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Interconnector between Iceland and GB, cost benefit analysis and impact assessment

Presentation for UK-ICE Energy Task Force

London, February 8th 2016

Contents

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1. Introduction and background

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Kvika and Pöyry

Kvika:

- The only privately held specialised investment bank in Iceland
- Provides all core services; capital markets, corporate finance, asset management and specialised banking
- Focus on Asset Management and Infrastructure investment advisory
- Market leader in Nasdaq OMX Iceland 2015

Pöyry:

- Europe’s leading specialist energy management consultancy
- Offering expert advice from strategy to implementation on policy, regulation, business operations, financing and valuation and sustainability
- Providing in-depth market analysis and strategic insight across Europe
- Over 250 energy market experts in 12 offices across Europe

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The project team

Kvika:

Steering committee:

- Dr. Sigurður Hannesson, Managing Director Kvika Asset Management. D. Phil in mathematics from University of Oxford
- Sigurður Atli Jónsson, CEO of Kvika
- Magnús Bjarnason, MD International Banking Kvika. Background in renewable energy, investment banking and governmental services

Project Manager:

- Rósant Torfason, Corporate finance Kvika. rosant@kvika.is

Pöyry:

Steering committe:

- Dr. Gareth Davies, director at Pöyry. Over 17 years of experience in energy policy anlaysis and energy market economics. PhD in Economics.
- Michael Martin, principal consultant at Pöyry. Has a vast experience in the modelling of both hydro and thermal markets.

Project Manager:

- Micheal Martin. michel.martin@poyry.com

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Scope of the work

Cost benefit analysis and impact assessment for Iceland

- **Cost Benefit Analysis for Iceland:**
  - Projection on wholesale prices in Iceland with and without an Interconnector
  - Producer and consumer surplus in Iceland
  - Cost of the Interconnector, losses and cable failures
  - Business Models / Evaluate optimal Business Model for Iceland
  - Support mechanism; CfD‘s, Capacity Mechanism, other guarantees.
  - Demand and supply projection
- **Impact assessment on Iceland:**
  - Households
  - Power Intensive industries, other industries and services
  - Energy sector and transmission system
  - Security of supply
- **Other items:**
  - Analyze potential options to mitigate higher electricity prices in Iceland
  - Experience from other countries i.e. Norway
  - Environmental issues

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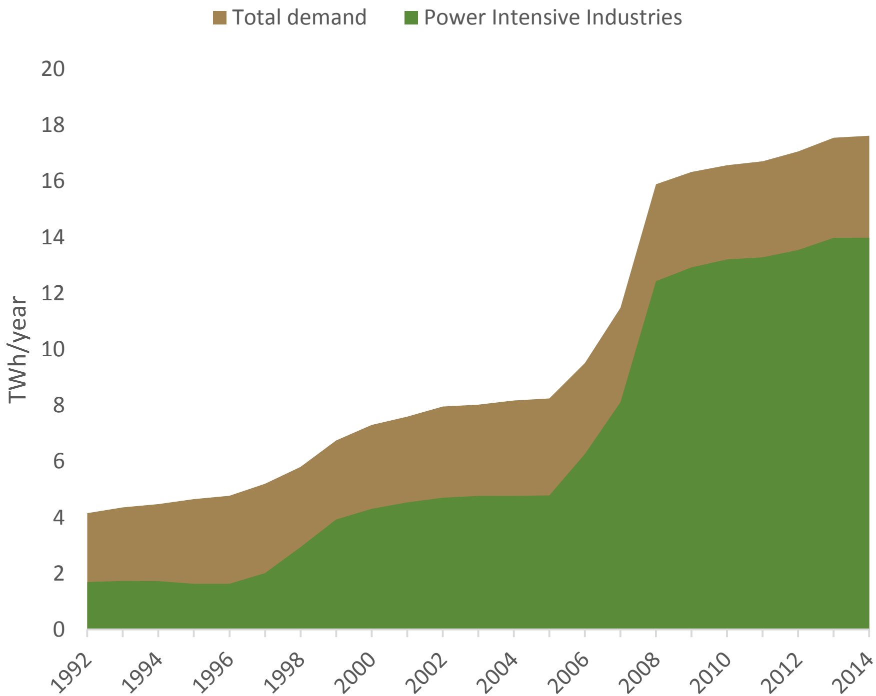
Overview of the Icelandic electricity market

Electricity Demand in Iceland 1992-2014

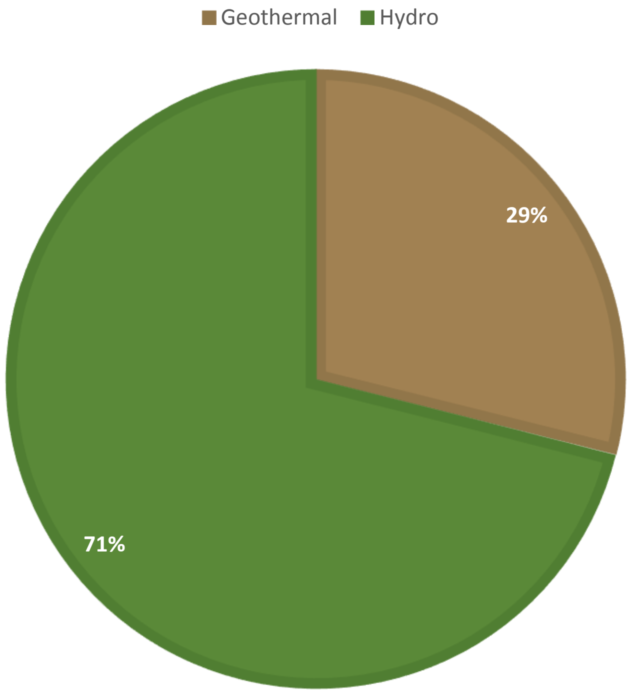
- **Driven by power-intensive industries (PII)**
- **80% of current demand from PII**
- **Three aluminium smelters, 75% of demand**
- **Long term Power purchase agreements (PPA)**
- **Households use, 5% of total consumption**



Overview of the Icelandic electricity market

Electricity generation in Iceland divided by source

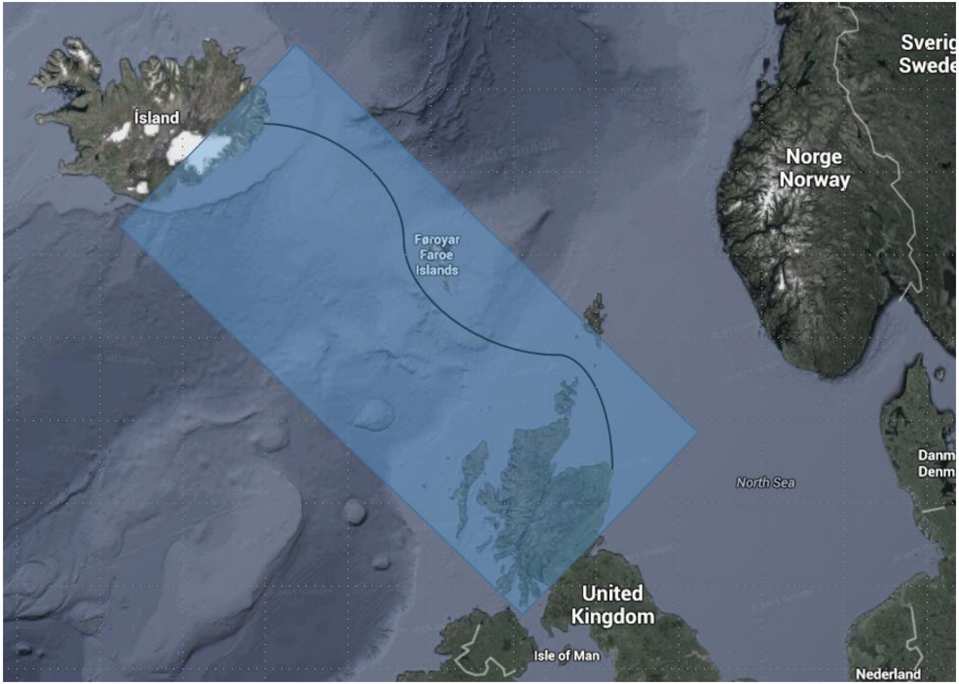
- 71% from hydropower or 12.9 TWh
- 29% from geothermal or 5.3 TWh
- Only 8 GWh from 4 onshore windmills
- Landsvirkjun is the far largest producer with 71% share
- Two other producers with total 26% share



Icelink project introduction

Key figures

- **Shortest distance between the countries less than 900 kM**
- **Example on graph approximately 1,200 kM**
- **Capacity of 1,000 MW**
- **Calculated availability 92%**



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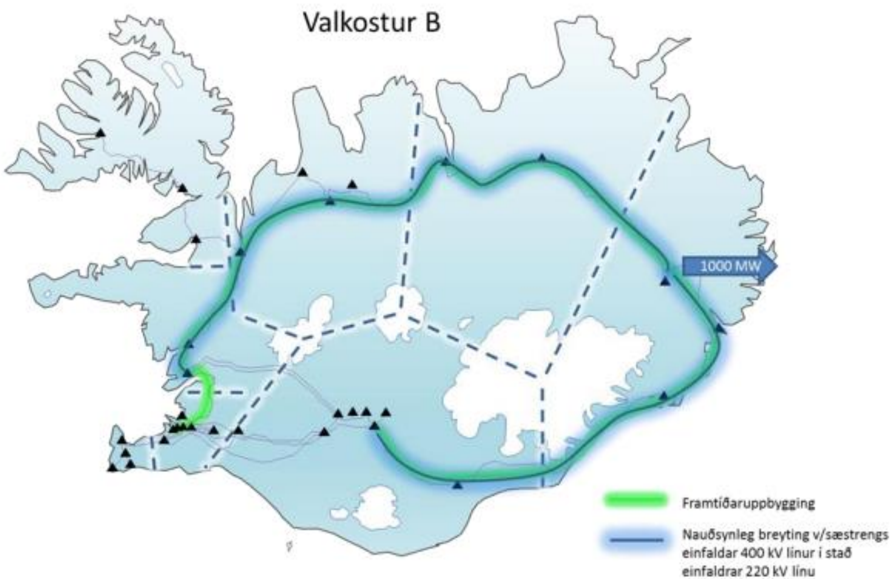
Icelink project introduction

Onshore transmission system in Iceland needs to be strengthened

- **If landing is on the east coast the circular transmission system needs to be upgraded from 220kV lines to 400 kV lines**
- **If landing is on the south coast less investment is needed**
- **Need for investment in the onshore transmission will also depend on the exact location of the new generation**



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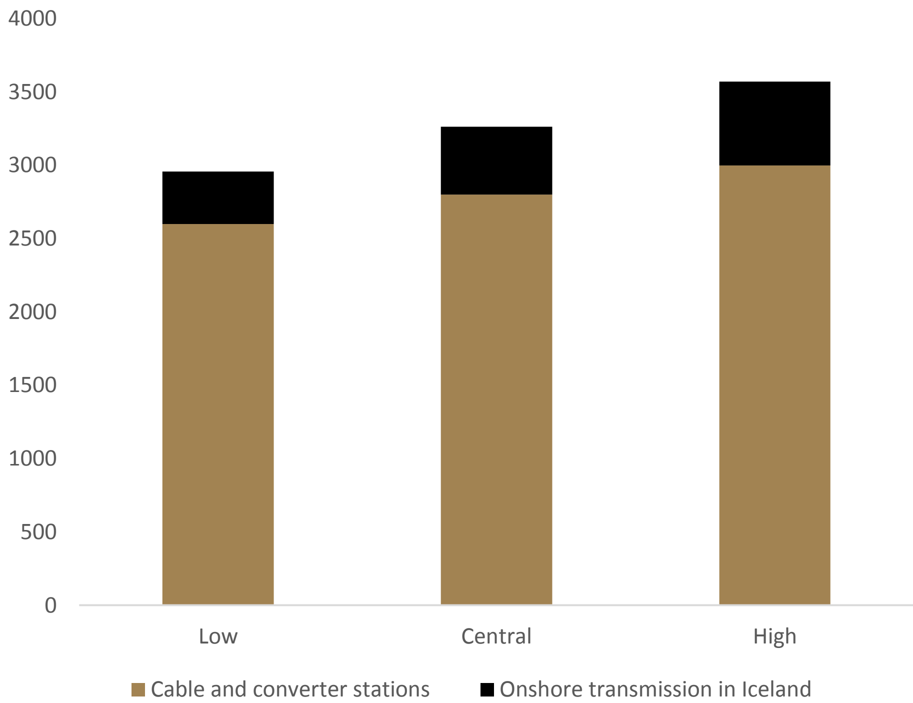
Icelink project introduction

