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Planning and Management of Geothermal Drilling at Þeistareykir, NE Iceland

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Presentation Outline

1. Landsvirkjun
2. Þeistareykir Geothermal Power Project
3. Drilling Strategy & Tendering
4. Conclusions

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Landsvirkjun
100% renewable

The Company generates 73% of Iceland’s electricity and is owned by the Icelandic state.

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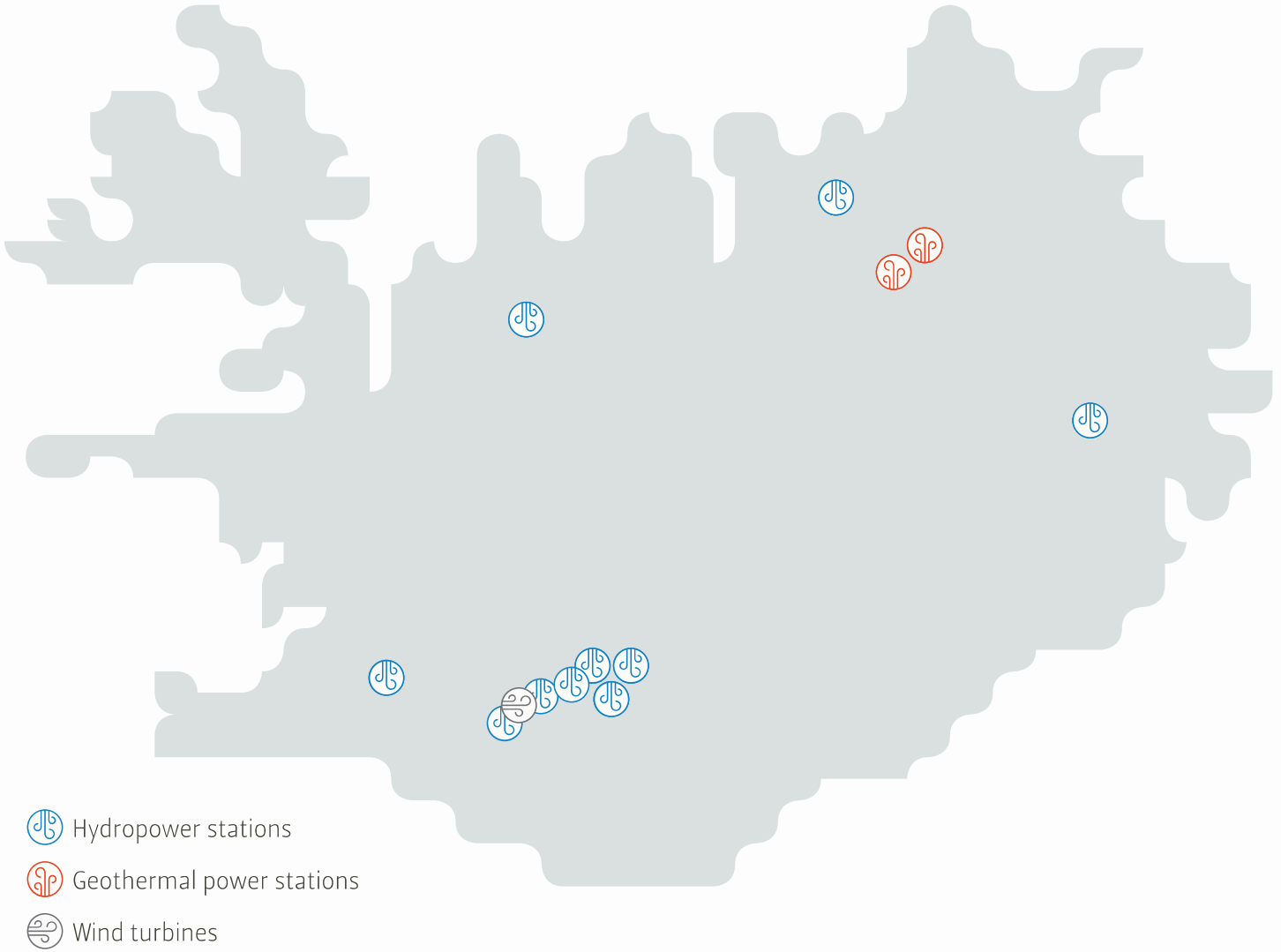
Landsvirkjun's current power plants

- 14 hydropower stations
- 2 geothermal stations
- 2 wind turbines

- 96% from hydropower
- 4% from geothermal
- 0.1% from wind power

- 73% of electricity in Iceland



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Power Project Portfolio

Around 20 power projects:

Hydro (12):	750 MW
Geothermal (6):	650 MW
Wind (2):	250 MW

Demand for power:

- Local market is limited
- Export through power intensive industry, electronic data
- Subsea cable to Europe

