 61:14 64:12 65:13,20 67:5 68:7 71:11 72:17 74:16 75:21 77:9 81:25,25 82:3,18 83:10,10 84:15,21 84:25 85:3,4,8,14 86:25 87:8,17,20 88:10,20,21 89:8,25 92:21 hydroelectric 1:15 42:14 43:2 45:18,22 46:16 51:22 95:12 111:7 hydroelectricity 86:19 hydrogeological 29:22 hydrology 3:20 hydropower 2:15 1:10 28:4 38:2 41:12 46:8 55:1 56:21,25 57:9,10,12,17 60:17 61:4,5,15 62:2,11 62:11,15,18,22,24 63:5,15,24 64:9,19 65:5 73:17 75:7 76:11 107:20,25</p>	<p>hydros 89:1 Hydro-Electric 2:20 Hz 65:16,17</p> <hr/> <p style="text-align: center;">I</p> <p>idea 24:20 26:17,20 34:14 73:24 identification 104:18 ignore 65:5 illustrations 51:16 ILYAS 2:5 image 48:10 imagine 37:7 imagines 140:21 immediate 105:14 immediately 93:18 102:6 107:6 135:13 impact 13:6 48:4 imparts 42:23 import 72:13 important 11:10 13:21 17:1,7 18:5 36:18 68:6 71:20 87:23 93:9 impression 98:2 improve 73:15 impulse 43:22,25 45:24 inaudible 39:3 112:6 114:13 115:5 119:1 119:5,19 125:19 126:2,16 127:12,15 128:8 129:11,21 135:8,12 incident 20:10 21:15 include 29:9 39:2 48:21 includes 51:11 including 42:2 47:17 86:15 increase 21:12 38:6 48:12 90:19,20 91:2 92:9,10 107:10 121:1 increased 39:7 increases 48:12 53:7 increasing 47:13 90:23,24 91:4 107:8 indeed 2:24 independent 74:11 independently 74:9 74:11 117:12 India 1:17 2:10 139:11,15,18 India's 139:21 indicate 23:4 72:7,8 indicates 16:14 103:14 116:8 indicating 38:21,25 46:15 66:9,16,20 71:11 72:13,15 78:16 79:9 81:11,13 113:15 indication 16:19 21:1 102:5 109:20 indistinct 67:17 101:7 107:15 110:6 113:5 116:6 124:8</p>	<p>individual 51:24 individuals 139:2 140:19 indoor 119:20 Indus 1:1 2:5,14 45:19 industrial 42:3 62:13 70:19 78:19 industry 2:9 70:20 inflow 91:24 92:10 94:22 106:16 107:5 inflows 94:8 107:2 information 59:9 73:9 102:11 138:17,22 139:13 informative 142:10 informs 107:6 Infrastructure 66:6 initial 31:5 38:2 42:6 62:17 inlet 10:21 11:3,17,21 11:24 12:3,5 14:21 38:17,23 39:8,9 40:9 43:19,22 46:22 46:24 48:21 49:2 50:7 56:8 114:4 120:6 121:19,20,20 124:20 125:3,3,5 innermost 30:13 inside 1:23 4:22 6:6,16 10:2 11:23 14:11,14 14:25 16:14,25 17:3 20:25 22:6,7 27:19 51:4 99:21 103:4 104:22 109:13,15 111:2,13,18 113:14 114:7 115:1 119:14 120:5 121:3 122:9 125:25 126:22,24 127:12 129:17,18 129:18,19,20,21 134:5,13 136:25 138:3 inspect 14:16,19 inspected 18:10 36:2 inspection 3:23 9:21 14:24 36:12,15 50:7 98:18 103:4 install 5:10 6:6 installation 5:1 6:21 11:7 57:1 installed 5:9 6:21 24:24 42:10 43:8 44:21 45:20 49:3,13 49:18 50:4 60:13 73:24 74:2 75:3 88:18 92:14 95:9 108:16 110:7 113:8 115:6 117:9 131:23 136:25 instance 130:14 instead 4:21 8:16 10:2 18:10 96:11 125:9 125:11 instructions 58:8 73:9 105:2 106:24 instrument 8:7 instrumental 141:1 instrumentation 13:8</p>	<p>100:13,14 108:15 109:21 116:17 117:11 119:13 135:25 instruments 13:5 33:8 insulated 121:8,9 134:5 intake 46:22 49:3 106:17 integrated 71:16 integrity 139:25 interconnected 74:10 interest 81:24 141:24 141:25 interested 66:15 78:14 interesting 85:20 88:12 89:9 92:18 101:14 108:13 110:25 135:3 interfaces 47:6 interlinked 76:12 intermediate 78:1,3 79:24 80:5,12 81:14 89:16 91:6 intermediate-load 76:25 internal 43:7 interrupt 41:7 inter-bedded 37:10 introduce 98:22 invention 41:20,25 42:4 invert 20:21 invite 129:9 involved 113:6 140:22 141:11 ionisation 101:12 irrigating 41:22 Islamabad 3:4,13 37:15 ISLAMIC 1:15 2:2 isolate 11:22 39:10 54:17 56:7 100:11 isolated 90:16 isolation 127:13,15 issue 9:11 95:18 issues 75:8 95:19 138:23 141:13 items 89:14 IX 1:1 i.e 64:3</p> <hr/> <p style="text-align: center;">J</p> <p>J 2:9 Jammu 1:5 January 4:2,2 74:6 92:3 96:22 JEFFREY 1:10 jet 44:1 45:25 Jhelum 2:15 3:1,2,8 34:25 35:2,10 37:14 37:20 85:6 86:8 join 130:15,15 joining 1:16 139:18 142:4 joint 39:20,23 joints 33:7,11 39:14 joke 140:6</p>	<p>journey 142:14 JOYA 2:13 judge 40:10 July 87:2 88:1 91:14 94:23 juncture 18:17 June 73:23 junk 71:10 just 5:21 7:23 8:22 10:12,21 11:21 12:7 13:13 16:7 17:2,14 18:20 19:6 20:2,4 20:12,16,24 21:3 23:7 24:19 26:17 27:4 31:4 32:23 33:19 34:8,10,13 38:5,8,25 39:13 41:7 56:7 58:4 59:4 67:14 69:25 70:17 72:6 74:15 75:19 77:5 83:24 87:18 97:4 98:2 101:24 102:10 106:4,21 109:20 110:13 111:18 112:13,16 113:14,19 114:5,9 115:23 116:1,20,20 116:23 117:5,17 120:11 124:2,8 127:11,19 128:2,4 128:16 130:17 131:16 132:14 133:15 134:8 136:9 137:20 139:20 140:1 141:5 Justice 2:3,6</p> <hr/> <p style="text-align: center;">K</p> <p>Kabul 66:17 KANUPP 71:15 Kaplan 44:7,15,25 45:4 46:5 48:1 Karachi 74:8,12 Karot 85:5,23 86:7 107:20,25 Kashmir 1:5 KC 2:7 keen 141:23 keep 55:4 117:18 keeping 10:20 90:14 kept 30:21 51:25 63:19 key 43:18 kg 61:18,19 77:13 Khan 2:20 3:18 46:4 59:21,23 74:18 75:1 83:24 84:1,2,5,7 Khwar 46:3,3,4 kiloamperes 68:15 kilometres 3:3,4 28:25 32:17 33:22 34:1,5 34:20,21,22,23 35:7 35:8,9,11,13,14,16 35:24 38:8,9,10,11 38:11,12,12,13,13 53:11 85:19,21 96:2 kind 17:19 18:8 20:9 21:14 22:19 120:15</p>
--	--	---	---	--	--

<p>kinds 13:20 18:15,21 106:8</p> <p>kinetic 10:22 41:15,23 42:1 43:10 44:1,6 45:25 47:6 61:9</p> <p>KING 2:23</p> <p>knew 20:16</p> <p>know 1:8 17:3,4,5 28:24 33:16 34:3 36:7 43:16 51:5 55:9 56:19 57:13,16 61:17 62:24 65:16 66:11 77:8 84:24 107:24 108:21 111:4 122:3</p> <p>knowledge 39:17</p> <p>knowledgeable 142:10</p> <p>known 63:4 64:8 66:23 73:12 79:15</p> <p>knows 69:5</p> <p>kV 43:1,2,2 53:2,3 54:18 68:9,14,23,24 69:25 72:7,8 85:17 85:19 115:10,24 120:18 131:21,21</p> <p>kVA 133:8</p> <p>kW 62:7</p> <hr/> <p style="text-align: center;">L</p> <hr/> <p>L 2:8</p> <p>lack 97:14</p> <p>Lahore 72:11 84:13</p> <p>land 41:22,24</p> <p>landscape 42:11</p> <p>large 29:17 37:12 46:6 51:17 54:14 71:11 71:12,17 82:4 93:17</p> <p>larger 10:24 48:13 52:16 95:13</p> <p>largest 45:18 52:15</p> <p>last 21:6 74:2 75:21 80:2 124:9 125:22</p> <p>lasted 16:9</p> <p>lasts 79:6,6,25</p> <p>later 33:19 40:22,24 41:1 42:3,10 63:18 88:16 94:18 95:4</p> <p>latest 113:10</p> <p>lattice 17:13 18:16</p> <p>Law 2:3,6</p> <p>layer 71:4</p> <p>layers 19:18</p> <p>lead 110:17,19,20</p> <p>leading 25:21</p> <p>leakage 50:11 128:14 128:15</p> <p>learn 141:13</p> <p>least 97:23</p> <p>leave 13:24 59:4 134:13</p> <p>leaving 54:11,12</p> <p>led 42:5</p> <p>left 37:22 85:16 136:9</p> <p>left-hand 99:19</p> <p>Legal 2:23,23</p> <p>legend 66:1 72:6 86:3</p> <p>length 17:21 30:20 34:5,14,20 38:4,7</p>	<p>38:11 59:24 112:23 112:25 113:1</p> <p>lengthy 14:20</p> <p>less 4:3,4,6 7:6 21:2 27:19,22 52:4 53:9 56:5 63:9,11 64:13 64:13 72:23 75:19 79:8 80:13 81:1,13 82:6,10 96:20 100:19</p> <p>let 2:21 26:2 41:7 59:4 78:2 83:24 97:4 105:18 111:23 127:21 141:5</p> <p>let's 11:16 14:3 30:4 45:6 90:15 92:16 108:19 114:3 134:22</p> <p>level 2:21 26:2 50:5 53:22 55:8,9,24 68:10,20 68:24 69:7,11,12,20 69:23 82:6 85:18 106:17 110:10 121:1 130:20</p> <p>levels 68:23 69:6 123:9</p> <p>life 49:12</p> <p>lifespan 49:6 50:1</p> <p>lifetime 27:15</p> <p>life-cycle 139:7</p> <p>lift 6:7,13 24:24</p> <p>lifting 112:1</p> <p>light 116:8,9</p> <p>lighting 79:4 119:20 119:21 135:24</p> <p>lights 78:13,18 117:15</p> <p>like 10:17 16:14 20:10 22:6 24:22 29:13,14 34:3 37:16,18 39:3 45:22 56:8 61:13 62:8 69:18 70:3,4,4 70:4 71:7,12 82:3 85:13 88:2 90:13 98:22 100:11,20 102:18 108:21 111:20,21 119:15 120:25 121:13 124:8 126:9 133:10 134:20 141:19</p> <p>limb 3:1</p> <p>limit 103:7,8 115:4 138:3</p> <p>line 8:11 9:24 54:5,12 