Cost of the interconnector and onshore transmission in Iceland

- **The cost was compared to other projects**
- **Discussions with project developers**
- **Overall cost EUR 3-3.5 bn**
- **Cost of onshore transmission built up based on information from Landsnet**



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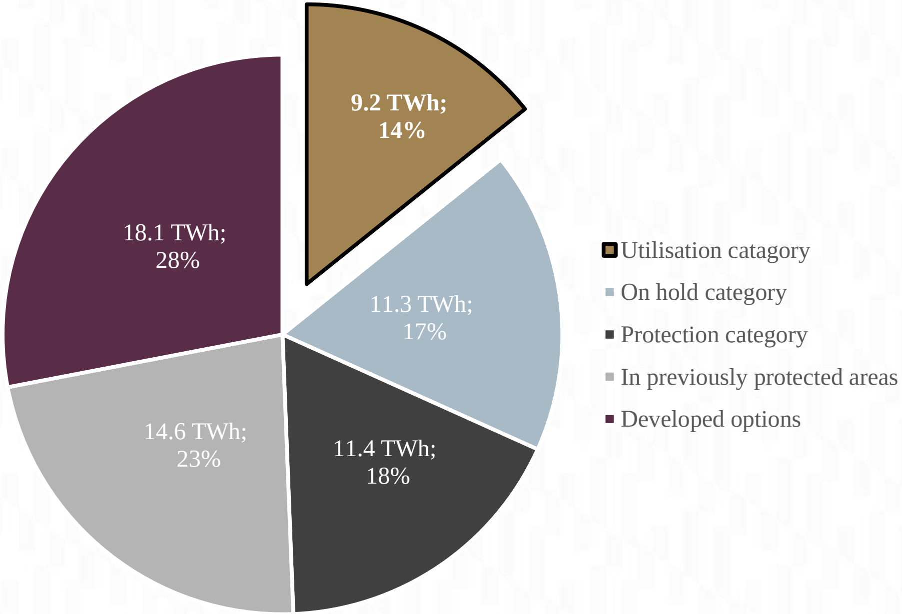
Iceland market key assumptions

The Master plan for Nature conservation and utilisation of energy

- **9.2 TWh in the Utilisation category or 14%**
- **Protected and developed options 44.1 TWh or 69%**
- **On hold category 17% or 11.3 TWh**
- **Onshore wind and small hydro were outside the scope of the second phase of the Master Plan**



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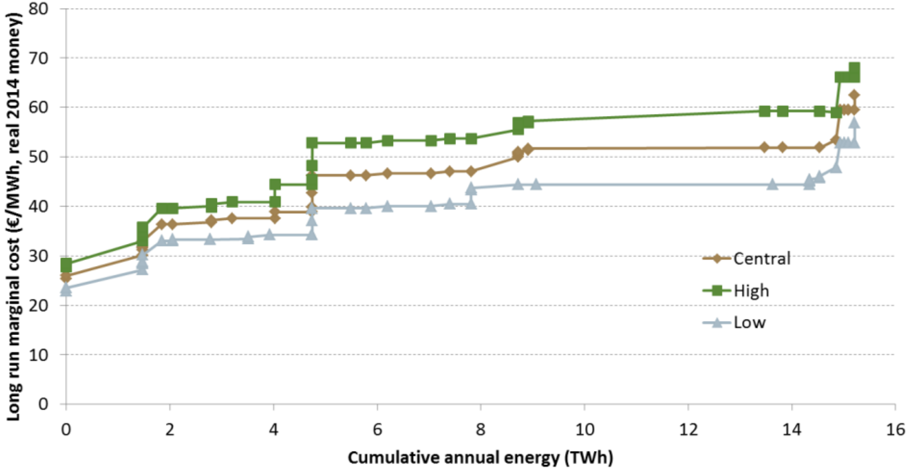
Iceland market key assumptions

Cost of generation build up in Iceland

- **Projects in the Utilisation category of the Master plan ≈ 9 TWh**

- **Onshore wind ≈ 6 TWh**
- **Small hydro ≈ 1 TWh**
- **Low temperature geothermal**

- **Assumptions based on information from DECC, IRENA and Landsvirkjun**



	Lifetime (years)	OPEX	WACC (real)
Geothermal	35	3.0%	7.9%
Hydro	50	1.5%	7.9%
Onshore wind	25	4.0%	7.9%

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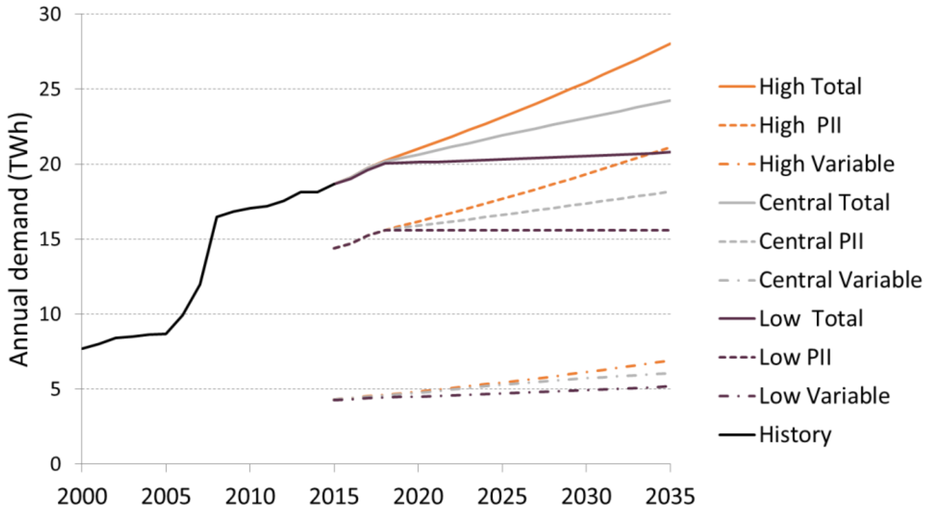
Iceland market key assumptions

Projected demand in Iceland

- **Three demand scenarios in Iceland**
- **Low with no further build up of PII after 2018**
- **High with same PII build up rate from 2018-2035, as was in the period 2009-2018**
- **Central with moderate PII build up rate**
- **Variable demand projection in line with population and tourist**



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2. Methodology

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PRINCIPLES OF THE ANALYSIS

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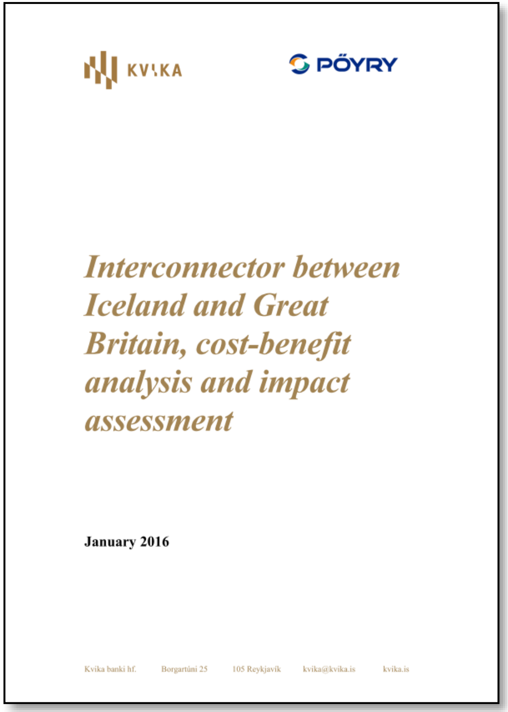
Pöyry has used a fundamental model and socio-economic analysis

- The economic value of the interconnector has been assessed through a CBA approach in line with ENTSO-E guidelines looking at socio-economic welfare
- A fundamental hydro-thermal power market model has been used to simulate supply and demand in GB and Iceland
- A proxy has been used for wholesale prices in Iceland, to simulate economic flows
- Several fundamental scenarios and business models for Icelink have been tested


KVIKA PÖYRY

Interconnector between Iceland and Great Britain, cost-benefit analysis and impact assessment

January 2016

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THE COST BENEFIT ANALYSIS

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The CBA focuses on consumer/producer surplus and congestion rent

- The cost benefit analysis looks at the consumer and producer surplus, as well as congestion rent
- Transfers from consumers to producers (or vice-versa) are not the primary concern of this type of analysis
- The aim of this analysis is not to look at contractual structures (who owns what) but to capture sources of costs and benefits
- Conventions, methodology and assumptions are in line with ENTSO-E guidelines

Category	Item
Interconnector	Investment
	Fixed opex
	Congestion rent
GB producers	Change in capex of generation park due to Icelink
	Change in fixed opex generation park due to Icelink
	Change in producer surplus due to the Icelink
GB consumer surplus	Change in consumer surplus due to the Icelink
of which 'government' surplus	Saved CfD payment (if Icelink receives a lower CfD strike price
Iceland producer surplus	Change in capex of generation park due to Icelink
	Change in fixed opex generation park due to Icelink
	Change in producer surplus due to the Icelink
Iceland consumer surplus	Change in consumer surplus due to the Icelink

BID3 – PÖYRY'S ELECTRICITY MARKET MODEL

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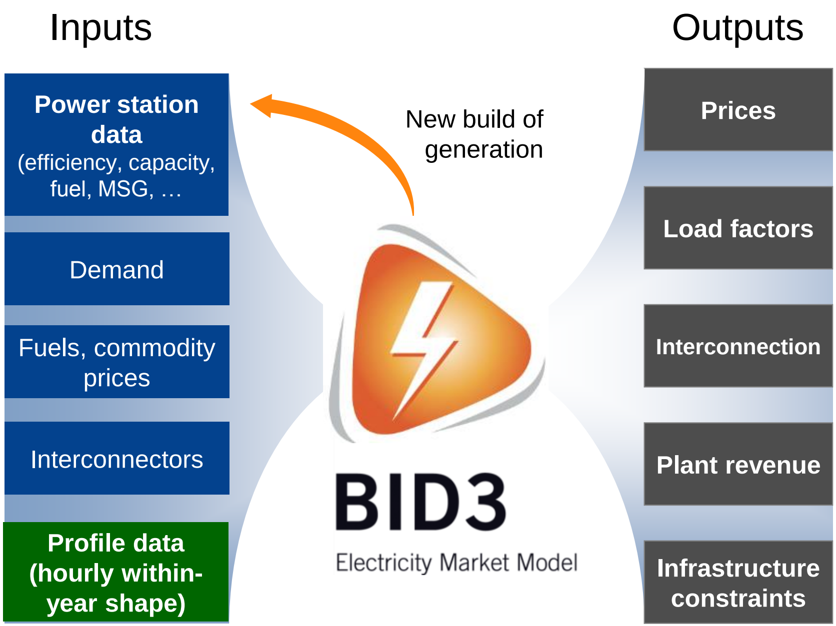
BID3 projects physical operation (generator output, electricity flows, emissions) and economic behaviour (electricity prices, revenues)