Demanding customers need low cost renewable energy

Þeistareykir
Geothermal Power Project

Þeistareykir Geothermal Power Project

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Project´s phases

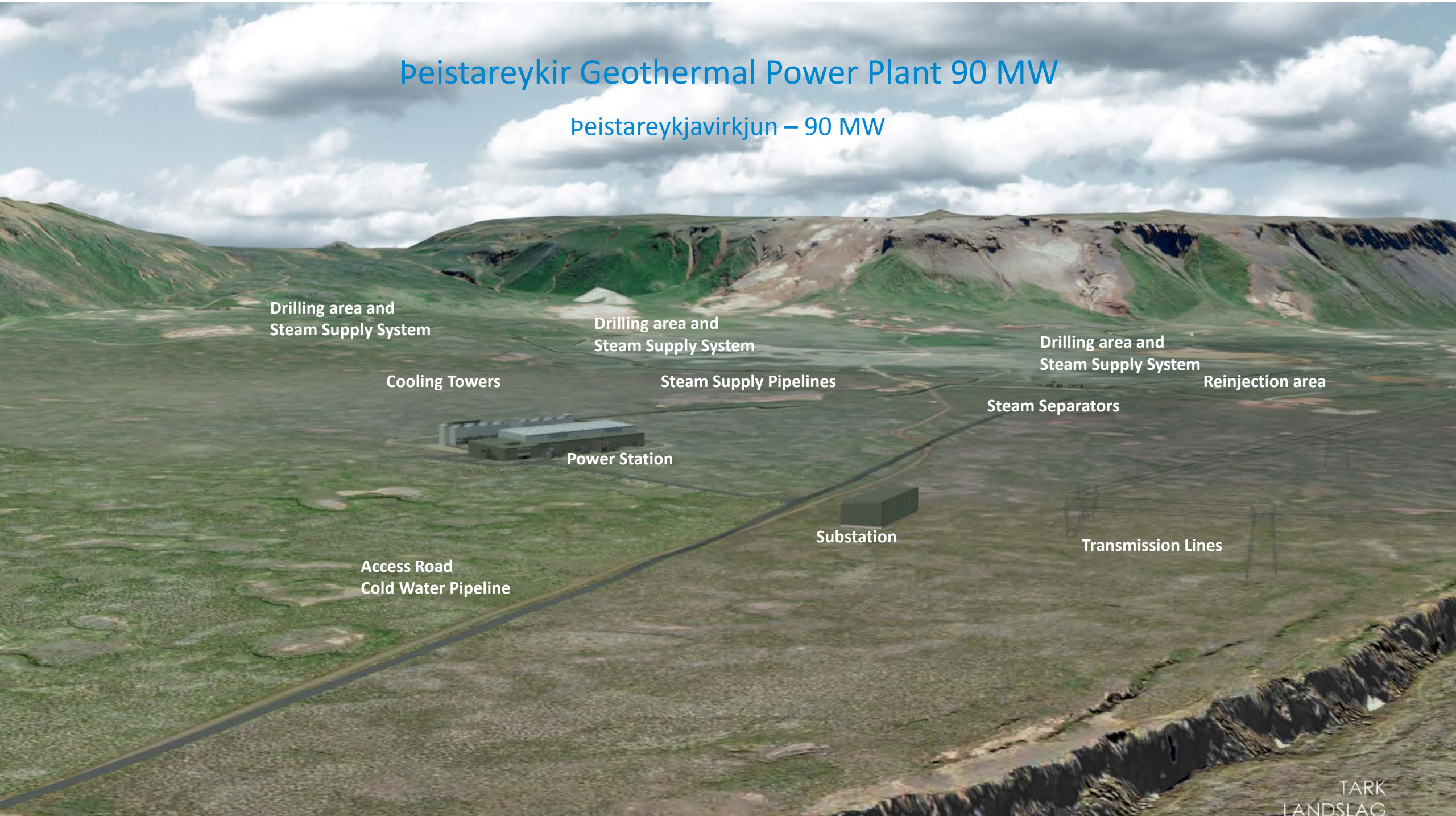
- Phase I – 45 MW
  - Under Construction
  - Geothermal steam available for 58 MW_e
  - Unit 1 online in October 2017

- Phase II – 45 MW
  - Contruction at preparation stage
  - Existing contracts extended
  - Steam well drilling 2016 and 2017
  - Unit 2 online in April 2018

Powerhouse - December 2015

Þeistareykir Geothermal Power Plant 90 MW

Þeistareykjavirkjun – 90 MW



Þeistareykir Geothermal Power Plant 90 MW

Þeistareykjavirkjun – 90 MW

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Þeistareykir – Project contracts

- THR 10-1 Steam separators - Vélsmiðjan Héðinn hf.
- THR 10-2 Steam supply system - LNS Saga og LNS A/S
- THR 11 Employer´s Material Purchasing
- THR 15-1 Civil works - LNS Saga and LNS A/S
- NAL 30 Turbine, Generator and Cold end Equipment
  Fuji Electric and Balcke Dürr
- NAL 31 Power Transformers – Tamini
- NAL 35 Control system - ABB Danmark
- NAL 37 Station auxiliaries - Rafeyri ehf.
- THR 02 Geothermal drilling - Jarðboranir hf.