56:10 68:18 72:12 72:16,19 79:12 100:5 102:18</p> <p>lines 43:2 46:15 53:10 54:20,24 55:2,21 56:3 69:2 71:25,25 72:1,2,3,6,7,7,8,9 72:10 73:11,18,19 73:20 85:17,22 101:1,2 103:15 107:18 108:7,9</p> <p>lining 34:12 35:1</p> <p>linings 34:14</p> <p>Lisa 1:21</p> <p>list 140:16</p>	<p>listening 59:10</p> <p>little 21:22 28:23 40:22,24 51:1 61:19 70:10,12 71:5 75:23 78:24 79:5 87:10 92:8 93:23 100:8</p> <p>living 55:21,22</p> <p>load 15:14 64:15,25 65:3 69:1,13,15 70:17 76:23 78:1,2 78:3,3,4,10,19 79:4 79:14,23,24 80:2,9 80:12,13,17,18,19 80:20 81:3,4,6,7,12 81:15,19 82:7,15 83:5,13,13 85:10 86:22 87:22,24 88:17 89:13 90:9,19 90:22 91:2,20 94:21 102:24 103:1,23,23 103:24 104:9,11 110:15,16 119:24 123:25</p> <p>loaded 30:17</p> <p>loading 65:9 69:3 77:25 98:4</p> <p>loads 82:12 88:2 89:23 91:8 110:16</p> <p>local 55:20 98:7 106:13 107:8 110:2</p> <p>locally 98:8</p> <p>located 3:2 45:19 46:3 46:8 47:11 52:22 58:7 63:12 70:17</p> <p>location 112:10 122:3</p> <p>locations 42:11 104:22 130:6</p> <p>London 2:7,7,8</p> <p>long 26:5 31:7 37:12 64:21 124:9</p> <p>longer 83:12</p> <p>longevity 24:9 47:16 48:5,17</p> <p>look 1:4 4:16 14:17 17:11 29:17 33:18 37:16,23 41:2 76:23 83:9 88:7,12 89:10 112:22 114:3 119:12 121:18</p> <p>looking 5:24 10:9 18:24 40:12 60:7,9 62:8 73:18 80:15,23 95:11 97:21,22 99:14 117:17 133:14,15 137:13</p> <p>loop 124:24,25 125:2 125:17 126:8,8</p> <p>losing 36:9</p> <p>loss 53:9,22</p> <p>losses 53:24 54:2 63:6 68:10,12,16,18,19 69:8</p> <p>lost 53:20</p> <p>lot 25:10 27:15 33:10 33:17 37:3 60:17 61:5,10 66:19,25 68:10 76:14 82:2 117:17 123:21</p>	<p>124:1</p> <p>low 44:19,25 45:3 46:6 48:1 53:21 63:7 76:19 82:17,25 88:17 89:13</p> <p>lower 3:1 14:9 20:21 52:11 82:18 116:12 117:24 119:9 120:22 123:11,14 126:12 127:12 130:17</p> <p>lowest 5:17 78:16</p> <p>lunch 1:21 59:12,16 59:17</p> <p>lying 86:1 93:22</p> <hr/> <p style="text-align: center;">M</p> <hr/> <p>machine 22:13 31:20 46:16 62:19 93:4</p> <p>machinery 26:16 31:19 42:3 70:22</p> <p>machinery-based 83:3</p> <p>machines 31:23 32:19 38:6 92:22,23,25</p> <p>made 25:8 30:10 33:23 87:2 98:4 141:12,17</p> <p>magenta 66:3 72:9</p> <p>MAHMOOD 2:14</p> <p>main 2:12 11:17,21,24 12:3,5 24:17,22 27:23 32:23,24 38:22,23 56:8 64:2 71:9 77:22 101:25 114:4 119:22,22,22 119:23,24 120:6,17 121:19,20,20 125:3 125:5</p> <p>mainly 59:24 98:12</p> <p>maintain 63:22 139:21</p> <p>maintained 73:11</p> <p>maintenance 11:22 15:2 25:13 41:11 56:10 59:25 64:13 75:9 92:24 93:1 97:12,14,17,18 98:23 99:1 100:23 102:19 120:5,9 130:8 142:11</p> <p>major 24:17 26:2 28:12 54:6 62:11 64:7 82:19 84:15</p> <p>make 25:15 27:14 28:21 63:23,24 68:16 80:19,19 83:2 93:4 95:24 98:8 106:4 124:2 139:13 140:22 142:10</p> <p>makes 38:12 90:11,13 93:5,19 94:5</p> <p>making 141:1</p> <p>Malik 2:6,16,18 3:20 34:16,20 35:3,7,14 35:17,20,22,24 36:6 38:5 39:23 40:1,4 43:24 45:9 60:15</p>	<p>83:21 84:9,10,11 95:11,20 96:15 97:4 97:16,19 98:3,14,17 118:11 129:8,9,14</p> <p>managed 29:2</p> <p>management 48:7</p> <p>mandate 73:16</p> <p>Mangla 45:22 66:10 66:13 85:6 86:8</p> <p>manifold 33:1 38:17</p> <p>manner 86:14 93:8,12</p> <p>manually 54:9</p> <p>manufacturers 52:16</p> <p>many 4:24 12:16 13:19 28:8,24,25 33:15 45:22 47:17 69:4,15 70:3,5 137:16</p> <p>map 65:20 71:24</p> <p>March 4:3 89:17 92:13 95:8 96:24</p> <p>markets 70:4 79:3</p> <p>maroon-ish 37:21</p> <p>master 55:8,9 58:5</p> <p>matching 47:23</p> <p>material 15:21 123:11 123:15</p> <p>materials 138:20</p> <p>Matiari 72:11</p> <p>matter 25:15 64:22 65:1 98:10 138:5</p> <p>maximise 27:12 117:25</p> <p>maximum 4:8,9 6:9 87:4,17,22,24 88:4 91:16,18,21 92:13 92:17 94:20 97:24 115:3 118:7</p> <p>may 10:20 15:9 29:3 48:19 59:3 63:16,18 67:25 68:1,2,2 70:19 71:6 82:23 139:12</p> <p>maybe 15:8,12,12 18:25 23:11 40:10 61:14 62:17 63:9,9 64:10 65:1 75:6,7,8 78:22 79:8,25 101:23 118:8,8 128:8,8 130:13 133:13 139:20</p> <p>McGowan 1:21</p> <p>mean 29:13 36:3 62:12,17 78:2 83:2 98:1 130:8</p> <p>means 28:12,17 36:9 38:10 41:18 64:13 79:17 92:22 115:12 119:23</p> <p>measures 48:16,18,21 48:24</p> <p>mechanical 13:9,11 21:15 41:15 44:2 48:23 49:5 50:3,5 51:7 53:18,19 61:11 61:12,13 64:4 99:6 136:11</p> <p>mechanism 32:10</p>	<p>39:6</p> <p>mechanisms 50:15</p> <p>medium 44:19,22,24 45:3,16 71:5 76:19</p> <p>medium-sized 71:18</p> <p>meet 43:18 52:17 72:23 87:19 99:2,7 99:11,13</p> <p>megawatt 103:15</p> <p>megawatts 32:5 75:4 80:3 103:18,18 106:22</p> <p>mega-city 74:13</p> <p>MEHAR 2:4</p> <p>MEHMOOD 2:5</p> <p>members 1:6 2:4 23:19 41:3 59:21 84:11 98:19 108:21 141:20</p> <p>mention 15:18 119:8</p> <p>mentioned 4:19 6:18 25:7 32:16 58:5 108:25 111:10,24 112:3 113:22 117:19 136:21 140:11 141:22</p> <p>merely 98:10</p> <p>merit 75:10</p> <p>message 107:7,7</p> <p>met 137:14</p> <p>metallic 17:17</p> <p>metering 71:2 100:13 109:21 110:12 130:4,4</p> <p>meters 110:6</p> <p>method 17:8,9 19:5 20:2 30:4 36:15 38:4</p> <p>methods 18:12,13,21 29:19</p> <p>metre 17:22,24,25 19:14 61:18 77:13 121:11,12</p> <p>metres 5:16,18 7:6,18 16:7,20 17:21 18:1 18:10,23,23 19:23 19:24 20:1 26:4,4,5 29:14 30:21 31:12 31:16 32:11,12,13 32:15 34:25 35:3,10 44:19,22,24,25 52:24 77:11 96:9,10 112:24,25 118:3,4,7 118:8 119:7,9,10</p> <p>metres-plus 118:12</p> <p>middle 109:2 116:14</p> <p>midnight 78:6,9,12 79:13</p> <p>MILES 2:8</p> <p>millimetres 40:2 48:14</p> <p>milling 42:2</p> <p>million 3:23</p> <p>milliseconds 30:12</p> <p>minds 77:22 96:13</p> <p>MINEAR 1:10 101:15 101:19 109:23 114:17,19 121:14</p> <p>minimal 62:19</p>
--	---	---	---	---	---

<p>minimum 50:10 63:14 63:21 64:9 76:1 78:11,15 ministries 140:17 Ministry 2:3,4,5 minor 28:11 78:19 minute 43:20 45:3 51:13 minutes 64:22,24 missing 83:10 mitigate 48:18 49:4 mitigated 125:13 MIV 11:5,6,24 38:23 39:23 40:2 114:13 128:10,10,21 129:3 130:2 mix 57:7 73:22 74:1 75:20,21 87:16 mode 65:14 modern 42:12 44:23 53:16 61:14,25 77:17 124:23 Mohammed 41:5 moment 1:14 11:2 20:13 21:8 41:7 97:25 100:16,21 101:16 102:22 103:9 104:6 112:20 113:14 115:10,16 116:19 119:10 momentum 45:14 money 67:22 monitor 121:16 monitoring 8:6,8 50:4 50:6,8,12 114:24 month 4:15 90:17,17 91:5 monthly 80:19 months 4:7,11,12,13 14:14 36:15 92:4 94:23 96:22 monumental 37:11 more 2:16 4:20 5:25 7:4 9:14 10:18 11:6 11:10 15:15 16:2 19:19 33:18 35:7 52:1 56:11 58:18,24 60:5,24 61:17 63:10 64:13,14 65:12 70:12,15 75:16,21 81:17 93:21 94:1 95:5,7,17 102:11 111:9,21,22 123:2 123:25 124:2 125:12 morning 1:7 78:17,20 79:6 138:10 MORRIS 2:8 most 4:10 16:25 17:7 18:5 28:4 52:15 71:7,20 72:24 75:10 79:1,21 81:21,22 111:24 126:14,14 mostly 2:17 64:18 101:21 motor 103:20 115:15 119:15 mountain 118:2</p>	<p>mounted 51:15 move 3:25 6:17 7:10 10:7 17:12 20:11 32:7 74:15 108:14 111:2 114:15 125:14 126:12 130:23 131:6 140:23 movement 40:1 moving 41:16 70:10 80:16 109:7 111:18 131:8 much 15:17 16:4 18:7 22:19,24 23:13 27:21,21 35:2 40:5 42:7 50:18,24 55:5 59:5,9,10,11 64:11 68:18 76:18 79:24 83:24 84:6 95:5 96:20 97:25 98:15 125:18 126:20 135:5 141:18 142:15,16 muck 31:6 mucking 30:16 mud 125:25,25 mudstone 16:18 Muhammad 2:4,13,15 2:16,17,19 1:8 23:22 multiple 31:9 32:14 43:17 51:23 52:2,11 52:17 54:17 55:17 56:3 multiplier 79:16 multiply 68:17 80:3 81:4 Murphy 1:9 99:2,7 Murree 37:8,20 MURTAZA 2:4 must 28:8 39:2 64:16 83:6,6 Muzaffarabad 3:3 MVA 133:22 MW 3:18 7:3,4,7,8 45:21 51:12 52:16 57:1 60:13 62:9 64:11,12 