Inputs and outputs of *BID3*



Basics of BID3

- BID3 is an optimisation which minimises the system cost in a year subject to constraints
- Pöyry has included in BID3 the following thermal plant dynamics
  - Start-up,
  - Part-loading (no-load), Minimum Stable Generation
  - Minimum off times, minimum on time
  - Start-up cost and variable maintenance costs dependent on start temperature
  - Ramping
  - Reserve/response

THE PRICE OF POWER IN ICELAND

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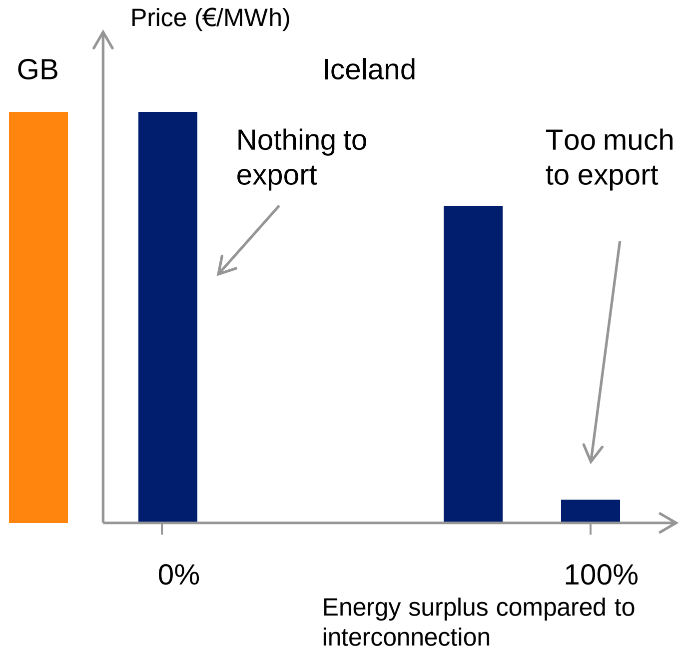
The price of power is not a simple subject when it comes to the Icelandic system

- In a hydro market connected to a thermal market, reservoir bids at the opportunity cost
- Another way of thinking about it: the price is set so that Iceland produces the optimal amount of water from reservoirs
  - i.e. so that the right amount is exported through Icelink
- This ‘spot’ short term price does not currently exist in Iceland, and may not materialise even with Icelink
  - But that is still the fundamental value of an incremental MWh of electricity
- Investments are modelled in BID3 to give the right equilibrium price: the wholesale price is equal or higher than the LRMC of new investments. The marginal LRMC is used as a proxy in parts of the analysis.



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3. Interconnector Business Models

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CASH FLOW ROUTES FOR ICELINK

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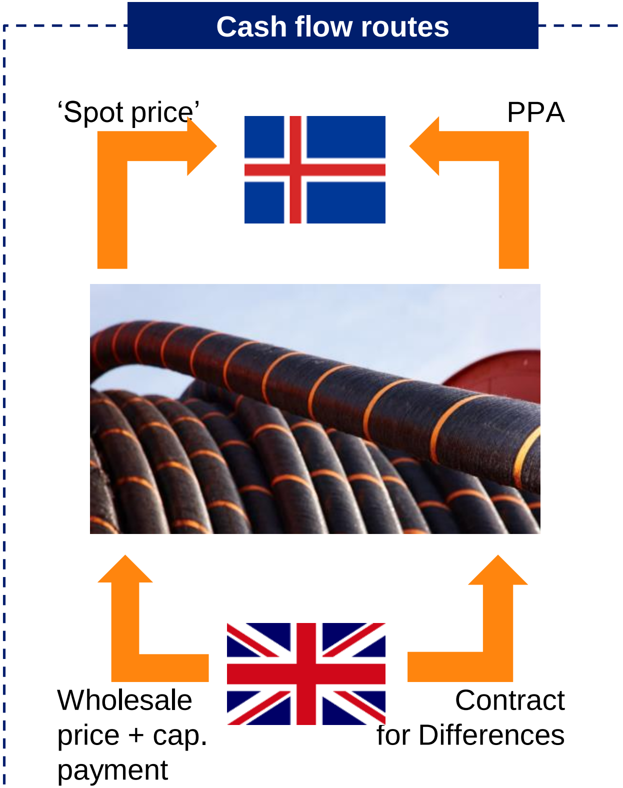
The benefits and viability of Icelink are heavily dependent on the project set-up

- Icelink is not a ‘standard’ interconnector in the European context
  - No ‘spot price’ in Iceland, no Short Run Marginal Cost
  - Icelink is in principle based on building renewable generation to export to GB
- Two revenue streams on the GB side have been analysed
  - The wholesale price (in the case of merchant interconnector, with or without cap & floor) and capacity payment
  - Wholesale price + Contract for Difference (CfD) remunerating carbon-free generation in GB
- On the Icelandic side, two ways for an interconnector to pay for electricity have been analysed
  - Through a PPA with a generator
  - A ‘spot price’ – which at the moment doesn’t exist



BUSINESS MODELS FOR ICELINK

- Depending on the combination of ‘cash flow routes’, we identify 3 business models
- ‘Full merchant’
  - Does not refer to ownership structure, but to source of revenues
  - Compatible with cap & floor regulation to stabilise revenues
  - Requires the emergence of a liquid spot price in Iceland
  - Uncoordinated build-out of cable and new generation in Iceland
- ‘Renewable export’
  - Requires multiple exemptions to the CfD regime, and therefore requires strong political will
  - Most probably the safest investment case
  - Coordinated build out of cable and generation in Iceland
- ‘Integrated merchant’
  - Merchant model compatible with current structure of Icelandic market
  - May be compatible with cap & floor regulation
  - Coordinated build out of cable and generation in Iceland

Business models analysed

	Full merchant	Renewable export	Integrated merchant
	‘Spot’ price	PPA	PPA
	Wholesale price + capacity payment	Wholesale price + CfD	Wholesale price + capacity payment
Comment	Compatible with cap & floor	Requires strongest political will	Perhaps compatible with cap & floor

THE ICELINK CONCEPT DOCUMENT

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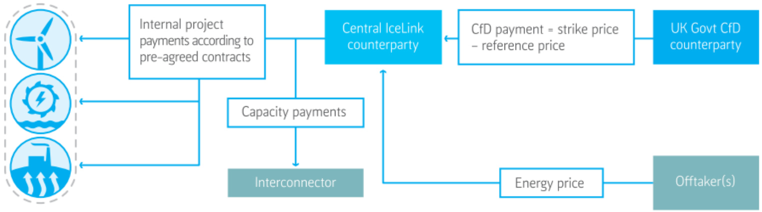
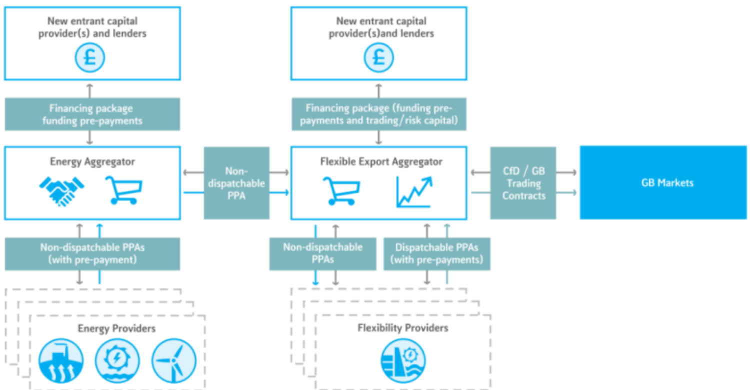
The ‘IceLink concept document’ gives a possible commercial design of Icelink

- The Icelink concept gives Landsvirkjun’s and National Grid’s view of a business model and commercial structure compatible with current market designs
- The document highlights the potential ‘exemptions’ to standard terms that would allow this structure to work
- The documents presents qualitative elements of rationale for the interconnector
- The document presents a calculation of a required CfD to ensure project profitability

High level commercial structure



Icelink into Icelandic market



THE ICELINK CONCEPT DOCUMENT VS. PÖYRY ANALYSIS

- The business case presented in the Concept Document is closest to the ‘RES export’ business case: the source of revenues for interconnector + generation is a Contract for Differences (+ wholesale price)

- The Concept Document assumes a circa 65% export factor, which is one of the sensitivities we have explored

- The basis for this 65% export is to reduce the need for grid reinforcements in GB, and for Icelink to be a source of flexibility as well as a source of imports

- Pöyry’s modelling suggests that there would be little use of this flexibility
  – In the ‘day-ahead’ market
  – In a ‘best guess’ scenario rather than a ‘objectives met’ scenario
  – Results in only 5% higher revenues per MWh than in the Central case

- Pöyry’s analysis does not consider North-South grid reinforcement costs in GB
  – How would a 65% export feed into the reinforcement cost? How would it be operated?

- The required CfD strike price in the concept document is very close to the level found in Pöyry’s analysis
  – Some assumptions are different (duration of CfD, discount rates, etc.)

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4. Market scenarios

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FUNDAMENTAL SCENARIOS

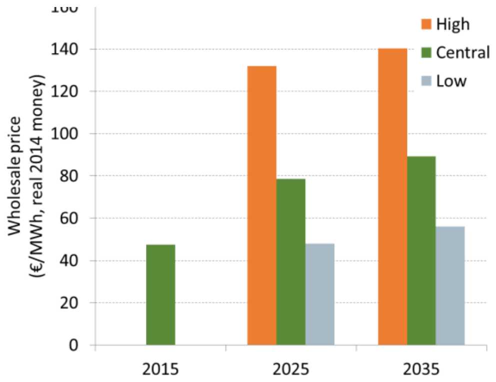
Pöyry's standard scenarios capture the fundamental drivers of Icelink

- Fundamental scenarios need to cover the drivers of value for the project: in this case, the wholesale electricity price
- Pöyry has used its own independent energy market projections, based on the detailed fundamental modelling of fuel and power prices
- The Central scenario reflects Pöyry's assessment of the most likely developments for power prices in GB
- The significant uncertainty in commodity prices leads to an equally significant uncertainty in GB wholesale prices
  – 2025: £36/MWh - £59/MWh - £99/MWh
  – 2035: £42/MWh - £67/MWh - £105/MWh

Commodity prices

	High	Central	Low
GDP growth (global)	5%	4%	3%
ARA coal price ($/tonne)	126	76	45
Brent oil price ($/bbl)	150	76	43
Gas price (p/therm)	82	50	32
Carbon price (€/tCO2)	26	14	4

Wholesale price in GB



Source: Pöyry

SIMULATIONS PERFORMED FOR THE ANALYSIS

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- Matrix of simulation from 3 fundamental scenarios and 3 business models
- The main fundamental difference is that in the RES export, Icelink replaces offshore wind in GB
- Sensitivities have also been considered:
  - 800MW interconnector
  - Constraining export factor to 65% by reducing generation investment in Iceland
- Some combinations are not compatible
  - In the Low fundamental scenario, there isn't enough new (uncommitted) offshore wind developed to be displaced by Icelink
  - The 65% export sensitivity is not compatible with a market solution

Simulations

		Pöyry fundamental scenario	Icelink replaces offshore wind in GB?
RES export	High	High	Yes
	Central	Central	Yes
	800MW	Central	Yes
	65% export	Central	Yes
Merchant	High	High	No
	Central	Central	No
	Low	Low	No

- Each simulation is performed under 20 weather patterns: difference in inflow between dry and wet years is up to 4TWh