Þeistareykir Drilling Strategy & Management

Drilling Strategy

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Drilling requirements

- 40-50 MW required
- Assume 6 MW per well average
- Therefore, 7-8 wells from 4 platforms
- In addition, exploration wells for further expansion at Þeistareykir and Krafla Geothermal Field

Well design

- 2500 m long wells
- Directionally drilled with 20-40° angle
- 8-$^{1}/_{2}$” production zone
- ANSI Class 900 and Class 1500 rating
- Temperature 280-380°C

Tender strategy

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Several contracts

- Drilling tender
- Casing tender
- Casing tools
- Wellhead equipment & material
- Wellhead construction

Drilling tender

- Ten wells
  - Lot A: 7 wells
  - Lot B: 3 wells
- “Integrated” & “hybrid”-type drilling contract
- Open tender published on EEA (English)
- FIDIC terms
- $50.000 paid for bids 2, 3 and 4

Landsvirkjun‘s drilling contract

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Integrated drilling contract

- To be provided:
  - Drilling rig with all equipment incl. BOP
  - Drilling tools incl. Bits, fishing tools etc.
  - Material incl. cement, mud etc.
- Works
  - Rig mobilisation
  - Drilling incl. directional drilling services
  - Mud engineering
  - Casing run
  - Casing cementing

„Hybrid-type“ drilling contract

- ***Meterage*** payments for drilling, casing run and casing cementing
- ***Day-rate*** payments for logging, stuck-in hole more than
- ***Lump-sum*** payments for rig mobilization, installation of wellhead etc.
- ***Risk sharing*** for loss-in-hole, well direction etc.

Results of tender no. 20195

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- More than 10 international contractors received tender documents and participated in pre-tender meetings
- Valid bids received from 4 contractors
- Lowest bid and contract value US $25 million
- $2.5 million each well

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Geothermal drilling works at Theistareykir / Tilboð opnuð í jarðboranir á Þeistareykjum

27. janúar 2016

Bids for geothermal drilling works tender nr. 20195 were opened Tuesday December 15th. The following bids were received:

Tenderers name:	Amount in ISK	Amount in USD
LNS Saga ehf. and Leonard Nilsen and Sønner AS	2.338.492.187	17.986.760
Daldrup & Söhne AG	3.801.169.183,07	1.528.832.854,69
Jarðboranir ehf.	3.341.942.347,33	
JV Entrepose Geodrilling and Borfélag Íslands ehf	6.703.567.955	50.888.696
LV Cost Estimate		**39.381.893,41**

As registered as remark at the opening of tenders for "*Geothermal Drilling Works, Tender nr. 20195*" some misunderstanding occurred among Tenderers positioning their Tender amounts in The Letter of Tender and whether the unit prices should have been single currency or not. After correction of arithmetical errors and converting the Icelandic krónur (ISK) amount of Tenders into USD (United States dollars) according to Tender Documents, THR-02, No. 20195, the Tender prices are as follows:

Jarðboranir hf.	$ 25.369.389,31-
LNS Saga ehf, and Leonard Nilsen and Sonner AS	$ 35.800.486,71-
JV Entrepose Geodrilling and Borfélag Íslands ehf.	$ 50.888.723,50-
Daldrup & Söhne AG.	$ 53.755.263,56-

Comparison from international experience

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- Information gathered from personal communication with managers from various companies in various countries 2010-2015:
  - 2500 m high temperature well
  - Deviated by 30°
  - 8-1/2“ production zone

USA	$7-15 million
New Zealand	$7-10 million
Philippines	$7 million
Japan	$15 million (guess)
Italy	$7 million
Kenya	$7 million (aim at $5 m)
Mexico	$7 million
Turkey, Romania	Lower

Thought: Higher cost in countries with oil industry?

Why difference?

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Geographical reasons

- Drilling time (Iceland, typically 35 days)
- Geological complexity (Iceland mainly basalt)
- Experience of contractor and consultants
  - Iceland drilling (almost) only drills geothermal wells, have drilled over 200 wells last 40 years
  - ÍSOR, Iceland Geoscinece, have provided advice, geological logging and well logging services for over 40 years all over the world
  - Small but experienced group of drilling engineers

Contract reasons?

- 7-10 wells
- Meterage (footage) vs. day-rate
- **Integrated drilling services**, i.e. the drilling contractor does:
  - Drilling
  - Casing
  - Cementing
  - Mud engineering
  - Direction drilling
  - Owner and Contrator share risk of loss

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How would lower cost of geothermal drilling affect the industry?

40% lower cost of drilling will have a 10% cost reduction to the overall development cost

Significant part of that cost is also **early on in the project** – a part that is hard to finance

However, it may be hard to have a drilling contractor take such risk in a new field (or a new country)

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A few final thoughts

Is this really possible?

Is the industry too conservative?

100 high temp. wells in Iceland drilled with integrated-hybrid drilling contracts

When is the right time to drill?

- Benefits of drilling several wells
- Impact of finance cost vs. drilling market situation
- Using “best information”


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Thank you