65:1,2 66:20,21,22 68:13 71:6,7,12,13,15 74:3,3 76:2 79:11 79:17,18 84:25 85:4 85:5,7 87:6,11,25 89:11,12 91:1,4 92:14 96:7,7 102:24 103:1,10,11,12,12 104:3 111:8 116:19 myself 56:15</p> <hr/> <p style="text-align: center;">N</p> <p>NAEEM 2:3 name 5:7 41:5 named 12:9 Nandipur 46:9 national 2:17 2:7 5:14 43:1 58:11,13,15,16 73:2,13 100:17 101:2 105:3 107:23</p>	<p>natural 87:25 naturally 89:12 Nayyar 2:16 9:12 15:25 NBCC 58:12 near 9:22 37:14 70:17 89:12 90:25 91:1,4 95:7 96:6 125:18 nearly 91:19 necessary 25:3,13 48:18 need 11:22 15:7,9 28:5 32:5 39:13 52:17 56:5,10,11 59:3 68:19 97:14 123:10 123:11 127:9 138:11,13,16 needed 24:11 112:10 140:9 needle 128:12 needs 58:6 69:24 86:16 Neelum 2:15 89:2 96:18 Neelum-Jhelum 1:9 1:11,15 3:13 25:6 25:18 26:1 32:3 33:22 38:2 43:9 45:23 51:5,11 52:23 53:2 54:18 56:20 60:25 62:9 66:9,10 66:11 68:8 73:7 76:2 82:3 83:20 84:21,25 85:12,17 86:1,5,15,25 87:5 88:10,12 89:18,20 90:16,21,22 91:9,18 93:9,14,15,20,23 94:6,7,15,25 95:2,5 95:7,15 96:21,23 99:3 111:7 141:22 NESPAC 2:17,19 net 71:2 network 32:16 69:10 70:16,24 71:1 122:4 NEUTRAL 1:12 new 14:11 18:2 72:9 73:19,20 next 11:6 15:4,12 16:5 16:24 19:13,15,21 22:17 23:12 24:5 27:25 36:14,16 40:8 41:13 52:20 54:3 55:14 56:13 57:20 57:24 58:18 59:13 59:15,17 64:24 67:9 67:13 71:22 73:21 74:14 75:1 76:9,13 77:2,3,24 80:10,14 94:9 141:5 nice 99:2,7,11,13 111:21,22 133:10 NIEUWLAND 2:24 night 78:6 NIZAMI 2:5 NJHEP 1:4 NJHPC 2:15,16,16 noise 101:8,13</p>	<p>nomenclature 104:17 noon 78:9 79:13 normal 53:11 82:17 88:24 normally 30:19,21,24 31:6 32:10 124:22 125:6 north 60:7 67:3,6 72:21,24 northern 67:1 nos 1:20 2:13 note 138:25 139:20 notice 24:18,21 25:2 117:16 November 4:6 nozzle 30:25 nozzles 46:1 NPCC 58:11,13,14 73:2,9,10 140:5 NTDC 58:11 73:13,17 nuclear 57:18 62:25 68:2 71:14,15 74:8 75:7,12,19,24 76:3 81:18 82:10,12,14 number 10:18 13:10 13:12 15:11 16:5 24:13 27:3,16,17 28:3 32:20 33:20 36:20 38:15 39:12 43:14 52:19 55:16 61:4 62:10 67:9,13 70:10 71:22 73:21 74:14 75:1 76:13 81:16 86:5,6 112:4 113:21 114:24,25 116:2,7,18 117:7,8 118:22 119:5 133:3 138:19 139:1 numbering 6:24 numbers 34:17</p> <hr/> <p style="text-align: center;">O</p> <p>observation 106:21 observations 139:12 observe 20:24 observed 137:25 OBSERVER 1:12 OBSERVING 89:4 106:20 obviously 68:15 73:15 74:10 77:7 78:4 82:7 occasional 97:13 occurred 20:13 occurs 122:14 October 4:5 off 56:10 88:15 89:14 93:4 97:11 110:14 116:10 office 2:6,6 1:14 84:13 officer 1:9 offices 78:23 off-peak 94:11,13,17 94:25 often 31:19 Oh 9:3 23:1 40:3 130:23 132:3 oil 50:5 63:2 122:10 122:11,16,17,24</p>	<p>126:1,4 okay 1:2 9:5 19:12 23:6,10 35:7,19 36:1 39:25 41:2,8,9 50:23 55:16 57:15 57:21 58:1,16,25 59:17 74:25 84:9 95:10 96:14 97:18 98:13,14 99:17 101:10,18,19 105:17 106:14 107:19,22 108:1,10 108:23 109:12,16 111:18 115:19,21 117:21 118:1,5,16 118:16,23,25 122:22 123:1 127:1 127:21 129:13,22 130:3,19,23,25 132:3,7 133:12 134:15,20 135:8 137:3,3,6,9 138:7,8 old 117:5 124:22 oldest 60:11 129:11 once 1:7 17:23 19:8 54:4 73:14 76:21 ones 29:17 54:15 86:4 124:12 one-and-a-half-brea... 100:18,18,22 102:14,15 one-size-fits-all 43:16 online 106:23 114:24 only 21:16 25:20,24 26:9 31:6 39:2 41:24 52:5,24 57:5 61:19 64:22 69:25 72:11 76:3 86:15 87:13 90:15,22 92:5 93:23 94:4 95:3 96:8,10,19 109:18 113:10 122:16 124:22 128:8,9 140:8 141:24 onto 31:4 onward 2:17 onwards 94:22 96:23 96:24 on/off 40:14 open 14:23,24 31:21 104:1 124:24 125:2 125:22 126:8 128:16,19,20 137:8 opened 54:9,13 127:19 opening 14:8 103:25 115:15 130:17 open-loop 124:21,23 operate 15:13 66:13 76:24 82:5 88:24 93:8 114:21 117:23 124:16 126:18,21 127:10 128:24 135:14 operated 6:12 11:25 15:4 66:5 112:7 operates 43:25 129:23 operating 20:23 21:7</p>	<p>52:10 53:23 74:11 85:2,9 88:14 93:11 94:20 102:23 117:11,13 operation 6:11 11:24 13:22 21:5,6,20 24:3,8 30:16 41:11 42:14 45:17 46:2,7 48:17,20 50:8 51:24 59:25 66:2 84:12 86:5 89:20 93:13,20 94:6 98:22 99:1,10 100:24 102:4,17 103:9 111:16 112:5 112:8 113:2 115:7 116:7,8 126:17 127:11,13 142:11 operational 49:12 50:1 65:22,23 66:4 117:10,14 operations 40:15 90:10 operator 6:12 73:3,6,7 76:6,22 81:19 86:18 90:11 92:19 93:3,4 98:5,8,11 104:9 105:18 112:7 116:21 122:2 operators 88:23 opportunity 99:15,18 141:17 opposite 121:18 optimal 52:10 53:23 optimum 82:6 order 75:10 83:16 139:24 141:8 orientation 3:1 1:5,12 23:25 other 2:15 5:25 12:16 13:7 21:3 28:8 29:9 31:10 45:22 51:16 54:8,16 55:17 56:6 56:8 57:16 63:22 66:25 70:25 77:10 81:2 83:9 85:3,13 87:1,8 88:6,22 89:1 89:25 93:19 95:19 96:1 103:13 107:13 107:21 108:21 109:3,25 110:10 112:14 113:17 114:13 115:6 121:16 123:7,16 126:10 127:14 130:5 131:5 132:12 134:7 others 29:15 33:15 51:6,25 83:16 otherwise 29:6 93:15 104:25 out 9:7 14:9 16:3 19:9 24:23 25:12 30:18 30:22 33:13 34:7,21 38:8,13 57:1 58:21 60:6 62:8 74:3 89:9 100:25 108:3 109:6 117:5 123:14 126:1 128:7 130:9 131:2</p>
--	--	--	---	--	--

<p>132:13,14,15,16 135:17,21 140:4,16 outage 104:9 outer 30:14 120:23 121:11 outermost 30:15 outflow 107:6 outgoing 107:18 outlet 3:11 9:22 14:22 16:13 119:10 120:4 135:11 outlets 9:6 outline 100:21 output 21:13 42:5 47:22 62:6 77:21 104:7 113:3 120:16 124:21 outset 2:2 5:9 139:9 outside 6:3,4,15 8:19 13:14 14:10 21:4 100:5 104:23 115:2 126:25 127:3 132:6 132:15 134:8,17,18 134:22 141:15 overall 85:25 89:7 90:2 116:5 Overburden 118:11 overcome 31:8 overground 27:22 overhead 9:18 116:23 119:19 overlap 18:1 overspeed 50:6 overview 2:11 3:13 24:2 owing 63:19 own 69:21 70:20 73:8 93:7 owner 66:5 oxygen 15:20</p> <hr/> <p style="text-align: center;">P</p> <p>P 1:10 77:5 pace 38:6 packed 129:16,20 pad 50:12 Pakistan 1:15 2:2,6,13 2:17 2:8 53:13 56:21 57:7 58:7 65:16,20 67:3 71:23 71:24 72:21 73:24 74:13 81:17 140:16 Pakistan's 45:18 84:22 Pakistan-administe... 1:4 panel 22:12 109:22 114:24 116:2,3,5,5 117:9,10,11 119:13 119:20 120:15 panels 21:21,22 111:11 116:24 119:12,16 120:13 122:8 126:3 paper 26:6,6 par 96:24 parallel 44:14 parameter 13:6,7</p>	<p>parameters 76:21 103:14,17 115:3,5 116:15,22,24 117:5 parent 15:21 part 5:5,6,7,18 6:6 16:16 17:10 20:21 25:8 26:9 38:18 53:14 55:22 63:13 63:15 67:21 68:4 84:15 87:4,21 112:1 112:3,4 116:12 117:24 136:20 138:18 particles 48:3,13 49:9 particular 11:23 58:22 93:7 106:6 particularly 48:14 84:20 92:23 140:2 parts 4:21 5:4,5 11:8 12:4,16 21:15 28:4 32:19 74:16 115:2 130:12 pass 136:18 passage 47:12 90:11 passes 11:12 44:17 passing 42:19 47:21 past 74:15 Patrind 85:4 86:6 pattern 64:15 87:7 90:1,3 94:20 95:2 96:22 pause 23:14 35:6 42:18,18 59:18 84:8 100:9 101:20 108:14 110:8 111:1 111:5,19,22 112:14 114:23 116:10,19 118:25 119:2,4 120:2,12 121:6,24 122:8,9,24 123:8 124:17 125:15,16 125:21 126:12,15 127:6,7,22 128:1 129:8,14 130:11,16 131:7 133:12 134:12,21 137:10 peak 52:5 78:2,3,20 78:20 79:4,4,6 80:5 80:9,13 81:13 82:23 87:3 88:8,14,16,17 89:4,6,23 90:22 91:7,14 94:18,22 96:16,20 peaking 63:19 70:18 79:8 83:13,13 85:10 91:1 94:2 peaking-load 77:1 peaks 80:1,25 87:15 87:19 89:4 90:2 96:24 97:13 pebbles 16:12 pedestal 129:5 Pelton 44:2,13,20 45:4 45:24 47:25 penstock 7:21 8:9 11:19,19 26:25 38:17,18 39:2,15 42:20 46:15,21</p>	<p>49:14 114:6 128:25 129:1,4 penstocks 7:20 33:1 34:7 39:14,20 people 78:17,22 79:1 81:1 111:16 136:15 140:8 141:16 142:11 per 4:1 5:7 17:7 18:22 29:16 43:20 45:3 47:22 51:13 61:18 67:3 68:22 77:11,13 89:23 percentage 56:19 