5. Key market projection results

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NEW GENERATION INVESTMENTS

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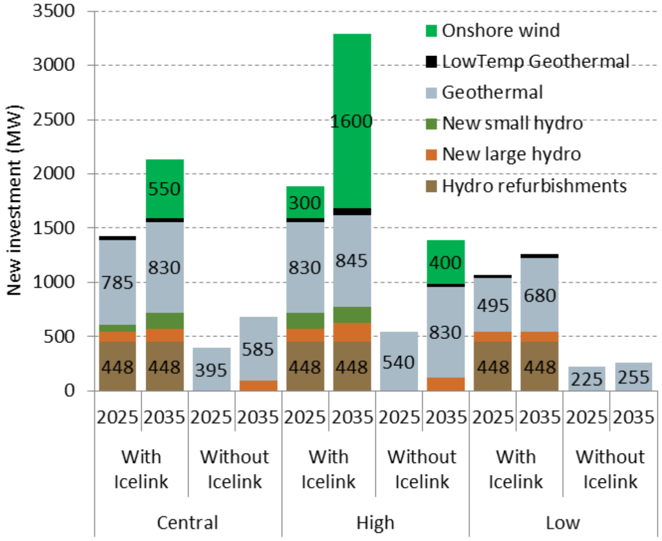
New investments are driving exports and prices

- New investments are made based on market principles: until the marginal value of electricity supports new investments
- In the Central scenario, 1450MW of investment is required on top of the 680MW. Overal:
  - 450MW of hydro refurbishments
  - 125MW of new large hydro
  - 150MW of new small hydro
  - 830MW of new geothermal
  - 550MW of onshore wind
- In the High scenario, total investment reaches 3.3GW (including 1.6GW of wind)

New generation investments (MW)



Source: Pöyry

SUPPLY AND DEMAND IN ICELAND

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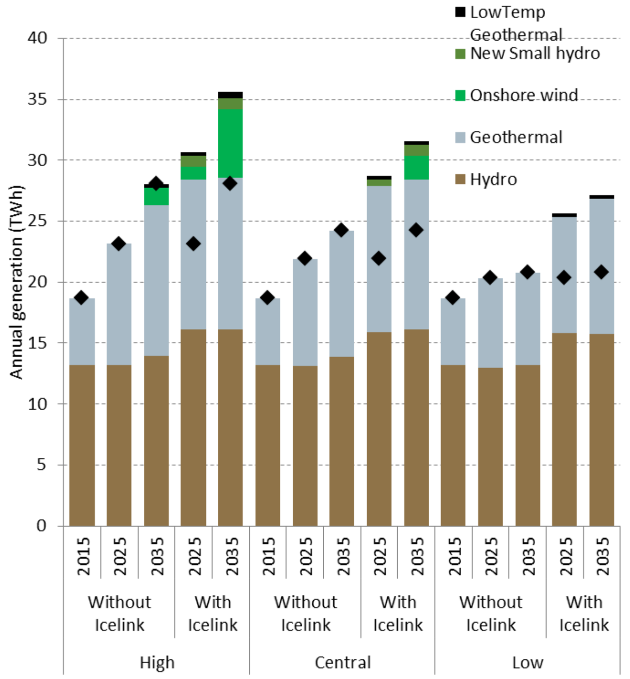
A mix still dominated by conventional hydro and geothermal

- Generation in Iceland meets demand and interconnector export
- The share of geothermal electricity increases in all scenarios
- Wind comes after a ‘plateau’ of maximum hydro and geothermal deployment
- Low temperature geothermal and small hydro are not significant contributors to the final mix

Generation vs. Demand in Iceland



Source: Pöyry

ICELINK IMPROVES THE USE OF RESOURCE

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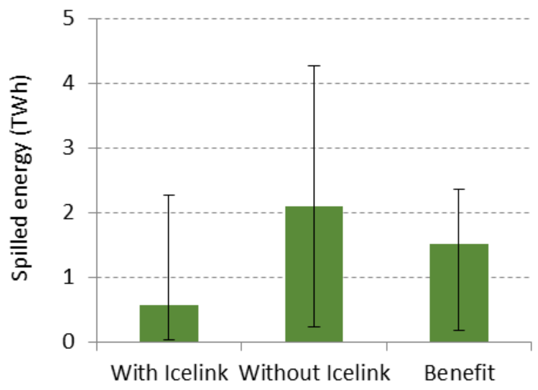
Icelink saves around 1.5TWh of spilled inflow per year on average

- Security of supply in Iceland is primarily an energy (TWh) issue
- There needs to be enough hydro generation to meet demand even in dry years
- This leads to a dimensioning of the system where there is a level of spilled hydro energy with normal weather around 2TWh, and up to 4TWh in wet years
- There are other mechanisms, like clauses in PPAs, which impose a potential demand response
- The presence of Icelink reduces spill significantly, down to 0.5TWh per year on average (between 0 and 2.2TWh)

Spilled energy in Iceland



Source: Pöyry

ICELINK IS AN EXPORT CABLE

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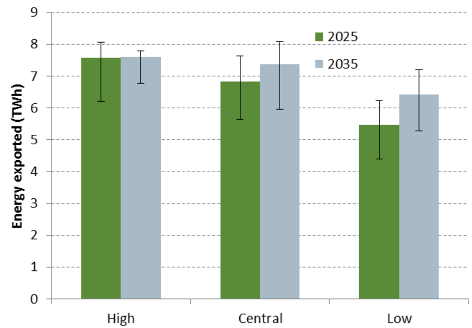
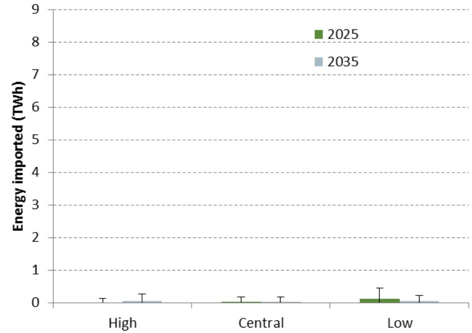
There is little reverse flow from GB to Iceland through Icelink

- The rate of export is close to 85% in the High and Central scenario, and 60-70% in the Low
- In order to have reverse flows, the following conditions need to be fulfilled:
  - Iceland has the ability to store energy: swings of 2GW from full export to full import
  - No prospect of spilling water in the coming weeks
  - Hourly price difference justifies running Iceland like a pumped storage unit
  - The hourly price difference is sustained for more than a few hours (assumed ramping constraints of 400MW/h)
- Market simulations suggest that this set of conditions is not frequently fulfilled
- Other forms of flexibility are likely to emerge in the timeframe of the lifetime of Icelink, making the 'flexibility' possibilities from Icelink even less attractive

Exports from Iceland



Imports into Iceland



Source: Pöyry

ELECTRICITY PRICE IN ICELAND

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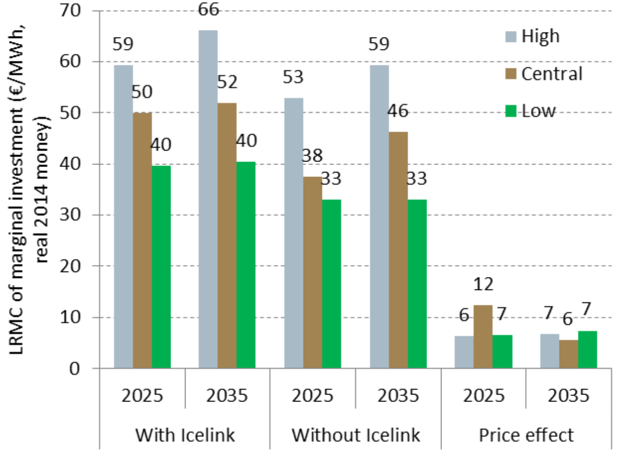
The presence of Icelink increases electricity prices by around €7/MWh

- On average the presence of Icelink requires the development of projects with a LRMC €7/MWh higher than if Icelink is not built
- Some ‘supply curve’ effects bring this number to €12/MWh in the Central scenario in 2025
- Overall, LRMCs of marginal projects are in the range €33/MWh - €66/MWh, relatively narrow in comparison to the range of GB prices
- This creates a very large variation of price spreads:
  - €40/MWh-€55/MWh in the Low
  - €52/MWh-€89/MWh in the Central
  - €66/MWh-€141/MWh in the High

Electricity price in Iceland



Source: Pöyry

800MW, 65% EXPORT SENSITIVITIES

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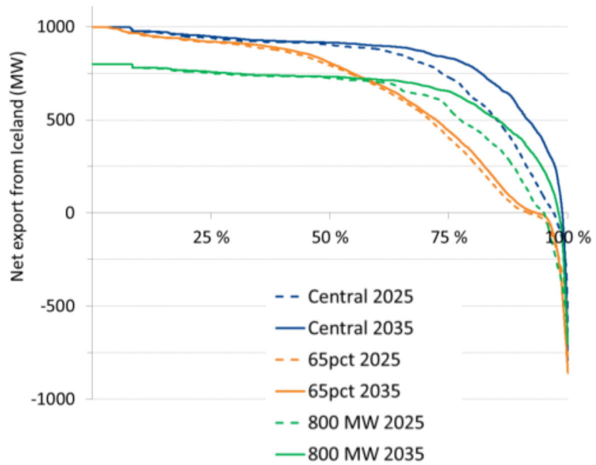
- The 65% export and the 800MW have (nearly) the same annual export result
- The difference between the two cases is the timing of this export, and the ability to act as a battery: the 65% case has more reverse flows
- The free market would (probably) not deliver a 65% export case: there would be an economic case for more build-out, leading to more exports
- The average export price is slightly higher in the 65% export case:
  - 800MW sensitivity: €86.1/MWh
  - 65% export sensitivity: €89.7/MWh

Flow duration curve under sensitivities



Source: Pöyry

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6. Cost benefit analysis

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THE COST BENEFIT ANALYSIS

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The CBA focuses on consumer/producer surplus and congestion rent

- The cost benefit analysis looks at the consumer and producer surplus, as well as congestion rent
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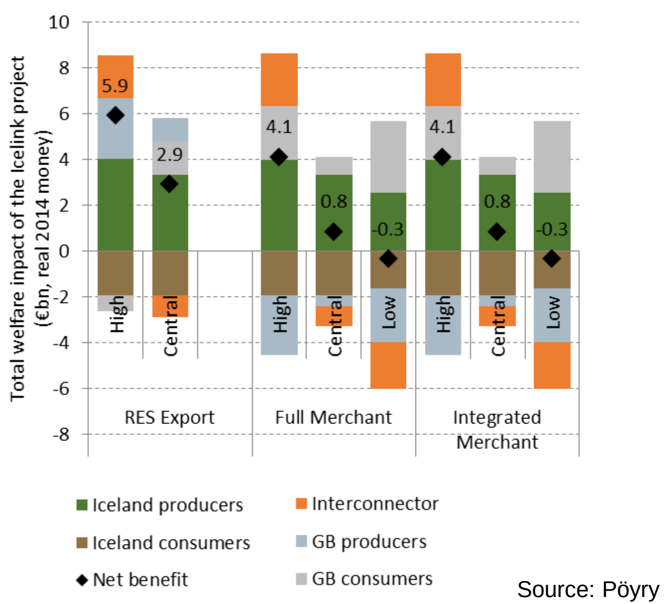
Category	Item
Interconnector	Investment
	Fixed opex
	Congestion rent
GB producers	Change in capex of generation park due to Icelink
	Change in fixed opex generation park due to Icelink
	Change in producer surplus due to the Icelink
GB consumer surplus	Change in consumer surplus due to the Icelink
of which 'government' surplus	Saved CfD payment (if Icelink receives a lower CfD strike price
Iceland producer surplus	Change in capex of generation park due to Icelink
	Change in fixed opex generation park due to Icelink
	Change in producer surplus due to the Icelink
Iceland consumer surplus	Change in consumer surplus due to the Icelink

SOCIO-ECONOMIC VALUE OF THE ICELINK PROJECT

The socio-economic value is in general positive, and highest in the RES Export cases

