

# Climate Risk Macroeconomic Forecasting

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# Today's Speakers

Economics & Business Analytics



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# Economics & Business Analytics ESGC Initiatives



Climate Change  
Economic Scenarios

Economic Losses of  
Climate Events

Connecting Climate  
Change drivers to  
Retail Portfolios

ESG Score Predictor:  
Scoring Un-Rated  
Firms

# Agenda

1. Regulatory Environment
2. Modelling Framework: Physical & Transition Risk
3. UK & US Climate Change Scenarios

1

Regulatory Environment

# Regulatory Environment

- » Network for Greening the Financial System (NGFS) and Task Force on Climate-related Financial Disclosures (TCFD) are leading voices for a call to action in the financial system.
- **NGFS** is a group of over 35 central banks and regulatory agencies worldwide established at the Paris “One Planet Summit” in December 2017. Includes: BoE, ECB/EBA, Banque De France, The Peoples Bank of China, EIOPA
- **TCFD** is a taskforce set up by the Financial Stability Board, comprised of over 785 influential organizations from around the world.
- Scenario-based risk analysis is an integral part to both the NGFS and TCFD’s action plans.

## **UK- BoE/PRA**

- SS3/19: Enhancing banks’ and insurers’ approaches to managing the financial risks from climate change April 2019
- The 2021 biennial exploratory scenario (BES) on the financial risks from climate change, BoE Discussion Paper 2019.
- Three scenarios corresponding to NGFS scenarios.
- Climate Change Committee/Climate Change Act

## **US-FED**

- Fed Chair Powell & Vice Chair Quarles indicated that the FED wants to engage with NGFS
- Financial Stability Report, November 202
- Statement by Governor Lael Brainard
- September 2020 – an advisory panel to the Commodity Futures Trading Commission released a report ‘Managing Climate Risk in the U.S. Financial System.’

# Economic vs Climate Risk Scenarios

Differentiation between standard forecasts and climate risk scenarios

Economic Scenario	Climate Risk Scenario
<ul style="list-style-type: none"><li>• 5- to 30-yr forecast horizon</li><li>• Used to measure capital and assess risk</li><li>• Shock inputs are provided by Moody's Analytics, clients or regulators</li><li>• Stable economic relationships</li><li>• Shock inputs do not depend on carbon dioxide trajectory</li></ul>	<ul style="list-style-type: none"><li>• 30- to 80-yr forecast horizon</li><li>• Used to assess risk</li><li>• Impact channels must be translated into shock inputs</li><li>• Increased uncertainty over how impact channels translate into economic inputs</li><li>• Increased uncertainty over how the economy transitions from fossil fuels to renewables</li><li>• Shock inputs depend on carbon dioxide trajectory</li><li>• Requires new forecast variables and model equations</li></ul>

# Constructing Climate Risk Scenarios

## Climate Risk Variables

### Physical Variables

Global & regional temperature pathways  
Health & productivity effects  
Sea level rise  
Energy demand and tourism

### Transition Variables

Carbon price pathways  
Emissions pathways  
Commodity & energy prices; energy mix

## Macrofinancial Variables

### Macroeconomic Variables

GDP & unemployment  
Inflation & central bank rates  
Corporate profits & household income  
Residential & commercial property prices

### Financial Market Variables

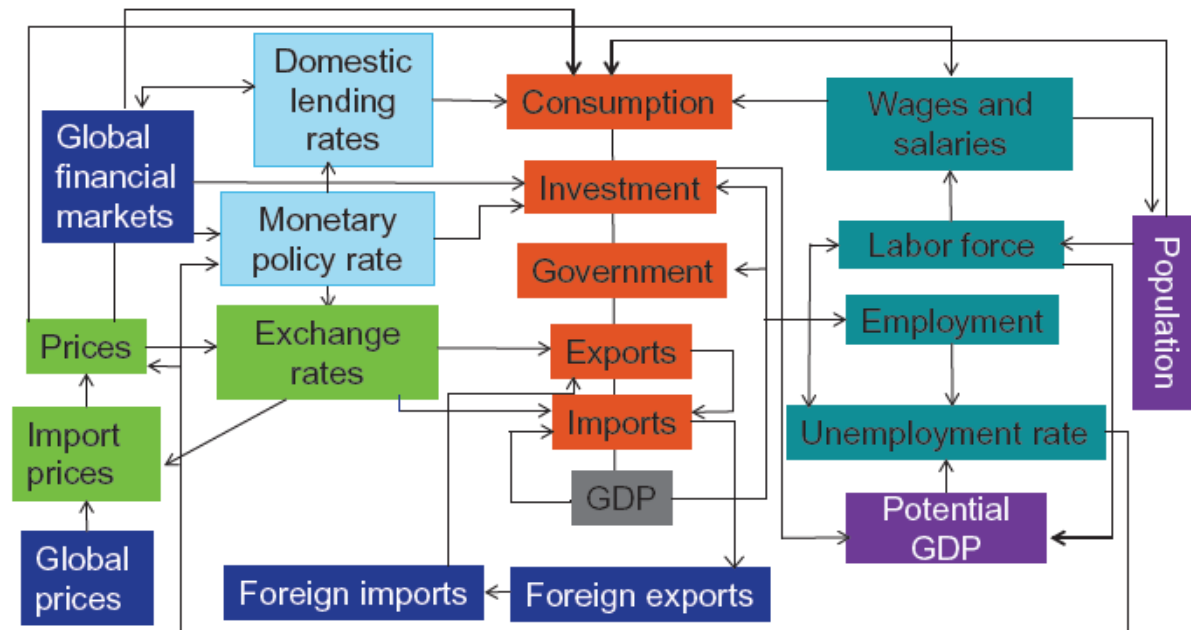
Government & corporate bond yields  
Equity indexes  
Exchange rates & bank rates