57:8 57:12 75:20,22 81:5 percentages 57:16 perfect 57:21 118:23 perforated 17:17 performance 47:16,25 48:4 performing 66:18 95:7 perhaps 95:16 118:14 period 27:14 55:15 72:25 87:16,25 88:4 88:13 89:11,15 90:23 91:6,15,17,21 92:2,5,17 93:2 94:12,21,23 95:3 96:19 97:16 periods 92:15 periphery 17:17 40:16 permanent 2:21 106:1 137:7 140:25 permanently 136:25 permissible 103:7 138:3 perpendicular 26:6 perpetual 62:19,19 person 58:5 107:2 129:11 personal 111:14 persons 130:13,16 perspective 76:23 PETER 2:9 phase 31:7 72:4 86:13 phenomenon 5:15 11:3 48:7 123:23 PHILIPPA 2:7 photo 10:9 25:18 51:4 51:14 52:20 118:14 photograph 2:21 5:22 9:18 16:6 19:13 25:23,23 31:25 112:16 131:11 photographs 4:25 9:14 16:2,9 118:24 photos 28:9 36:21 physical 8:25 physically 8:23 10:6 picture 18:24 19:15 88:7 103:13 114:25 116:11 118:22 pictures 25:1 135:4 pie 74:16 pink 99:24 pipe 19:1 pipes 17:18 121:3</p>	<p>127:23,23 130:4 131:14 135:11 136:9,10,10,13 137:1 pistons 32:9 PKR 3:23 place 6:3,14,16 54:4 56:6,6 58:6 106:25 118:3,24 123:15 130:21 132:16 133:10 134:14 placed 24:19,23 plain 67:7 plan 80:21 98:12 planned 86:14 92:25 planner 73:10 75:9 76:6 79:19,19 80:7 81:9 planners 77:22 planning 36:10,14 55:2 73:1,5 76:7 86:13 plans 36:6 92:19,19 118:17 plant 13:13,22 16:22 20:23 21:14,20 32:6 39:11 42:14 45:18 46:16,17 49:20 50:13 51:22 54:11 54:12,24 55:10 56:20,22 62:25 63:15,17,24 64:6,8 64:9,10,10 65:6 66:12,13 68:2,3 71:14 73:6 75:7,8 75:14 76:4,25,25 77:1,25 80:8,8 82:5 82:8 85:14,15 92:21 92:25 93:6 98:8,11 107:20 113:5 115:7 plants 28:24 43:3 45:22 46:3 51:17,17 51:20 73:16,17 55:7 55:9 58:20 63:2 71:12,17,18,19 76:8 76:11 79:20,21 80:21 81:18,20 82:10,16 83:3,4,11 86:10,12,14,18 89:25 90:10 95:12 107:13,16,17 plant's 54:20 plates 5:9,10 126:9,10 play 42:15,17,22 46:13 played 42:16 46:14 playing 43:4 plays 54:6 please 2:10 3:15 7:10 10:7 11:15 15:24 16:5 23:1,16,23 24:13 27:3,25 28:3 32:20 33:20 34:15 34:18 35:5 36:20 38:15 39:12 40:8 41:9 42:13,15,18,18 42:22 43:6,15 45:5 46:10,13 48:15 49:8</p>	<p>51:3 52:19 54:3,19 55:16 56:24 61:4 62:10 65:19 67:9,13 71:22 73:21 74:14 76:9 77:24 80:10,14 84:23 86:3,23 88:6 89:15 90:15 91:11 92:18 94:9 96:15 97:3,7 102:2 111:15 122:25,25 126:13 126:13 130:15 131:19 134:11 pleased 41:4 pleasure 1:23 23:20 51:1 59:8 84:5 98:17 99:9 141:21 plenty 28:7 plug 8:5 plus 28:7 29:10 31:11 38:9 112:23 133:19 plus/minus 118:8 point 9:9,20 15:9 24:23 52:10 53:23 54:22,22 55:24 59:4 78:15,16,16 80:6 81:8 104:8 119:6 125:20 139:18 pointed 8:22 34:7 89:9 pointing 108:22 points 10:21 18:11 76:7 pole 108:9 113:24 poles 5:10,10 113:24 Pomper 1:12 130:15 pondage 76:16,17 85:1 93:21,23 94:5 95:14,17 portal 119:8 portion 20:1,10 25:20 50:19 67:4,7,17,23 79:9 81:24 87:12 portions 25:19 position 103:20,21 130:24 positioned 46:23 positions 84:14 possibility 25:9 139:17 possible 50:10 75:5 138:17 141:1 potential 44:5 53:17 61:8 65:21 87:17 powerhouse 1:4 3:1,9 3:23 1:3,5,11,22,23 1:24 2:11,17,25 3:2 3:3,9,10,14,15 4:1 4:22,23 5:2,15,20 6:20 7:25 8:1,3,8,10 8:13,18 16:7 17:12 21:24 22:2,15,21 23:18 24:1,2,7,14 28:2 33:7,14,21 38:22 40:1,13 41:13 51:5 52:22 60:1,10 60:12 61:22 64:2,17 66:17,23 76:22 85:21 98:18,20,21 99:19 100:7 102:4</p>	<p>104:21,22,23 106:7 106:9 109:13 110:5 111:2,6 112:2,21 113:5,16,20 114:15 119:14 121:25 123:8,16,25 125:8 134:6,7 135:13 136:7 powerhouses 59:25 60:8,9,11 62:8 65:21 66:2,3 68:6 70:16,20 71:4 72:15 72:17,19 74:4,18,20 75:2,5 90:12 powering 42:2 PPEs 111:14 134:13 PPIB 66:6,7 74:21 precautions 18:7 precise 34:19 56:24 57:23 precisely 7:4 predictable 78:5 prefer 88:23 preferred 42:8 82:13 82:14,19 presence 28:19 39:4 present 2:11 28:19 82:12 86:16 112:18 presentation 3:1,9,17 3:23 1:4,5,18,20 2:2 2:3,10,13 9:15,19 16:16 22:18 23:12 23:16,18,22 24:2,5 25:17 40:17,23 43:12,24 45:9 48:9 49:1 50:20 56:14 57:20,24 58:18 59:2 59:13,15,17,19,20 60:14 84:19 98:16 98:18 112:4,17 113:11,23 142:5,5 presentations 2:14 25:7 76:15 111:24 141:24 142:9 presented 82:13 83:21 presenter 23:21 presenters 142:1,3 presenting 61:1 104:18 139:23 presently 84:12 pressure 10:22 20:25 21:13 29:1,6 31:22 33:2,5 37:13 39:4,4 39:7 47:20 48:22 49:14,17,19 50:7 102:25 106:19,19 125:5,7 126:19,19 126:20,21 128:18 128:20 130:5 137:24 pressures 69:3 pressure-reducing 125:6 pressure-related 49:19 pressurised 28:24 46:24 pretty 15:9 78:5</p>
--	---	--	--	---	--

<p>139:21 prevent 18:8 49:3,19 50:16 prevented 95:24 preventive 93:1 previous 7:24 12:14 18:2,15 20:2 74:19 75:11,15 76:15 107:12 previously 25:7 26:3 32:16 pre-feasibility 142:12 primarily 98:6 primary 69:24 70:2 principle 43:13 principles 46:12 private 66:5,6 74:21 110:2,4,6 problem 14:4 21:7 31:8 56:4 100:24 problems 29:3 54:16 proceed 23:16 41:9 105:1 proceeding 139:18 process 11:7 14:21 19:6 53:20 66:22 141:6 produce 53:25 97:15 produced 1:21 12:25 51:7 52:15 53:1 54:24 60:18 producers 74:21 produces 55:11 product 6:19 19:22 70:5,6,6 production 3:17 42:24 52:2 56:21 59:20 60:20 63:16 67:10 79:22 92:19 94:12 94:17,24 96:16,20 101:15,17 119:13 Professor 1:9,10 2:7 2:5 22:25 23:2,9 56:19 57:6,8,11,15 57:21,25 58:2 97:5 97:6,18,20 98:13 101:23 107:12,15 107:19,22 108:1,4,7 108:10,12 110:17 110:19 121:3,6,10 121:13 136:17,23 137:3,6,9 profile 48:11 progress 31:8,11,15 project 2:18,19,20 1:15,15 26:1 27:15 32:3,17 33:22 34:2 38:2 84:16,16,21,25 85:1,5,6,7,12,17 86:1,6,7,7,8,15 90:16 93:18 94:11 96:9,16 99:3,4 111:8 140:18 projects 37:11 66:25 84:15 85:3,3,8,9,14 86:4,25 87:8 88:20 93:10 prolong 49:11</p>	<p>prolonged 79:5 prolonging 49:6 prominent 45:6 prone 27:19 proper 20:4 47:9 50:8 properly 20:1,3 property 63:20 64:18 protect 49:15 54:15 protecting 109:5 protection 13:8,9,10 13:12 17:13,14 48:23 50:3,6 56:9 100:12,13 108:24 109:18 110:12 115:6 121:23 122:12 131:22 protections 13:12 protective 13:5 15:20 48:16,21 49:24 54:8 111:14 protects 15:21 provide 4:17 20:5 49:24 56:22 105:6 provided 11:21 17:23 17:24 19:18,19 20:4 132:14 provides 47:12 providing 101:7 138:17,19 provision 17:13 public 135:13 pump 76:17 127:24 pumps 136:25 purchase 69:22 purple 8:10 9:23 12:20 purposes 25:14 42:2 61:13 123:5 126:1 pursuant 1:1 pushes 45:14 put 6:14 14:11,11,12 14:13,21,22 17:16 18:18 19:20 20:6 30:23 31:13 36:13 39:14 65:14 82:24 100:22 113:9,12 128:6,7 134:20 137:1 putting 17:17 18:19 106:20</p>	<p>141:25 quick 64:25 65:17 82:21 97:9 quickly 29:7 43:3 48:24 64:20 65:8,9 quick-setting 31:3 quite 7:6 9:17 10:1 27:18 28:15 60:2 73:1 81:2,12,13 89:2 98:16 138:22 141:22</p> <hr/> <p style="text-align: center;">R</p> <p>rack 48:22 racks 49:2 radial 44:12 radially 45:12 RAE 2:9 rail 112:12 rails 14:11 24:23 132:13 railway 70:4 rain 99:15 127:24 raise 1:17 23:23 RAJA 2:3 ramp 43:3 ramping 64:24 65:7 65:17 82:11,17,18 82:22 range 71:6 ranging 44:21 Rasul 46:8 rate 3:24 45:7 47:17 47:21 48:11 rated 45:20 51:12 54:18 64:23 rates 45:16 52:11 rather 52:10,13 reach 8:3 69:8 reached 90:7 128:10 reaching 115:24 reaction 43:22 44:4,4 45:10,14 46:5 reactions 62:14 read 39:22 readied 51:9 reading 109:21 readings 116:25 119:17 ready 1:2 23:15,17 59:19 84:9 107:9 ready-made 70:5 real 26:8 135:4 140:5 realise 5:21 realising 18:25 really 11:11 28:22 137:15 138:21 139:4 140:8 141:16 141:20 reason 93:13 94:3,16 117:22 137:23 138:13 reasons 27:23 rebars 18:14 recalling 5:22 recap 32:23 33:19 receive 1:10 58:8 105:2</p>	<p>received 138:16,22 receiving 