- The total socio-economic value of the Icelink project is the sum of the elements previously described
  - Socio-economic value in Iceland
  - Socio-economic value in GB
  - Socio-economic value of the cable
- The socio-economic value is highest in the RES Export case, driven by GB side: Icelink reduces consumer costs related to CfD payments
- The socio-economic value is positive in the merchant cases in the Central and the High, and slightly negative in the Low
- The value of saved CO2 emissions in the Merchant cases is not accounted for
- GB transmission reinforcements costs are not included

Socio-economic value of Icelink



Source: Pöyry

PRODUCER/CONSUMER SURPLUS IN ICELAND

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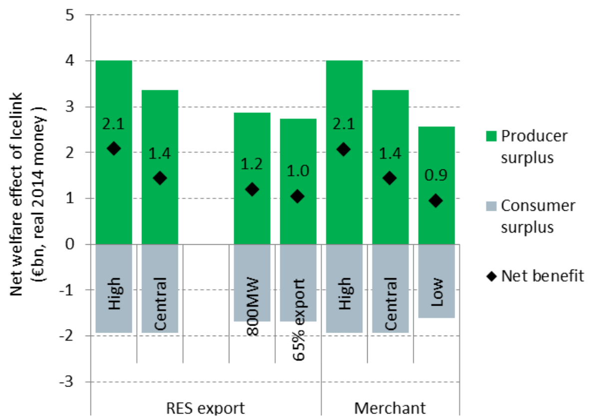
The net benefit on the Icelandic side is significant

- The producer and consumer surplus effect is the sum of
  - Increase in price creates higher producer surplus and lower consumer surplus
  - Less spill increases producer surplus
  - Higher power generation increases producer surplus
  - Investment and fixed costs in new generation decrease producer surplus
- Net benefit is circa €1.4bn
  - real 2014 money
  - discounted back to 2014 with 4% discount rate
- No change by business model, as prices and volumes in Iceland are not affected

Producer/consumer surplus in Iceland



Source: Pöyry

SIGNIFICANT WEALTH TRANSFERS IN ICELAND

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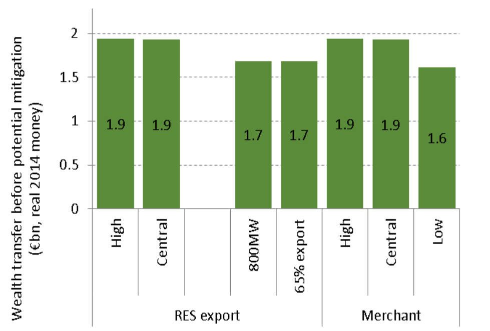
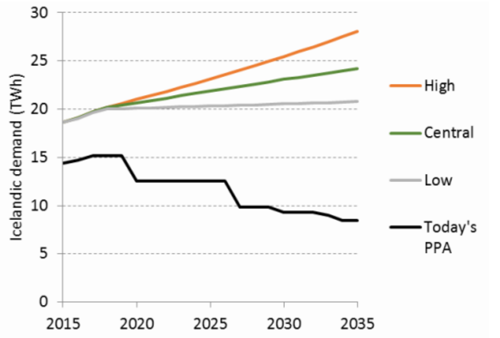
The introduction of Icelink would create significant wealth transfers from consumers to producers

- The introduction of Icelink would increase the marginal value of electricity (the ‘price’)
- Over time, this higher marginal value would be reflected in price paid by consumers
  - Transfer of wealth in the area of €1.9bn (real 2014 money discounted to 2014)
- The exact magnitude timing of the increase in price paid by consumer is uncertain
  - Some consumers covered by long term PPAs
  - Some consumers may have a significant negotiation power
  - The ‘price’ may not emerge in a transparent way
- In any case, transfers of wealth can be mitigated by other policies, and are not considered either as positive or negative in this analysis

Unmitigated wealth transfer



Demand vs. today’s PPAs



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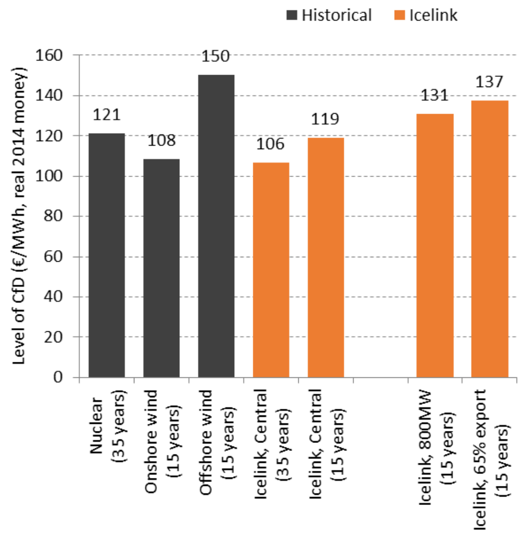
REQUIRED STRIKE PRICE IN GB

Icelink provides renewable electricity at a lower cost than offshore wind in GB

- The strike price is calculated as the level of payment required to ensure a 7.9% IRR for the whole project (generation and transmission)
  - After 15 years, revenues come from wholesale prices and capacity payments
- In the Central scenario, the strike price would be €119/MWh (£96/MWh) for a duration of 15 years
  - Level would drop to €106/MWh (£86/MWh) with a 35 year contract
- The level would increase to €137/MWh (£111/MWh) under the 65% export sensitivity

Required strike price for Icelink



Source: Pöyry

PRODUCER/CONSUMER SURPLUS IN GB

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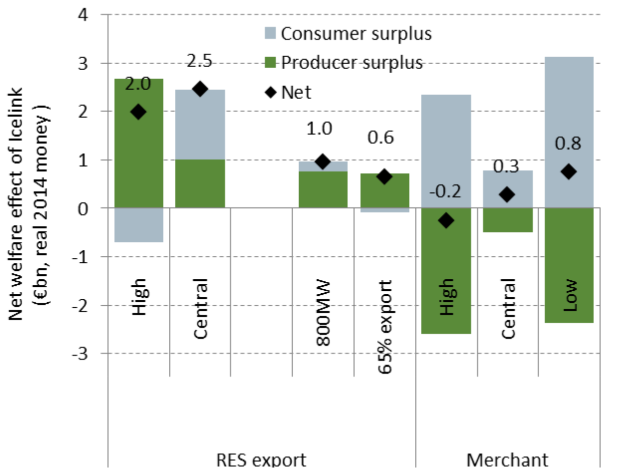
The benefit is highest in RES export cases

- The net position corresponds to
  - Change in consumer surplus due to price
  - Change in producer surplus due to price and generation
  - Avoided cost for consumers in paying for a cheaper CfD (to Icelink rather than offshore wind)
  - Avoided costs in thermal investments (due to capacity market)
- Merchant cases do not save any CfD payment, hence the lower net benefit
- Merchant cases have a net CO_2 benefit which the RES export cases do not have
- This excludes the cost of reinforcing the Scotland-England transmission network

Consumer and producer surplus in GB



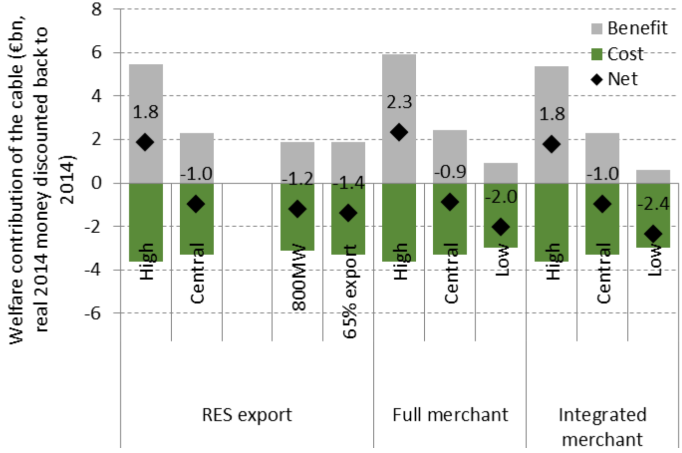
Source: Pöyry

SOCIO-ECONOMIC VALUE OF THE CABLE (ISOLATED)

Costs outweigh the socio-economic benefit for the interconnector alone

- Excluding the welfare benefits in GB and Iceland, the cable itself is not socio-economically beneficial
- Costs (capex&opex) are lower than the congestion rent in the Central and Low scenarios
- In the High scenario, costs (capex&opex) are higher than the congestion rent
- The congestion rent is different from the revenues in the RES export and integrated merchant cases

Socio-economic benefit for the interconnector



Source: Pöyry

SOCIO-ECONOMIC VALUE OF THE ICELINK PROJECT

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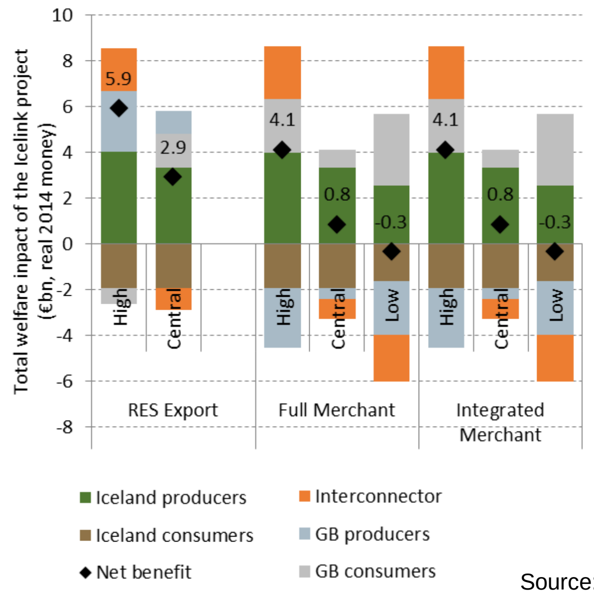
The socio-economic value is highest in the RES Export cases

- The total socio-economic value of the Icelink project is the sum of the elements previously described
  - Socio-economic value in Iceland
  - Socio-economic value in GB
  - Socio-economic value of the cable
- The socio-economic value is the highest in the RES Export case, driven by the GB side: Icelink reduces consumer costs related to CfD payments
- The socio-economic value is positive in the merchant cases in the Central and the High, and slightly negative in the Low
- The value of saved CO2 emissions in the Merchant cases is not accounted for
- GB transmission reinforcements costs are not included

Socio-economic value of Icelink



Source: Pöyry

SOCIO-ECONOMIC VALUE IN SENSITIVITIES

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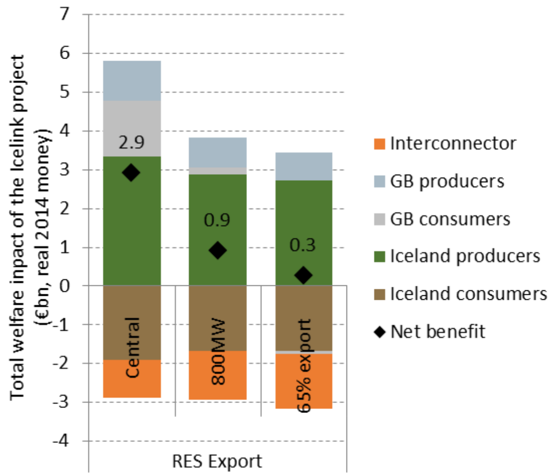
The socio-economic value of the Icelink project in the sensitivities is significantly lower than in the Central case

- The overall welfare decreases significantly in the 800MW and 65% export sensitivities
- The welfare decrease in GB, Iceland and for the interconnector itself
- This does not take into account that grid reinforcement in GB may be cheaper under some of these sensitivities
- This aspect may need to be analysed in more detail

Socio-economic benefit of sensitivities



Source: Pöyry

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COMMERCIAL RETURN OF ICELINK