139:14 recognise 6:22 10:16 11:10 12:6 13:17 16:11 recognised 20:22 21:12 record 105:22 116:20 116:23,25 117:1 recorded 104:12 106:1 141:3 records 105:19 117:2 recovery 17:10 rectangles 72:16,18 red 23:8 67:16,24 72:6 72:7 86:10 91:13 94:13 115:1 116:8 117:14 135:20,20 reddish 37:21 reduce 49:10,25 69:7 69:10 104:9 reduced 138:2 reduces 83:5 91:24 92:1,1 reducing 10:22,25 120:25 refer 34:16 reflected 87:7 89:16 94:10,12 reflecting 90:8 94:14 reflects 88:9 regard 139:20 regarding 2:5 3:15 61:23 62:4 98:4 region 1:5 27:18 60:7 63:13 85:2,25 regions 42:9 registered 98:10 regret 139:10 regular 50:6 regularly 14:16 regulate 47:2 65:15 regulates 107:6 regulating 46:17 regulation 2:5 regulations 2:8 regulators 65:14 regulatory 2:6,7 rehabilitating 136:8 rehabilitation 60:10 reinforcement 18:14 19:17,18 20:3 36:25 reiterate 139:9 related 18:7 33:16 relatively 60:8 69:20 71:18 78:21 81:1 98:1 138:14 141:8 relays 110:12 release 20:5 49:18 released 3:8 releases 12:12 reliability 62:23 64:14 65:4 reliable 48:17 62:12 65:11,12 79:21 82:9 reliably 64:18 81:21 relief 48:22 49:17 50:7 remaining 18:10</p>	<p>34:22 50:19 87:19 134:3 remains 44:14 remarkable 141:16 Remarks 3:25 137:11 remember 2:4 95:21 97:16 remiss 140:24 remote 36:17 remotely 54:9 remove 14:5 25:3,8 49:9 removed 51:24 123:10 removes 33:24 removing 25:9 renewables 74:8 repair 15:25 16:22 19:5,6 21:16 repeat 38:8 replace 13:25 14:3 15:7,10 replaced 124:10,11 replacement 14:15 representatives 139:10 REPRESENTED 2:10 representing 81:5 REPUBLIC 1:15,17 2:2,10 request 72:5 111:10 111:12 requests 98:8 require 40:4 63:1,2 70:5 76:3 78:13,13 79:18 required 7:7 10:18 55:15 79:11,12,14 80:4,5,6 82:20 88:4 91:17,20 116:16 126:19 132:17 133:21 137:8 140:18 requirement 18:22 32:4 65:10 78:4,10 78:10,11,15 81:6,12 87:22 requirements 43:18 64:18 80:2 86:17,21 87:10,19 89:25 90:4 92:20 requires 27:8 96:7,10 requiring 65:11 reserve 83:1,1,5,6,17 reservoir 42:19 44:6 66:10,12 76:17 94:4 95:24 reservoir-based 66:13 resident 99:6,8 resistance 49:22 68:17 resolved 138:5 Resources 2:4 respect 13:22 44:9,18 45:2 50:13 139:13 respectively 45:4 respond 142:1 response 50:16 responsible 41:11</p>	<p>73:4 74:12 102:3,8 104:10 107:2 rest 3:10 4:7,12 22:9 57:15 74:9 81:14 112:24 126:15 restaurants 78:14 restores 96:20 restricted 102:23 103:1 result 68:10,18 95:17 resulting 42:12,24 resume 59:13 return 79:2 138:11 returned 106:5 Revolution 42:3 revolutions 43:20 45:3 51:13 right 2:23 26:23 37:23 55:4 66:8,17 73:7 81:23 117:13 129:2 132:11 rings 12:8,9 46:17 rise 90:20 risen 74:6 riser 89:18 91:9 risings 52:6 95:4 risk 48:19 49:4 river 3:1,2,8 33:25 34:13 37:17,20,23 37:25 45:19 62:1 63:8,20 66:17 85:6 86:8 rivers 41:21 63:8,12 67:5 72:23 road 37:22 rock 18:18,19 28:14 28:14,16,18 29:2,6 29:22 32:8 33:7 37:4 rockfill 112:23 rocks 28:11,12 37:17 37:19 49:4 138:21 role 24:6,10 43:4 54:6 60:25 65:5 86:21 roller-compacted 37:5 room 1:23 26:8 36:8 101:25 104:24,25 105:6 110:9 111:13 113:18 122:5 131:6 134:17 141:14,15 rooms 78:13 rotate 125:25 rotates 12:22,23,23 rotating 5:5 32:7 41:14 126:23 rotation 11:14 12:11 12:24 44:15 45:15 115:1 rotational 41:17 42:23 rotting 5:6 rotor 5:7,8 6:9,13,15 11:16 12:21,23 13:3 112:3,4 113:25 115:1 rotors 5:3 roughly 56:23 round 70:25 76:4</p>
--	---	---	--	--	---

<p>115:4 121:18 route 136:7 ROV 36:11 103:3 RPM 51:13 64:23 115:13 127:3,3 RRS 18:13,14 rubber 21:25 129:18 129:21 rubble 17:1 21:4 rules 101:21 run 32:4 51:12 52:5 63:15 64:2,15 74:20 75:5 76:2,4,7 81:21 82:4 83:12 87:17 89:6 runner 12:10,17,23 14:10,10,11,15 15:22 23:7,7 25:16 25:18,20 44:11 45:12 46:18,19,25 47:5,11 48:23 49:21 114:9 116:13 130:24 131:3 runners 15:19,21 49:22 130:19 running 36:12 37:25 51:25 52:9,10 61:7 61:8 62:18 63:17,19 64:7 65:2 72:17,25 73:17 74:9 87:5,9 89:2,5,21 91:20,22 98:4 126:22 run-of-river 66:11 76:16,17 83:11 84:16,25 85:3,14 run-of-the-river 142:13 rupture 125:7 rural 70:14</p> <hr/> <p style="text-align: center;">S</p> <p>safe 22:15 124:2 142:14 safely 18:3 21:7 safety 1:12 18:7 20:12 21:18 22:6,8 39:6 49:17 56:8,9 101:21 107:3 111:14 sake 67:14 salient 112:22 same 10:19,20,21 11:3 41:21 64:15 70:11 80:11 83:16 87:7 90:1 93:11 94:19 101:21 110:21 112:16 117:9 134:14 135:7 Sand 48:13 sandstone 16:18 37:9 37:22 satellite 106:11,12 Saturday 1:6 1:1 80:24 saves 25:10 saw 37:5,18 107:12 132:5,6 135:4 saying 140:24 141:5 scale 24:20 26:17</p>	<p>40:10 scarcity 71:3 scattering 22:11 scenario 83:9 90:8 schedule 1:18 scheme 11:20 100:18 100:19,20,22 102:15,15 schemes 108:24 SCHISTS 37:24 SCHOFIELD 2:22 screen 107:12 screens 48:21 49:2 104:21 scroll 10:13 12:6 se 29:16 sea 41:22 seal 50:10 sealing 33:10 seamless 141:17 Sean 1:9 99:2,7 season 4:3,16 63:9,10 63:16 64:16 72:20 72:22 77:23 81:24 82:2 83:10 85:9,13 87:3 88:8 90:5 91:15 94:2,22 97:10 97:12 seasonal 75:25 seasons 89:12 seats 102:2 SEBASTIAN 2:23 second 9:23 24:7 60:4 70:2 77:11 82:15 133:15 136:7 140:12 seconds 65:1,2 Secretary 2:6,22 sections 30:1 security 54:6,7 136:15 141:15 sediment 14:4 15:14 sedimentation 47:18 48:3 sediments 15:15 48:5 49:9 138:21 seeing 86:2 seek 105:7 seem 95:13 seems 97:23,25 133:10 seen 2:20 3:12 4:24 7:17 9:23 18:15 28:8 31:2 32:22 33:17 36:21 46:21 51:14,16 75:20 93:24 99:20 112:15 112:20 121:17 123:9 131:11 132:4 133:16 134:7 seismic-prone 27:18 selection 45:7 send 58:9 SENDHU 2:18 senior 99:10,12 sensible 125:14 sensing 36:17 sensitive 33:8 sensors 50:3</p>	<p>sent 55:5,12 separate 27:10 116:2 117:10 122:12 125:16 127:10 130:1 separately 117:11 September 4:5 92:16 sequence 6:1 series 54:7 serve 86:15 96:24 service 59:24 60:2 84:15 Services 2:17 servicing 54:25 60:3 87:9,19 servo 103:20 115:15 set 62:5 104:8 135:14 sets 110:9 settle 78:22 setup 29:21 seven 4:12 several 123:9 Shadiwal 46:8 shaft 7:16,18 11:13 12:18,18 14:12 25:3 26:14,15 33:17 38:24 39:6 41:18 42:23 46:18 47:7,8 47:9 50:9,10,11 116:14 117:25 126:23 127:2,2,5 SHAH 2:4 shales 37:9,21,24 shape 10:16,17,17 shapes 42:8 share 56:21 74:5 shared 23:22 sharp 139:22 sheets 117:5 133:16 shield 31:22 shift 102:1,3 104:10 105:18,21,21,22,22 106:3 shifts 102:6,7 116:22 short 38:23 42:13 46:11 95:3 141:8 shotcrete 30:24 31:3 34:12 shotcreted 18:20 shotcrete-lined 34:21 35:11,25 show 10:12 16:2 66:8 72:17,19 105:18 108:15 113:10 116:20 120:11 124:5,6 134:16 showed 25:17,22 122:4 showing 7:16,24 10:8 16:6 25:19 65:20 86:12 103:15 104:22 115:24 116:13 128:4 shown 12:20 20:2,18 24:25 26:3,13,25 28:9 65:22 67:18,19 74:5,23 99:23 118:22 135:22</p>	<p>shows 38:16 48:10 51:4 75:13 86:24 94:13 shut 11:21 16:22 39:11 89:14 92:23 116:9 120:6 128:12 shutdown 50:15 93:3 sic 133:8 side 2:23,23 6:24,25 11:16,17 15:14 16:13 17:11,12 22:18 31:10,10 37:6 37:20,23 67:1 83:19 85:16 88:6 99:19,20 99:25 102:22 108:11 109:2 113:17 117:21 118:15 121:18 123:15,16 125:7 127:14,14,15 128:18,18 131:15 131:25 135:18 136:11,12 137:2 sides 37:16,19 123:16 135:17 sight 40:13 signal 122:2,7 signboard 61:13 significant 38:4 48:4 significantly 87:15 signs 106:3 silt 37:9 siltstone 16:18 similar 21:19 88:2 89:14 91:3 115:8 120:14 124:13,14 128:5 similarly 4:5 47:21 103:24 116:18 117:7 119:21,25 121:16 125:22 simple 60:23 67:11,14 68:11 69:16 70:9 77:4 simultaneously 6:13 since 2:15 11:1 14:19 16:21,24 21:6 117:2 single 33:23 34:24 35:7 52:9 112:25 132:23 SIRAJ 2:6 sirs 11:15 50:22,25 sit 23:5 136:15 site 1:4,7 2:12 1:11,12 1:22,25 2:11 3:5,14 7:16 21:24 37:18 45:7 47:24 93:21,25 98:20 106:7,9,10 112:16,21 124:13 138:11,12,15 139:1 139:11,15 140:11 140:22 141:10 142:8,17 sitting 1:16 73:6 84:21 situation 16:23 25:5 139:5 six 14:18 18:17 60:8 135:19</p>	<p>size 26:22 33:16 48:12 71:5 120:25 sketch 32:22 sketches 28:9 sleep 78:5,7 sleeping 78:12,25 sleepy 78:6 slice 74:17 slides 48:24 77:2 87:23 94:10 99:24 133:17 138:19 slight 115:13 slightly 103:24 slow 31:8 slowing 21:13 slowly 35:4,6 36:8 small 2:22,25 10:1,1 11:1 12:6 13:20,21 16:12,12 25:15 29:13,16 39:23 40:2 41:25 46:8 60:9 70:16 71:7 85:1 87:7 96:5,19 111:8 113:18 123:6 128:1 128:15 130:13 131:3,9,12 133:17 smaller 29:12,13,17 51:17,20 61:20 62:7 71:19 78:21 smooth 13:22 21:5 102:3 snack 136:14 snow 69:3,3 soft 37:9 solar 67:8 70:16 110:22 solars 71:19 sold 70:7 soles 21:25 some 2:21 8:6 13:17 17:19 18:11 22:5 24:3 25:1 31:17 32:12 33:6,19 36:17 36:20,25 43:18 56:11 63:1,1,2 65:22,23,24 66:3,4 75:8 79:25 87:10 88:15 89:4,4 90:20 90:23,23 91:2 92:8 92:23 93:21 94:5 97:17 98:9 108:15 109:20 111:15 112:17 117:4 119:18 124:7 128:15 130:5 134:6 137:18,24 138:20 139:3,3,18 SOMEIR 2:6 someone 22:6 something 9:14 18:25 20:8 121:13 139:24 sometimes 27:13 28:14 29:4 30:8 31:13 53:10 92:25 110:11 somewhat 84:24 somewhere 9:13 58:7 soon 20:24 21:12</p>	<p>103:25 sorry 23:1 39:13 108:20,20 110:18 124:5 134:3 sort 31:4 32:9 56:9 58:5 sorts 34:11 source 47:19 61:16 sources 88:24 south 67:6 72:22,24 space 26:19 30:14 100:19 118:20 span 66:24 spare 119:18 122:11 122:20 132:12,18 132:19,22 133:4,14 133:19,21 specialised 31:19 32:5 36:10 specially 137:2 specific 43:18 46:1 54:10 specifically 85:12 88:13 specified 6:14 specify 15:11 spectrum 62:16 80:18 speed 47:20 64:23 115:12 spent 60:2,5 66:19 spikes 39:4 90:20,24 91:2 spillways 2:16 spiral 10:13,17,23 11:7 12:5 25:8 39:24 42:20 45:11 46:19,20,23,24 114:7,7 116:13 128:15 spot 52:12 spray 31:1 square 68:16 squared 77:12 squeezing 28:15 stabilise 37:6 stabilisers 65:18 71:9 stabilising 83:8 stability 43:5 83:8 staff 140:7 141:15 stage 40:19 65:24,25 stair 119:3 stairs 123:12 Stallard 1:21 stand 61:22 118:21 121:9 137:12 standard 65:15 standards 68:22 standing 119:1 140:5 start 11:16 14:12,18 17:10 24:13 36:22 64:20,22 73:5,7,8 81:23 99:14 105:23 111:23 117:2 started 3:16 19:24 21:1,13 61:16 88:16 90:18 136:21 starting 1:22 4:2 5:17 13:10 19:23 26:13</p>
---	--	---	---	---	---

<p>68:23 72:11 78:9 80:24 82:1 91:14 102:9 103:17 118:7 124:7 142:4,12 starts 5:8 6:24 9:10 12:6 29:7 35:14 95:7 96:23 129:1 station 41:12 53:12 56:25 60:3,3,4 62:18 63:5 67:25 69:13 75:7 85:23 93:22 96:25 107:21 108:6 123:5,19 124:22 132:22 137:18 138:12 140:13 stationary 5:5,6 114:8 115:2 stations 46:4,8 56:7 67:24 70:4 stator 5:6,13 12:22,25 stay 12:8,9 141:21 steam 63:25 82:16,16 steel 5:9,10 18:16,17 38:19 steelwork 13:15 steel-lined 33:2 34:13 35:1,10 38:19 steep 94:24 step 68:20 69:6,9,25 115:23 123:2 131:21 STEPHEN 1:12 stepped 53:3 54:5 55:23 109:9,10,11 110:11 stepping 104:16 steps 141:6 step-down 53:6 55:19 55:25 104:19 step-up 52:21 53:5,6,7 68:5 104:12,13,19 109:13 120:21 122:14 sticks 31:4 still 20:15 29:14 78:25 83:17 97:2 stones 16:12 37:9,9 stop 62:4 136:14 stoppage 21:10 stopped 92:4 storage 76:18 85:6 90:13 93:15,17 stored 44:5 66:12 88:15 story 62:4 straight 72:16 79:12 strategies 48:8 stratigraphy 31:24 stream 2:22,25 strength 19:19 20:7 28:13 29:22 31:5 strengthened 20:1,9 stresses 28:14 strip 26:16 structure 2:16 13:15 13:16 27:5,10,19 41:14 43:9 46:22</p>	<p>structures 27:21 studies 44:23 study 65:25 142:13 studying 73:20 subject 94:25 submerged 14:19 submersible 36:13 substation 52:22 56:4 69:9,18 substations 55:18,19 55:25 56:1,3 subtract 52:6 succeeded 18:3 successful 22:20 sudden 21:10,11 49:15 sufficient 22:12 42:5 54:22 64:12 124:16 sufficiently 20:8 sugar 70:20 suggested 68:23 suggests 62:1 suitable 45:15 46:6 47:25 48:1 68:21 summer 89:12 98:7 Sunday 80:24 supplied 71:10 supplies 120:1 supply 13:1 56:1 116:6 119:23 123:5 123:19 124 124:8 supplying 74:12 94:21 support 18:14,20 30:24 supported 20:9 supports 13:18 47:8 sure 40:9,11 83:25 100:9,9 108:23,23 122:19 131:7 141:3 surface 3:9 31:4 surge 7:16,18 9:16 29:10 33:17 48:22 49:13 surges 49:14 54:15 surplus 70:23 71:2 sweet 52:12 switch 56:10 103:13 109:7 115:22 switched 88:15 97:11 110:14 116:10 switches 54:8 56:6 116:4 switchgear 108:16 119:25 120:1,13 134:5 switching 56:2,3,7 78:18 109:4 switchyard 3:9 5:14 7:12 8:18 46:16 51:10 54:3,18 85:16 99:14 100:2,4,10 102:10 108:25 115:24 SYED 2:4,4 synchronised 64:24 systematic 13:4 systems 13:10 50:4 54:17 55:18 60:17</p>	<p>60:21 67:11 73:19 87:20 123:6,7 125:10</p> <p style="text-align: center;">T</p> <p>tackle 21:3 Tahir 2:14 50:19 tailrace 3:11 9:10,11 12:13 13:14 15:25 27:2 29:10 33:24 42:21 47:13 Tajikistan 72:13 take 14:9,10 17:1 19:8 21:4,22 23:11 32:10 39:6 40:21 41:1 53:12 56:15 64:25 70:25 71:3 95:22 99:18 102:2,5 110:15 111:13 116:22 117:5,24 118:16 122:25 123:12,14,24 125:2 125:4,24,25 126:13 128:7 130:9,21 131:2 132:13,15 134:11 taken 18:8 30:18 33:12,13 53:2 88:9 91:11 96:2 105:23 107:1 125:11 126:1 130:10 takes 7:4 55:2 100:19 105:21 124:7 taking 25:12 84:20 90:15 100:6,16 101:4 109:6,20 125:11 131:14 talent 139:1 talk 51:1 76:18 talking 25:12 58:17 60:16,20 67:10 68:1 76:10 78:1 79:16 80:18 103:21 114:5 tandem 6:10 112:5,7 tangential 44:10 tangentially 44:11,13 tank 48:22 tanks 49:13 Tarbela 2:18,19 23:24 41:12 45:19 60:2 64:21,22 66:20,20 66:20,21,23 71:13 82:3 84:17 91:10 93:17,17,18 94:5 tariff 62:21 Tariq 2:19 3:14 23:22 24:8 40:19 41:3,5 41:10 50:22,23,25 51:6 56:16 60:5 66:21 76:19 TBM 32:2,15 35:12 35:22 TBMs 31:20,20 32:3,5 32:6,10,12 34:22 38:14 tea 23:11 team 98:23 tear 47:10 49:11,25</p>	<p>50:9 technical 2:8,9 28:17 68:11 97:9 techniques 31:17 tectonic 29:21 telecom 105:8 telephone 106:12 tell 58:21,23,24 73:5 95:21 temperature 40:5 50:12 89:13 90:6 temperatures 63:7 88:1 temporary 17:23 ten 15:8 34:2 38:1 tension 101:11 terminates 108:2 terminating 100:1 terms 27:17 28:17 38:24 57:23 65:9 75:22 77:1 80:7 96:3 terrain 67:3,7 69:1 textiles 61:13 thank 1:2 15:17,23 21:17 22:19,24 23:9 23:13,19,23 36:19 40:6,7 41:10 50:18 50:22,24,25 56:13 57:15,25 58:3 59:9 59:11 74:25 83:24 84:2,5,6,7,10 96:14 97:4,6,20 98:13,15 98:17 101:20 108:12,13 111:1,19 134:12 135:5 137:9 140:2,15 141:18 142:15,16 thankful 141:23 142:3 142:6,13 thanking 83:23 thanks 140:1,24 141:11 their 6:3,15,20,21 14:17 15:6 24:8,9 28:13 42:8 45:6 48:17,20 49:22 50:8 64:23 69:21,21 70:20,22,22,24 72:3 75:5 78:23,23 79:2 79:3,22 98:8 102:6 104:18 114:15 117:10,10 139:16 139:16 theme 64:5 77:22 theoretically 53:17 77:16 thermal 57:18 63:6 64:10,10 67:8 68:3 68:7 71:11 72:19,25 74:4 75:8,12,15,17 82:22 84:14 87:12 87:13,16 thermals 71:7 87:18 thick 38:19 thing 7:14 11:10 15:17 16:11 17:1 18:5 20:24 27:24 35:5</p>	<p>85:20 89:9 93:19 96:1 105:19 134:3 135:5 140:4 things 28:21 33:9 70:12 77:10 84:20 88:2 90:13,14 95:20 96:12 97:1 98:5 102:8 106:5 109:5 112:14 128:6 130:5 138:13 141:9 think 1:2 15:7 18:24 22:13 23:3,10,15 25:6 27:11 32:20 34:8,13 36:6,14,18 36:21 37:10 39:18 39:21 40:2 56:13 57:20 58:10,19 59:1 59:19 79:20 97:1 98:14 111:3 118:3 118:21 124:10 126:20 130:21 134:24 137:12 138:10,18 139:11 141:10 third 24:10 39:6 103:11 106:12 thousands 30:8 120:18,24 threats 48:19 three 2:14 31:14 34:11 44:18 45:2 