The basis for the calculation of the IRR is different from the socio-economic analysis

- In the IRR calculation, the overall profitability of the relevant scope of Icelink is assessed
- In the Full Merchant, only the interconnector is assessed
- In the Integrated Merchant and RES Export cases, interconnection + new generation is assessed
- Payments from Cap and Floor are taken into account in the calculation of profitability, with the assumption that the range 2.5-8.5% IRR is guaranteed by the mechanism
- IRR is calculated as real, pre-tax value

Elements of cost/revenues in IRR calculation

Category	Item	Business model
Cable	Investment (cable and onshore)	All
	Fixed opex	All
New generation (Iceland)	Capex	RES export and Integrated merchant
	Fixed Opex	RES export and Integrated merchant
Revenues	Contract for Differences (strike price)	RES export case
	or	
	Wholesale revenues - *price x export*	Integrated merchant
	Capacity payment revenues	Integrated merchant
	Cap and Floor	Integrated Merchant
	or	
	Congestion rent	Full merchant
	Capacity payment revenues	Full merchant
	Cap and Floor	Full merchant

INTERNAL RATE OF RETURN OF ICELINK

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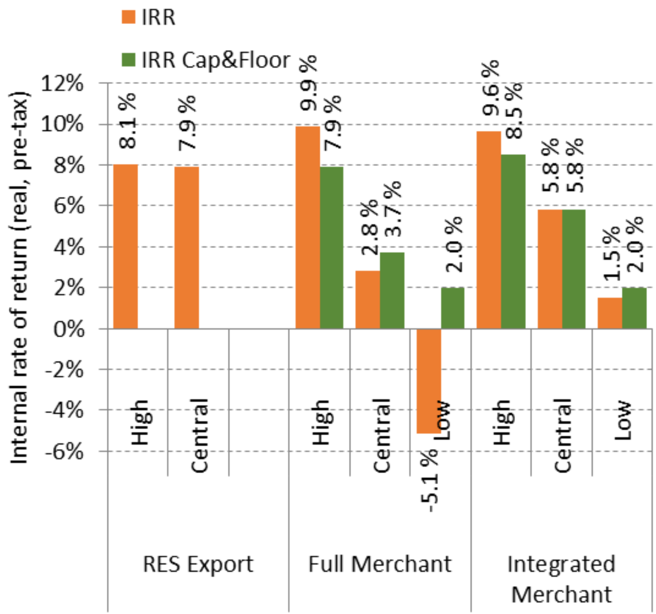
The commercial viability of the project is not guaranteed without integrating

- In the RES Export, the IRR is an input: the strike price is calculated to give a 7.9% IRR
- In the Full Merchant case the 'straight' IRR of 2.8% is increased to 3.7% with a cap and floor, by reducing the downside weather-related volatility
- In the Integrated Merchant, the rent generated by the cheapest new build in Iceland brings the entire project to a 5.8% IRR
- In the Low scenario, IRRs in the merchant cases are supported by the floor of the Cap and Floor mechanism

IRR of Icelink



Source: Pöyry

CONCLUSION

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- The RES export case is a valid business case which can deliver a safe return for the Icelink project as a whole
  - A detailed commercial and regulatory analysis could be performed to find ideal setup for the project, starting from the Icelink Concept Document
  - A clear political support is required for this option, to support Icelink over a local offshore wind project
- The Full Merchant case has a positive socio-economically value, but a poor commercial return: it could get a cap and floor arrangement but would not find investors
- The Integrated Merchant case internalises the rents made by the cheapest of the new generation in Iceland, and reaches a rate of return closer to a commercial hurdle rate but still on the low side
  - A cap and floor would made the revenues less risky than standard generation investments
  - This option requires less political support, but is less attractive financially

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7. Iceland Impact Analysis

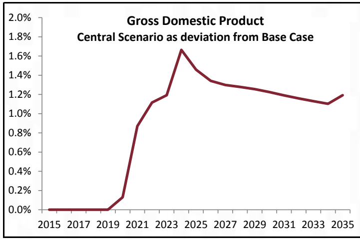
Presentation for UK-ICE Task Energy Task Force

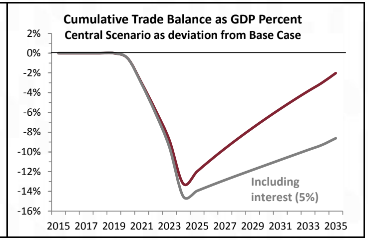
London, February 8th 2016

Economic impact analysis

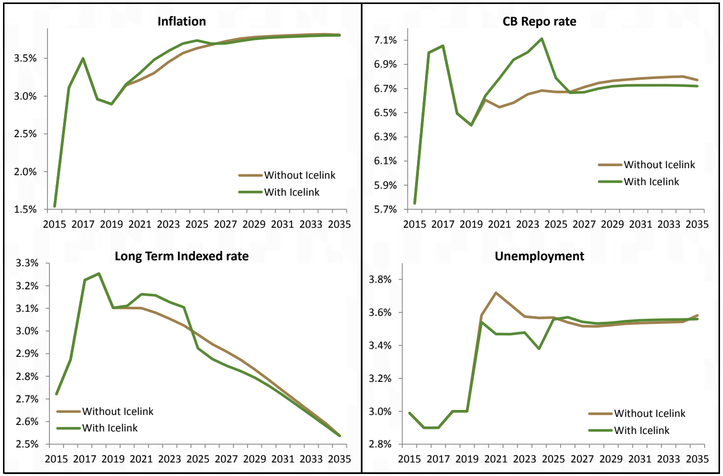
Central scenario

- **Indicates significant benefit**
- **1.2-1.6% increase in GDP levels**
- **Short term impact during construction on:**
  - Inflation
  - Unemployment
  - Interest rates
- **Cumulative trade balance negative by 15% of GDP after the construction period**





Central Scenario plottet against Base Case



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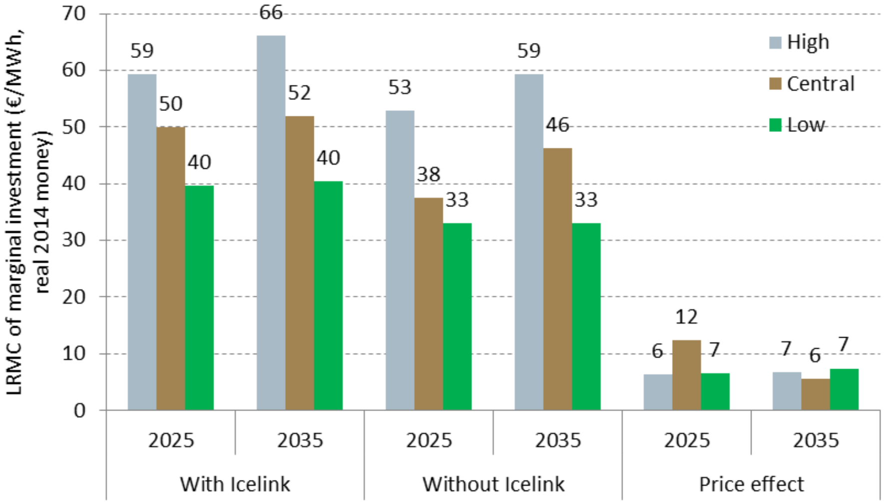
Impact on electricity prices

EUR 6-12 / MWh increase with IceLink

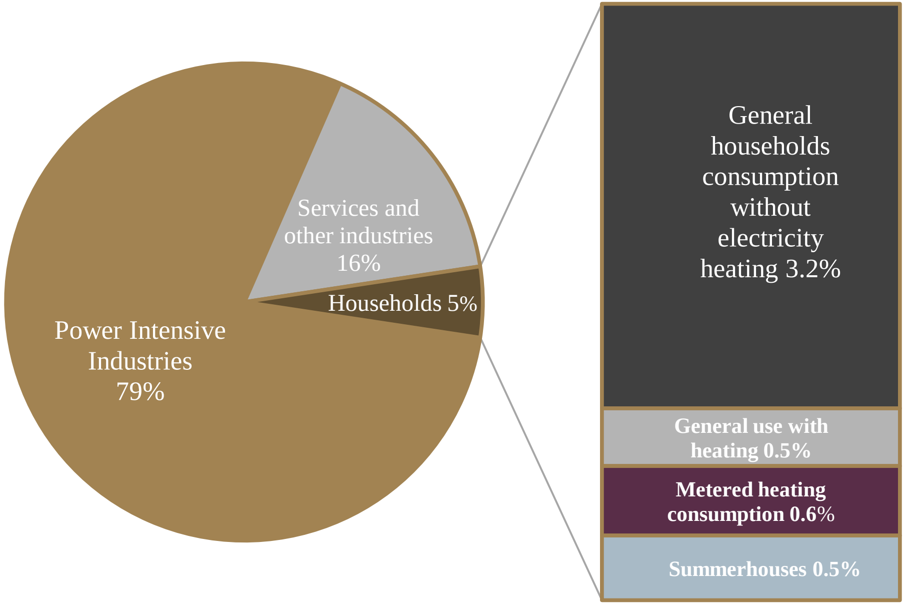
- **12-32% increase in electricity prices**
- **Determined by the long run marginal cost of electricity**
- **Higher electricity price as a result due to the utilisation of higher cost generation**
- **Price would still be substantially lower than in GB and North West Europe**



Impact on households

Households use 5% of the electricity in Iceland

- **90% of the population has access to affordable geothermal heating**
- **10% of the population uses electricity to heat their houses**



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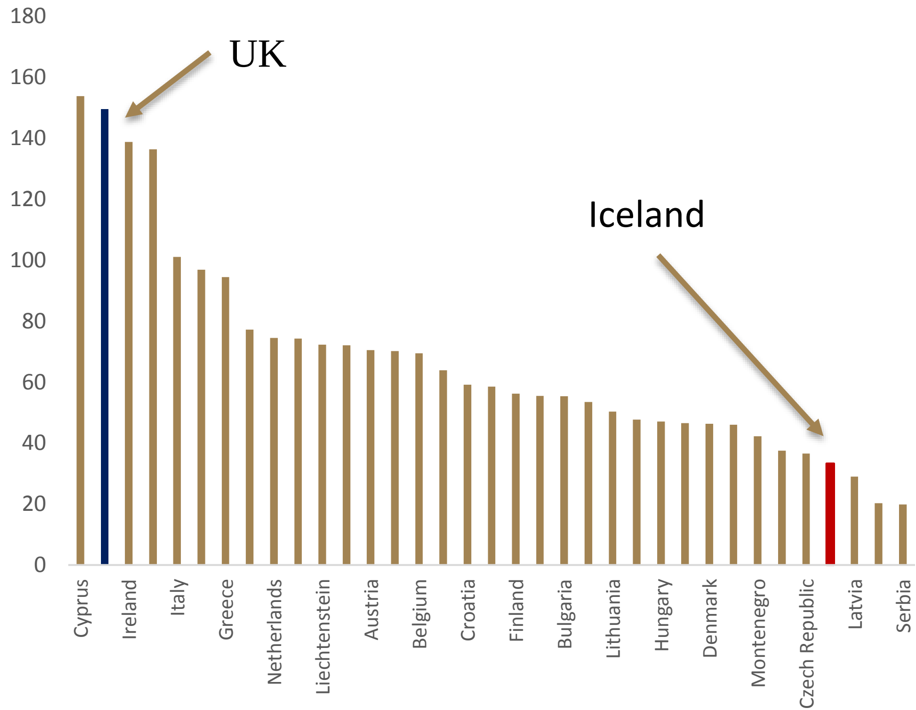
Electricity price to European homes (EUR/MWh)

Without network cost and taxes (consumption 2,500-5,000 kWh/year)

- **Electricity prices in Iceland to households relatively low in comparison to other European countries**
- **Comparison without network and taxes**
- **In Iceland the electricity price is 1/3 of the total electricity cost**



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Impact on households

Summary

- **0.85-1.7 ISK/MWh increase in electricity price (6-12 EUR/MWh)**
- **Total impact on households**
  - ISK 717-1,432 m.
  - EUR 5-10 m.
- **Consumers without access to geothermal heating the most vulnerable group**
- **Potential mitigation**
  - Lowering VAT
  - Support for energy efficiency
  - Increase subsidies for rural areas and vulnerable consumers

- **Increase in households electricity cost due to Icelink**

ISK millions	0.85 ISK/kWh	1.7 ISK/kWh
General consumption	486	971
General use with heating	69	139
Metered heating	84	167
Summerhouses	78	155
Total	717	1,432

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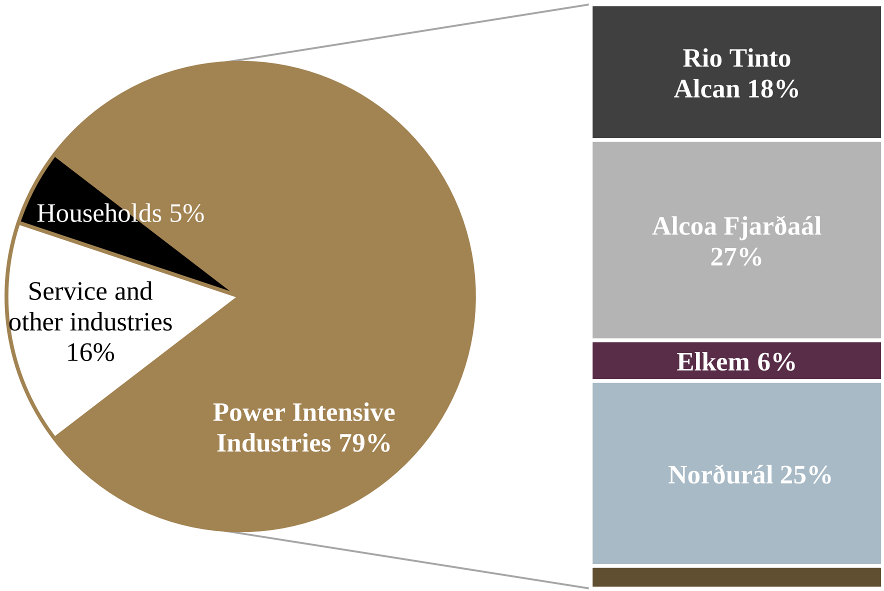
Impact on power intensive industries

Largest consumer group with 80% of current consumption

- **Current Long term Power purchase agreements provide some shelter for future price increase**
- **Old PPA's with average price around 20 EUR/MWh in 2014.**
- **New PPA's with price above 30 EUR/MWh**
- **50-52 EUR/MWh is too high price for aluminium smelters in current environment**



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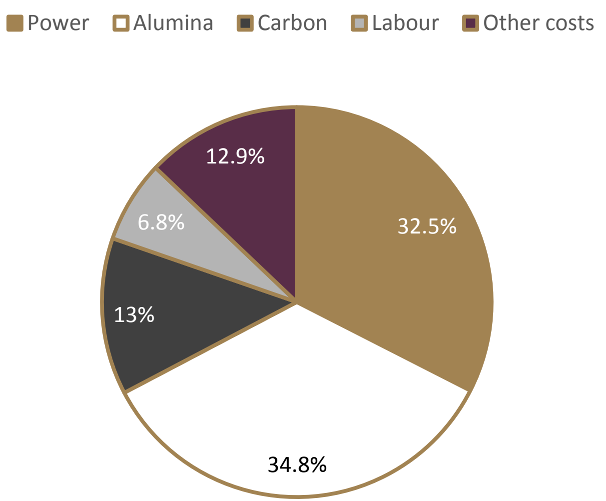
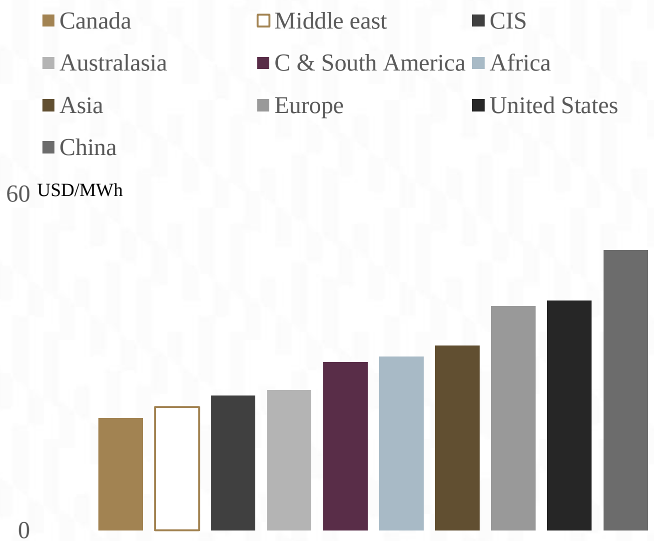
Impact on power intensive industries

Iceland produced 1.5% of global primary aluminium production in 2014

- **Power cost is substantial part of production cost of primary aluminium**[1]



- **Lowest power cost in Canada and in the Middle east in 2014**[1]



[1] CRU Aluminium Smelter Power Tariffs: Winners and losers

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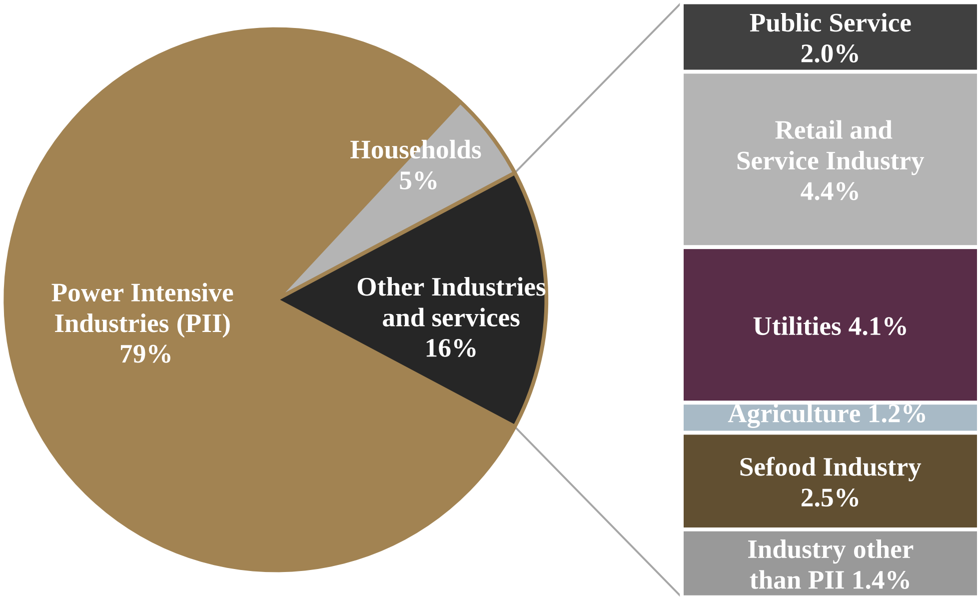
Impact on other industries and services

16% of current electricity use in Iceland

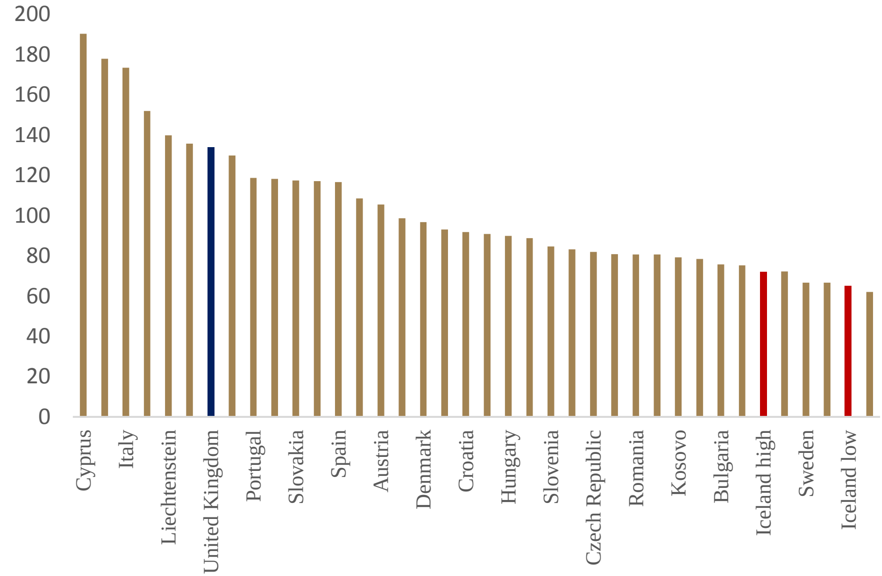
- **Retail and service industry the largest group**
- **Utilities including producers own use is also large**
- **Agriculture and horticulture with only 1.2% of total demand**



Impact on other industries and services

Electricity price to industry to industry in Europe (500-2,000 MWh/year)

- **Comparison includes unrecoverable taxes, distribution and transmission charges**
- **Most other industries and services in Iceland are small and medium sized enterprises**
- **Electricity price to SME's relatively low in Iceland compared to Europe**



Impact on other industries and services

16% of the total electricity use in Iceland

- **Total annual impact on other industries and services ISK 2,111- 4,218 million**
- **EUR 15-30 million**
- **Most vulnerable users are**
  - Agriculture & horticulture
  - Fishmeal factories
  - Bakeries

Annual impact of price increase due to Icelink

ISK millions	0.85 ISK/kWh	1.7 ISK/kWh
Retail & service sector	657	1,312
Agriculture & horticulture	195	389
Public service	302	603
Seafood industry	377	754
Industries other than PII	266	533
Utilities without power producers own use	314	627
Total	2,111	4,218

APPENDIX

THE WATER VALUE CURVE

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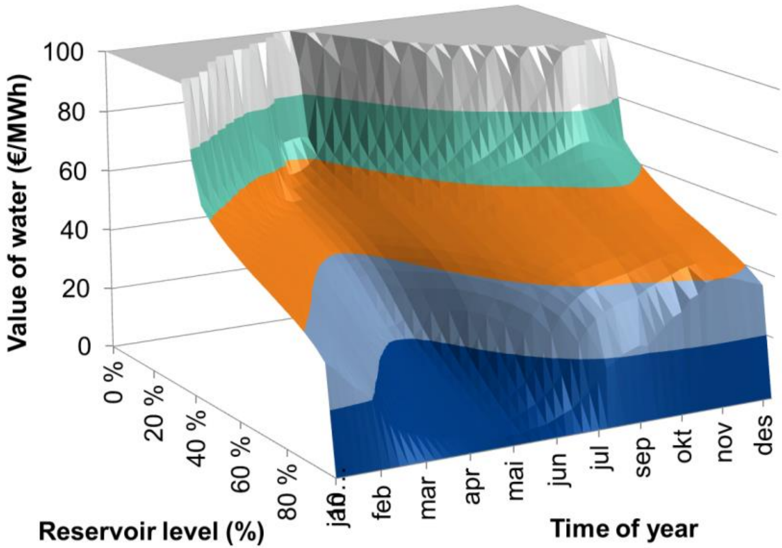
The opportunity cost of hydro power is given by fundamental power market models

- Hydro displaces production from thermal plants –the water in the hydro plant's reservoir has an opportunity cost
  - This is the value of water storage
  - This is how water is actually bid into the market in the Nordics
- Water values depend on market conditions
  - system tightness,
  - Fuel/CO2 prices,
  - interconnections,
  - supply/demand balance