62:11 69:17 71:13 85:3 102:16,17 104:21 106:8,14,15 133:1,2 133:5,21 through 2:24 8:16 9:25 11:12 19:1,1,9 20:14,15 21:23 26:2 27:2 28:6 32:1,17 33:3,6 37:3 42:19 42:21 43:1 45:12 47:22 48:24 74:4 86:13 96:4 100:25 105:8 106:12 122:14 123:12 127:21 136:18,18 136:24 139:7 140:9 throughout 64:16,16 66:14 76:5 87:5 89:5,22 91:19 95:14 96:17 138:15 140:7 142:2 thrust 13:19 39:21 thrusted 32:9 Thuraya 106:12 till 3:22 92:7,16 94:20 113:8 142:5 time 16:4 18:9 25:10 36:9 39:10 41:5 47:22 48:7 55:11 58:7 60:2 64:21 66:19 72:25 75:6 76:2 78:8 80:3 81:4 81:5,10,12,13 88:16 89:4 90:11 91:17,21 92:5,17 95:3 96:19 97:16,22 102:6 105:24 123:23</p>	<p>124:7 129:10 130:13 times 32:22 61:17 82:18 139:23 tiny 13:20 today 3:21 4:19 5:18 9:2 10:5 40:9,12 41:21 52:24 74:23 113:12 137:22 138:9,20 140:4 today's 1:18 3:24 together 6:12 told 38:5 61:24 75:4 94:3 tomorrow 138:10 tonnes 6:8,10 30:7,8 111:25 112:1,5 131:4,4 top 5:17 10:9 13:3 26:18 51:15 83:1,15 100:6 107:15 115:11,25 topography 67:3 topology 69:1 total 3:21,22 34:4 38:7 38:12 53:25 56:21 56:24 57:3,7,9,10 57:13 73:24 85:19 87:1,13,14 88:10 89:10 113:1,1 120:19,20 126:20 133:20 totally 29:24 94:7 touch 22:4 78:24 111:11,15 122:18 122:19,20 132:8,8 towards 24:23 33:7,14 33:21 tower 7:18 33:16 100:6 track 52:3 Transcript 1:21 transfer 47:2 transferred 41:17 transformer 4:23 8:14 8:15 10:4 32:23,24 51:9 52:20,21 53:3 53:5,5,6,7,21 55:17 68:5,20 100:12,12 104:16 109:15,17 113:18 115:22,23 119:22,22,23,23,24 120:17,17,21 122:10,11,15,16,17 122:18,23 131:6,10 131:16,20,23 132:13,18,19,20,23 133:8,14,18,22,25 134:17 transformers 133:1,2 133:20,21 134:1 transforming 53:20 transmission 24:4,12 43:2 46:15 51:2,9 53:4,9,10 54:5,10 54:12,20,23 55:2 67:18 68:17,21 69:2 71:25 72:1,2,3,7,8</p>
---	--	---	--	--	---

<p>72:10 73:11,13,18 73:19,20 100:5 102:1,18 transmit 68:9 transmitted 43:1 transmitting 47:7 transport 46:22 transportation 9:1 141:16 transported 5:14 120:23 transporting 85:18 trash 48:21 49:2 travel 112:12 travelling 111:13 Treaty 1:1 tremendous 141:11 trend 91:3 Trevor 1:21 triangles 86:2,10,12 tried 139:21 142:10 trigger 114:20 triggered 50:16 tripping 123:22 TRT 9:21 16:15,17 21:6 106:19 113:1 135:22 136:8,25 truck 30:17 try 111:11 113:20 tube 9:7,8 12:12,13 27:2 42:21 46:20 47:11 120:4 tubes 9:7 132:5,6 133:23 tunnel 7:15 8:1,2,4,4,8 8:12,19 9:4,10,11 9:17 10:1 11:20 12:13 16:21,25 18:10,18 19:2,9,11 19:15 20:10,14,15 20:20,21,22 21:5,16 27:2 28:7,19 29:8 29:10,23,23 30:1,5 30:18 31:7,20 32:16 32:18,25 33:24 34:6 34:11,23,24 35:7,9 35:11 36:1,12,13,21 36:23 37:7,12 38:5 38:7 99:22,22,23 100:1 111:3 112:25 119:8 127:17,18 128:23 134:7 135:15,16,17,23 136:11,17 137:5,5 137:25 tunnelling 7:11 28:1,1 28:3,21 29:9 32:1 38:10 96:2 112:19 tunnels 8:22,23 9:2 10:1 24:6 28:5,8,24 28:25 29:5,10,12,15 29:17,20 30:3 31:22 32:21 33:18,24 34:20 35:1,3,8,22 36:11 38:9 tunnels/adits 32:25 turbine 10:15 11:4,8 11:12,16 12:4,10,11</p>	<p>12:22 13:18 14:4,6 14:20 15:14,18 24:3 25:4,10,12,18,21 26:15,15 38:24 41:14,14 42:14,20 43:8,21,22,22,25 44:2,4,4,13,17,18 44:22 45:2,6,10,10 45:12,24,24 46:5,5 46:12,18,22 47:5,7 47:8,8,11,16,19,20 47:22,23,23 48:6,10 48:11,12 49:3,6,10 49:11,12,14,18,20 49:21,24,25 50:6,9 50:11,14,17 52:8 61:15,25 63:25 64:3 64:12 65:8 77:15,16 77:17 91:12,25 116:1,12,21 turbines 14:1,17 15:3 21:9 24:8 27:1 33:25 34:6 42:6,12 43:16 44:7,9,10,11 44:12,14,15,16,20 44:25 45:15,17,20 45:21 46:1,6,7,25 47:25 48:1,5,16,19 49:7,15 50:2 51:8 51:15,18 52:12 53:16 62:5 64:3,20 64:25 65:13 76:19 82:21,24 83:14 97:11 109:7 137:21 TV 78:13 Twenty 2:7,7 twice 1:25 twin 33:23 34:20,23 35:3,8,9,10 38:9 two 5:4,24 6:7,8,11,11 9:22 18:14 19:18 20:24 23:2 27:23 29:19 31:11,14 32:2 38:5,14 43:21 52:5 53:6 64:7 76:21 85:17 88:20 95:12 97:8 99:21 100:21 102:1,14 107:13 108:7,9 109:1 110:9 111:23,25 123:6 125:10 131:11 135:10,19 two/three 15:12 type 31:23 37:7 45:10 45:24 46:1,5 47:23 types 24:9 28:11 29:25 43:21 44:18 45:2,6 53:6 55:18 57:17 69:15 typical 30:9 T4 60:4</p> <hr/> <p style="text-align: center;">U</p> <p>ultimately 5:23 68:10 90:25 91:4 92:13 UMAR 2:17 umbrella 66:7 74:21 uncoated 25:19,20</p>	<p>unconstrained 93:6 under 34:25 35:2,10 65:23 66:4,7 67:1 72:14 74:20 75:9 86:11 100:23 126:18 underground 3:10 7:12,25 10:5 24:15 24:18 26:20,21 27:5 27:9,10,12,21 52:23 123:25 underneath 34:12 118:1 understand 18:25 23:11 59:3,12 78:2 86:3 138:16 139:5 142:11 understanding 67:15 72:5 77:5 138:23 understood 34:10 140:3 undertaking 37:10 underwater 11:1 UNIDENTIFEID 129:21 unit 6:3,5,16 7:1,3,7 11:22,22,23 15:2 47:22 52:1,9 62:2 64:11,19 73:5,8 96:6 100:21 103:10 103:10,11,12,25 113:21 114:16,25 115:12 116:2,5,7,8 116:9 117:7,8 118:21 120:6,7 121:16 124:17 125:16 128:12 132:20 133:1,21 135:20,21,21,21 units 3:18,20,22 6:2 6:18,19,20,22 7:8 7:21 10:8,12,14 39:9 51:16 113:2,3 52:2,11,15,17 67:8 67:8,8 72:25 91:20 100:21 102:12,23 103:9 99:21 113:2,3 117:9,10 133:4,20 135:18,19 unless 40:18 unlike 93:16 unlined 35:16 unlucky 133:7 until 79:13 upcoming 43:13 upgrade 115:8 upper 115:4 upstairs 112:16 120:12 upstream 8:9 11:17 23:7 37:6 93:16 94:4 114:5 117:19 125:3,4,12 127:15 128:18,19 136:11 136:12,19 137:1,2 uranium 63:1 82:12 Urdu 104:13 105:19 105:20 106:9,17</p>	<p>107:14 USA 62:3 use 17:8 25:22 28:24 29:19 30:2 31:17,19 32:2 38:3 42:9 70:22 75:10 79:20 81:21 88:3 96:5 124:3 125:6 136:7 136:10 used 17:9 18:13 30:8 32:19 38:5 45:17,21 55:14 61:12,16 63:18 65:13,18 83:12 91:25 94:1 96:17 110:2 122:10 122:17,23 128:2,3 users 54:25 uses 44:5 45:25 using 21:25 22:1,5 36:17 83:13 125:2 USMAN-E-GHANI 2:14 usually 9:21 51:22 93:1 US\$640 3:23 utilise 44:21 utilised 42:1 75:12 88:25 utilising 75:2 utterly 41:23</p> <hr/> <p style="text-align: center;">V</p> <p>V 70:7 115:18 120:1 123:18 value 95:13 valve 11:18,21,24 12:3 12:5 14:22 38:23 40:9,14 48:22 50:7 50:7 56:8 120:6 121:19,20,20 125:3 125:4,5,6 128:2,12 128:13,13 129:6,15 129:16,19 130:7,11 valves 39:8,9 49:17 vanes 46:17,18,18,19 46:19 47:2,4 114:8 Variability 82:6 variable 45:16 variables 88:20 variation 82:19 115:5 115:13 variations 52:3 82:13 87:7,10 varies 118:6 various 29:25 31:21 32:21 42:8 48:19 50:3 54:2 55:7 140:10,16 vary 63:16 64:17 77:16 79:24 varying 79:23 Vaughn 1:21 vehicle 10:2 vehicles 9:1 velocity 45:13 103:6,6 103:7 138:2 vent 130:7,11 ventilation 127:20</p>	<p>verbal 105:10,14 vertical 51:14,19,19 Verulam 2:8 very 1:7,10 2:23 4:6 4:13 6:22 11:1 12:14 13:4,20,21 14:23 15:3,17 16:1 16:17 18:6 20:17 22:1,15,19,24 23:13 27:11 29:13,17 31:8 32:17 33:6 37:14 38:19 40:2,25 41:4 42:6 50:18,24,24 53:11 55:2 58:25 59:6,10,11 62:18 63:7 64:20 68:6 74:25 75:23 77:4 83:24 84:1,6,19 88:14,17 93:8 96:5 98:15,24 107:11 108:13,13,17 110:8 110:25 113:13 117:16 125:14,18 126:2 128:1 130:3 133:10,10 134:24 135:3,5,9 138:8 139:4,8 140:6,13,23 141:12,17,18,18 142:1,6,7,10,14,15 142:16 vest 22:3 via 51:9 vibration 10:20 50:8 vicinity 86:6 video 42:13,16 46:11 46:14,21 138:20 videographer 2:24 141:2 videos 51:16 view 4:21 6:17 24:16 43:7 80:15 85:25 90:14 violet-coloured 86:11 visit 1:7 1:22 5:20 22:15,20 40:12 59:6 93:24 137:18 138:15 139:1,11,15 139:25 140:1,7,22 141:11 142:4,9,17 visiting 101:22 voltage 53:1,9,21 54:4 55:20,20 68:8,10,14 68:20,24 69:6,7,11 69:12,20,23 70:1,17 85:18 101:11 103:18 115:17 120:17,21 121:1 131:15 volume 47:3,21 volumes 46:7</p> <hr/> <p style="text-align: center;">W</p> <p>wait 57:22 108:19 waiting 83:23 walk 9:25 26:2,9 100:8 140:9 walkaround 135:3 walking 21:23</p>	<p>wall 10:9,11 46:23,24 137:13 want 8:14 22:3,4 33:7 33:9 34:18 65:11 111:15 117:3,4 120:5 122:19 126:18 127:10 128:6,23 130:7 133:13 138:25 139:9 140:2,15 wanted 141:13 WAPDA 2:13,18 41:6 45:18,21 46:2,7 59:23,24 60:16 73:14,16 74:18,19 83:22 84:14 86:25 87:8 88:10 89:25 Warsak 2:20 45:23 60:1,10 66:17 wasn't 95:16 waste 62:13 wasted 41:23 waters 1:1 2:5,14 124:18 125:12 waterwheel 41:20,25 42:5,9 waterwheels 42:7 watts 77:5,19 way 13:5 14:7,8,14 18:3 21:3 33:6 57:18 70:25 80:15 84:3 130:25 134:24 139:7 ways 27:11 weak 18:11 weaknesses 18:22 wear 47:10 49:11,25 50:9 wearing 22:2 weather 90:6 WEBB 2:7 week 80:24 102:25 138:1 weekends 81:1 weekly 80:18 weeks 14:15 weighing 131:3 weight 114:15 131:4 weights 130:18 welcome 97:3 98:20 111:6 135:6,7 139:17 well 1:24 6:22 8:9,12 8:12,25 9:4 13:7 16:19 36:17 76:7 84:24 86:20,20,25 92:21 93:22 94:17 100:1 109:19 118:17 123:1,16 134:9 135:16 137:12 139:15 140:18 142:6 went 19:25 were 2:15 3:12 6:20 7:17 17:18,18 18:8 18:18 20:23 27:22 32:19 37:1 41:21 42:6,8,10 73:14,15</p>
---	--	---	---	---	--

95:25 97:11,17 112:15 119:9 127:17 131:12 133:14,15 137:19 139:11,13 140:3,13 140:22 142:3,10 west 62:6 67:4 wet 63:9,16 72:20 77:23 81:24 82:2 85:12 87:3 91:15 97:10,12 we'll 1:18,19,20,21 2:24,24 4:20 5:19 5:19 6:25 7:1 8:2,3 9:1,1 10:5 14:24 19:13 22:2,3,5,10 22:20 23:12 59:13 99:14 102:20 108:14 111:2 112:13,13 113:17 113:18,19 114:9 115:23 116:3 118:14 119:3 126:23 129:9 131:6 131:16,17 134:8,13 134:14 we're 5:24 57:11 84:9 114:5 128:4 139:4,8 140:23 141:17 we've 121:17 123:9 136:9 138:14,15 139:21 wheel 44:2,20 while 5:6 25:12 32:8 36:12,24 51:17,24 57:11 62:14 76:7 85:5 86:7,10 white 63:4 whole 19:2 21:5 39:11 53:14 86:24 90:17 116:11 118:22 142:4 wicket 23:2,6,8 40:16 103:20 104:1,4 114:8 115:15 116:13 126:17,18 127:3 128:14 width 5:16 26:4 WILLIAMS 2:23 wind 67:8 68:3 69:3 81:18 windmills 70:16 71:19 window 14:24 Wisconsin 62:2 wish 142:14 wished 139:13 wonderful 99:13 101:20 118:20 135:5 138:19 wondering 39:13 words 141:19 work 10:22 32:10 38:6 60:10 92:24 102:2 109:19 116:21 127:22 141:2 workable 70:1 worked 64:21 WORKER 129:21	working 43:13 46:12 59:24 66:7,15,16,21 78:25 81:2 84:12,14 85:13 103:3,8 132:11 workplaces 78:23 works 4:21 29:9 58:9 58:10 79:3 98:7,9 100:20 world 55:22 Wouter 1:10 2:5 22:25 97:5 101:23 Wow 126:6 130:3 132:7 writing 105:24 wrong 58:11 95:21 <hr/> X <hr/> XLP 8:16,17 <hr/> Y <hr/> Yard 109:8 YASIR 2:19 year 3:18 4:2 63:9,16 66:14 74:2 75:11 76:5 80:20 87:4,16 87:21,25 88:5 89:11 89:17 93:2 94:12 95:15 96:18 97:22 97:23 138:1 years 14:18 15:4,8,8 15:12,12,12,13 25:13,22 38:1 60:6 66:19,24 84:13 117:1 129:11,14 yellow 23:8 74:22 106:20 115:2 135:20,20 yeoman's 141:2 yesterday 1:25 2:1,15 2:21 9:12 16:1 34:10 140:3,11 <hr/> Z <hr/> ZAINAB 2:6 zero 64:23 92:4 97:13 <hr/> 0 <hr/> 0 77:16 0+248 19:24 0+251 16:8 19:23 0+293 16:9 17:11 19:23 0+308 19:25 0.2 48:13 0.4 48:14 121:12 0.9 77:18 <hr/> 1 <hr/> 1 3:1,2 4:16 6:4,19 7:2 7:21 9:8 10:12 17:24,25 26:12 27:16 51:5 56:23 66:20 102:12,16 103:12 108:25 117:8 119:5 121:11 123:19 135:20	142:5 1% 53:20,22 1+585 18:23 1+700 18:23 1,000 61:18 77:13 79:17 85:7 1,026 115:18 1,410 66:22 1,728 66:21 1,750 66:20 1.293 61:19 1.5 79:7 10 3:17 1:20 2:13 11:15 34:21 35:11 35:13,24 59:19,20 74:14 75:1 88:14 10% 54:1 57:2,8 10,800 120:20 10.04 105:25 10.21 105:25 100 3:4 65:1,2 77:17 82:18 100% 81:10 115:13 11 3:23 13:23 15:24 34:5 42:13 69:25 76:9 98:18 142:5 11.40 105:25 110 55:22 12 16:5 20:19 43:6 76:13 79:11 133:4 133:19,20 12,000 79:18 89:11 90:7 12-storey 26:18 12.00 78:9,12 79:13 120 70:7 124 103:12 125 103:10,23 13 3:5 16:24 18:9 43:15 77:3 130:16 133:3,7,19,20 130 62:7 103:12,24 132 43:2 136 64:23 137 3:25 26:5 138 68:23 14 45:5 77:24 80:12 119:9 14,000 90:8 14/15 79:25 149-150 116:19 15 31:16 32:11,11,15 43:14 46:10 68:14 80:10 15.5 104:15 15.75 53:2,7 68:9 104:15 115:10 120:18 131:21 15.78 115:10 150 71:6 81:17 85:4 103:11,25 159 115:18 16 19:21 47:15 80:14 129:11 160 112:24 17 20:11 21:18 45:20 48:15 81:16 178 3:23	18 3:6 21:25 49:2 80:1 1833 61:14,25 1882 62:1 1897 62:5 19 22:17 34:20 49:8 84:23 19th 42:4 19.56 3:22 19.6 113:10 19.9 113:10 1960 1:1 60:12 1998 73:15 <hr/> 2 <hr/> 2 2:10 6:4,19 7:1,21 9:8 10:12 24:13 26:12 27:17 43:24 45:9 51:5 61:4 64:24 66:20 78:22 79:7 86:5 102:12,16 103:11 108:6 109:1 117:7 123:19 135:21 2V 110:13 2,000 64:12 118:8 2,300 71:15 20 3:7 32:12 38:9,9,9 38:11,11,12,13 49:13 60:6 66:19 85:24 20,000 87:25 89:12 20-tonne 40:10 200 118:7 2008 3:16 2018 3:17,18 117:2 2021-2022 97:22 2022 16:10 2022/23 75:11 2023 73:23 87:2 88:8 2024 1:6 1:1 74:6 89:17 21 49:17 86:23 22 3:3 49:21 88:6 22,500 71:12 220 43:2 55:23 72:8 123:18 220V 110:10,13 23 3:8,9,10 50:3 88:8 89:15 23% 74:6,23 24 79:7,25 80:11 87:6 89:22 90:15 24-hour 102:6 24/7 76:4 240 70:1,7 242 7:3 51:12 60:13 68:13 133:5 242.25 7:4,7 25 5:16 26:4 41:1 51:3 91:11 97:7 25,000 57:3 79:17 25-30 57:14 250 16:7 251 136:21 26 52:19 56:23 92:18 26% 74:7 26-27 74:23 27 3:11 1:1 54:3 94:9	27th 1:6 275 111:25 28 54:19 96:2,15 28.5 38:8 28.6 33:22 280 91:19 285 85:19 29 55:16 290 96:7,7 293 136:22,24 <hr/> 3 <hr/> 3 2:8 2:3,20 6:4,19 7:1 7:21 9:8 10:12 19:24 26:12 27:3,25 31:11,11 51:5 62:10 64:22 102:12,16 103:10,25 116:7,18 123:20 135:21 3D 46:12 3,000 64:12 3-3.5 30:21 3-4 18:1 3.5 32:13 34:1 30 32:12 44:21,25 56:13 30% 4:12 52:14 300 44:19,22 51:13 115:13 118:3,4,8,12 127:3,3 300-plus 118:11 300-350 118:10 31 84:13 87:2 31-year 59:24 32 129:14 33 25:17 34 3:12 350 71:7 126:21 353 7:18 36 115:17 39 3:13 <hr/> 4 <hr/> 4 3:15 6:4,19 7:1,22 9:8 10:12 26:12 28:3 29:14 51:5 65:19 66:21 79:6 86:6 102:13 103:10 113:21 114:24,25 116:2 118:22 123:20 135:21 4th 2:19 23:24 41:12 4,888 45:21 71:13 4.5 35:14,16,17 4.6 113:4 4.66 3:20 40 38:10,12,13 131:4,4 40% 52:14 400 91:1 120:1 41 3:14 42 16:20 18:10 19:14 42-metre 19:17,22 420 7:6 96:10 450 6:9 450-460 112:5 46,035 74:3,3 75:3 460 6:10 468 96:8,11	48 110:11 48V 110:10 48% 115:16 49% 103:22 <hr/> 5 <hr/> 5 1:6 3:3 3:25 8:1 29:14 32:20 66:23 67:9 79:6 5th 2:18 50 65:16 50% 52:13 75:16,18 500 43:1 44:24 72:7 85:17 103:5 51 3:15 51% 103:22 52-55 74:4 525 53:3,8 85:19 104:16 115:24 131:21 53 26:4 530 102:24 103:1,5 104:3 54 5:18 55% 103:25 550 6:8 112:1 56 3:16 575 54:18 59 3:17,18 594 119:6,11 <hr/> 6 <hr/> 6 4:19 25:17 33:20 48:9 49:1 67:13 6-7 31:12 6.00 78:18 6/7 130:13 60 20:1 65:1,17 600 64:11 103:5 118:11 119:7 614 119:10 65-70 112:25 68 32:17 69 96:9 <hr/> 7 <hr/> 7 6:17 36:20 70:10 7,500 87:11 7-8 17:21 70 7:4 65:2 96:10 70% 4:10 52:13 700 4:15 91:4 700,000 4:18 720 85:5 732 34:25 35:3,10 74 3:19 750 52:16 765 68:24 <hr/> 8 <hr/> 8 3:1,4 1:4,5,19 7:10 17:22 34:23 35:7,8 38:15 43:12 71:22 79:8 80:2,12,13 112:4 80 85:21 80% 52:13
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<p>800 61:17 84 3:20</p> <hr/> <p>9</p> <p>9 3:9 1:20 2:13 10:7 23:16,18 34:22 35:9 39:12 40:8 73:21</p> <p>9,400 57:1</p> <p>9.30 105:25</p> <p>9.8 77:11</p> <p>90% 52:13 53:23 54:1 77:17,18</p> <p>94% 53:16</p> <p>95 3:21</p> <p>969 3:18 7:8 57:1 62:9 76:2 84:25 87:6 92:14 111:8 138:6</p> <p>97 3:22</p> <p>98 3:23,24</p> <p>98% 62:20</p> <p>98.5 53:19</p> <p>98.7 133:8,22</p> <p>99.9 115:12</p>					
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