Illustrative water value curve



Source: Pöyry's BID3 power market model

DETAILED P/C SURPLUS IN GB

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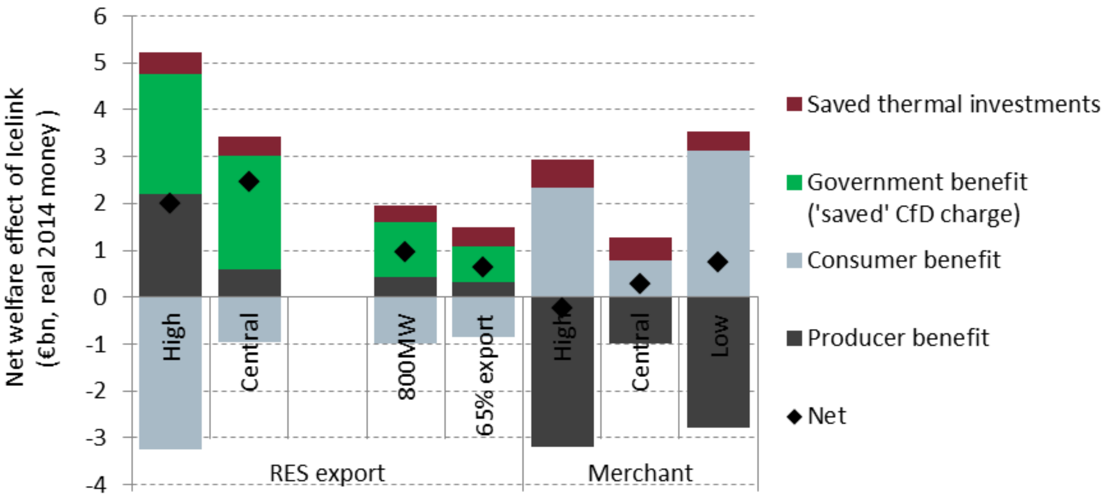

SECURITY OF SUPPLY WITH ICELINK

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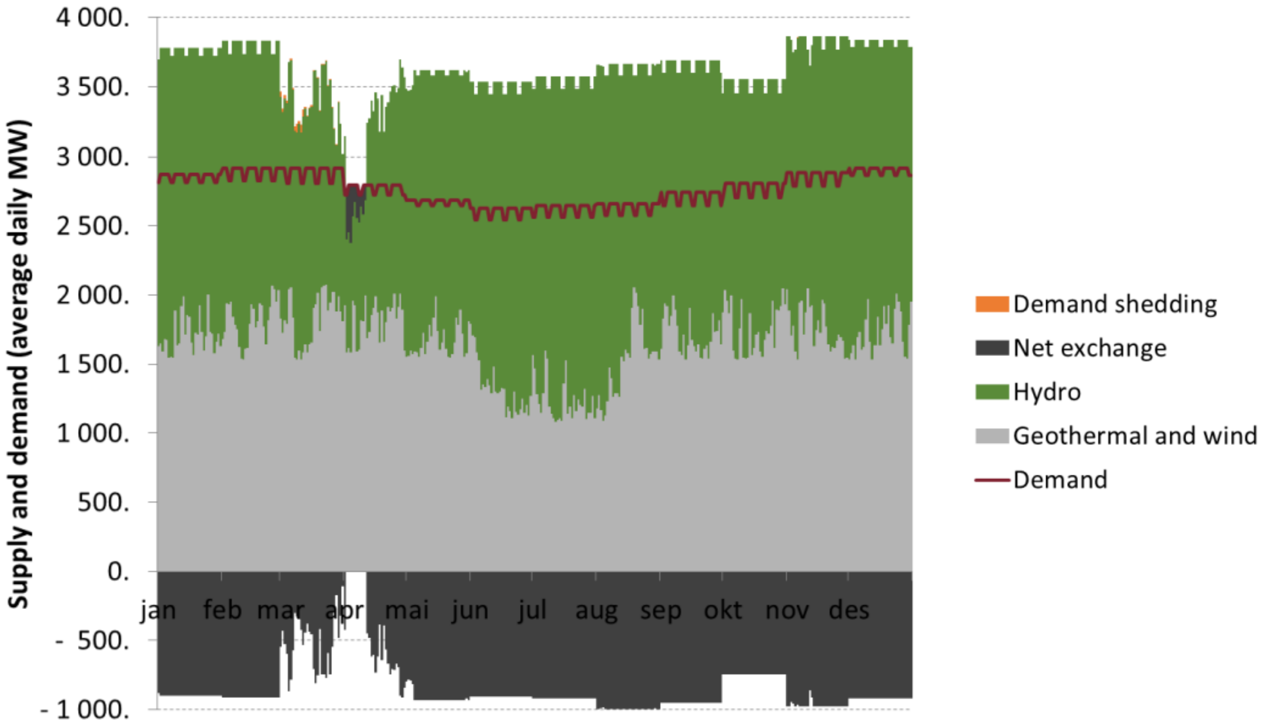
Icelink ensures ample supply is available, even with largest plant (Kárahnjúkar, 850MW) out for 6 weeks



SECURITY OF SUPPLY WITHOUT ICELINK

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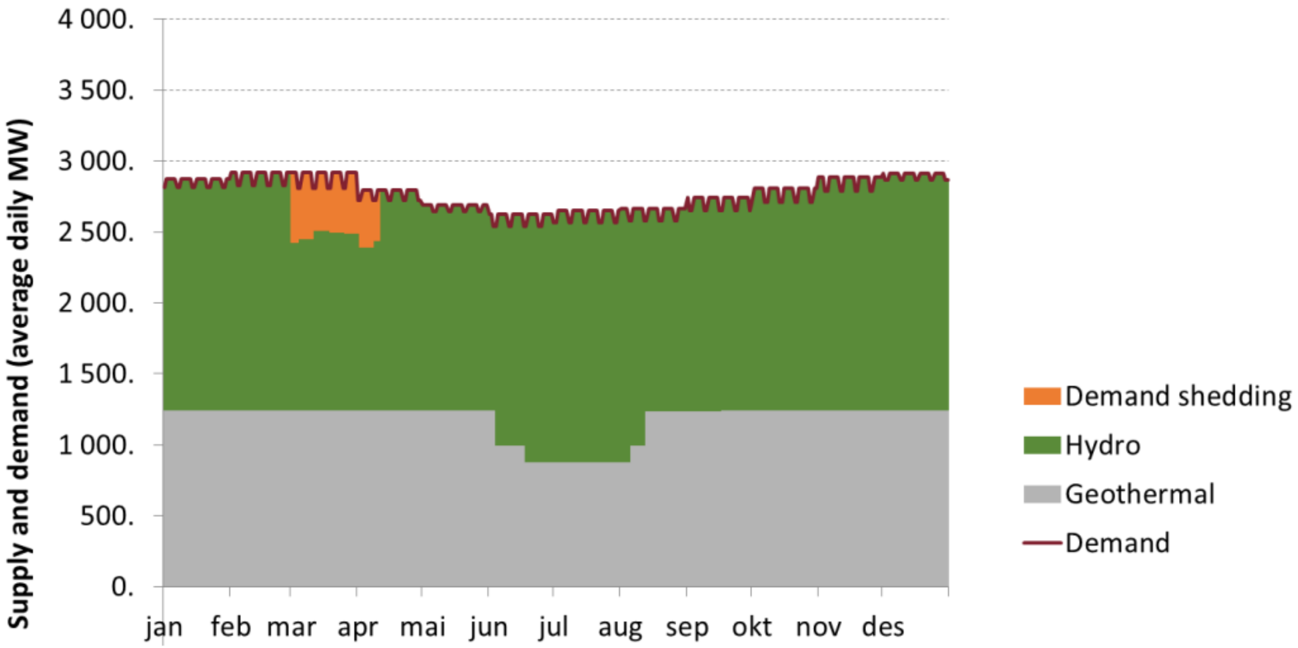
Without Icelink, a large outage leads to rationing



EFFECT OF THE WEATHER

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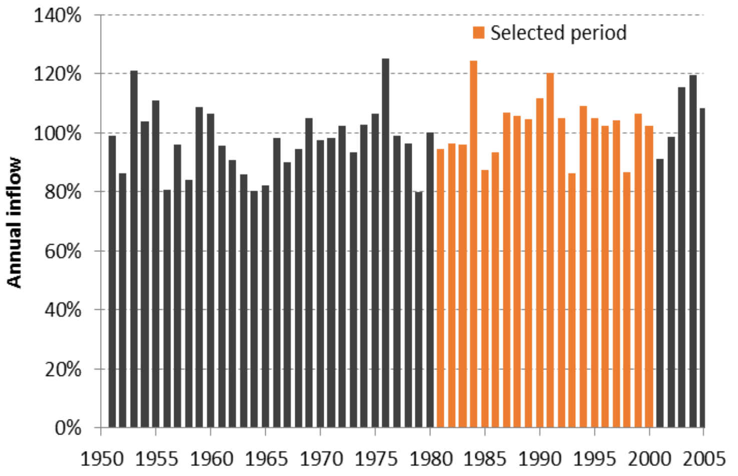
Hydrology is a critical driver of Icelink

- The weather is the main driver of variability in Iceland
- It leads to a 4TWh difference in annual inflow in Iceland, around 20% of annual demand
- Hydrology needs to be well represented in order to in order to capture the fundamentals of Icelink

Inflow patterns in Iceland



DURATION CURVE OF FLOWS THROUGH ICELINK

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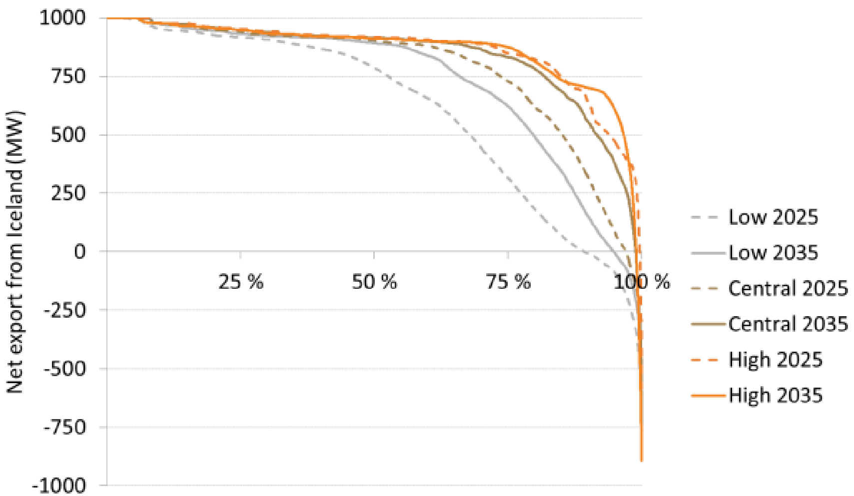
- Detailed market modelling suggests that ‘flexibility’ (i.e. less than full export) comes in the form of reduced flow from Iceland to GB
- Even in the Low, limited number of hours with full export from GB to Iceland

Duration curve of flows through Icelink



Source: Pöyry

GENERATION IN GB

- In the Central scenario, a moderate amount of new capacity is expected to enter the market in the medium-term.
  - CCGT, nuclear and renewables are the main new entrants in the long-term.
  - In the Central scenario, we assume the 2020 NREAP renewable target will be met in 2030.
- In the High scenario, relatively more new capacity is expected to enter the market to meet the increase in demand and to replace plants scheduled to close.
  - We assume the 2020 NREAP renewable target will be met in 2020.
- In the Low scenario a moderate amount of new thermal capacity, mainly CCGTs and OCGTs, is expected to enter the market in the short to medium-term.
  - We assume the 2020 NREAP renewable targets are never met in the timeframe to 2035.

Evolution of generation in GB (Central)