**Start with regulators' parameters**  
**Expand scenario to extrapolate additional variables**  
**Using global macro model with climate risk components**



# Moody's Analytics Global Macroeconomic Model

100+ Country Modules Linked via Trade and Finance



## Specification choice

- » Theoretical reasoning versus statistical properties

## In-sample equation fit

- » R-squared, RMSE, information criteria
- » Fitted values and residuals

## Forecasting performance

- » Back-testing: conditional and unconditional evaluation
- » Benchmarking during important past episodes

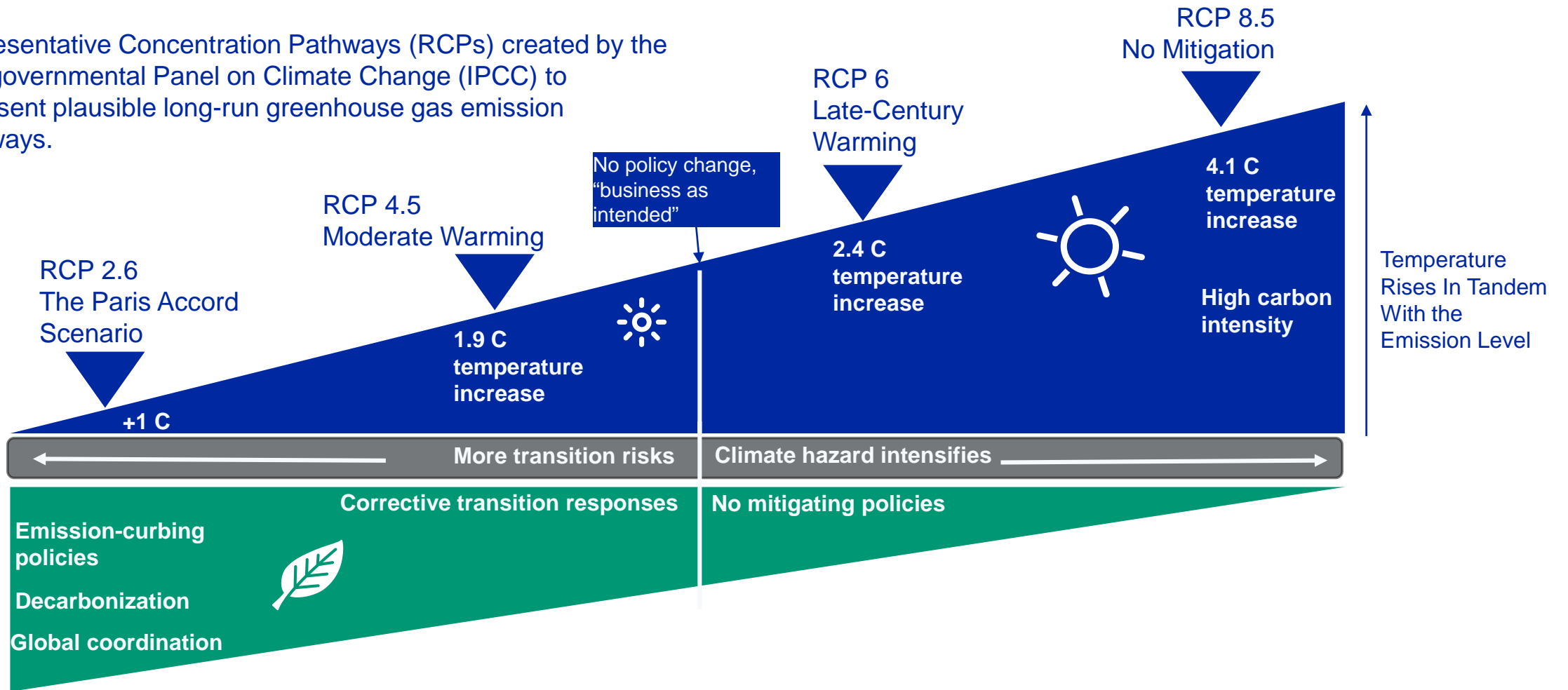
## Sensitivity to shocks

- » Forecasts across scenarios
- » Response to individual shocks

# IPCC Scenarios

Greenhouse gas concentration levels define four distinct scenarios

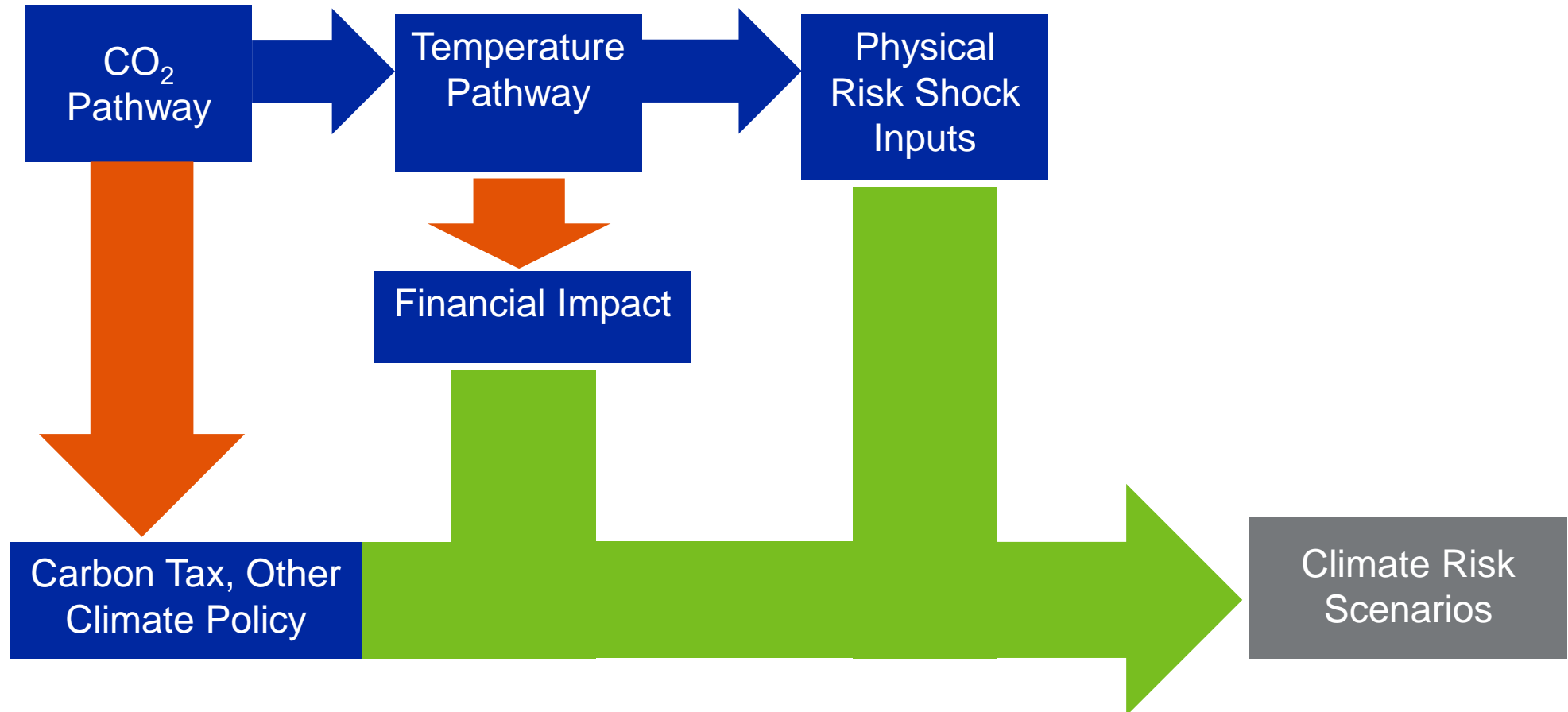
Representative Concentration Pathways (RCPs) created by the Intergovernmental Panel on Climate Change (IPCC) to represent plausible long-run greenhouse gas emission pathways.



# 2

## Modelling Framework: Physical & Transition Risk

# Incorporating Transition and Physical Risk



# Modelling Framework

## Impact Channel

1. Sea level rise
2. Agricultural productivity
3. Heat stress effect on labor productivity
4. Human health effects
5. Tourism
6. Energy demand

### Mnemonics

*FC\$\_GEO*  
*FPROD\$\_POT\_GEO*  
*FPROD\$\_POT\_GEO*  
*FPROD\$\_POT\_GEO*  
*FNETEX\$\_I\_GEO*  
*FCPIFICEBOIU\_US*

## CO2 Taxes

1. Dividend dummy
2. Carbon tax dummy
3. Carbon tax rate
4. Carbon tax revenue
  - 4-i. Carbon tax revenue: Coal
  - 4-i. Carbon tax revenue: Natural gas
  - 4-i. Carbon tax revenue: Petroleum

### Mnemonics

*DUM\_CARBONDIV\_IGEO*  
*DUM\_CARBONTAX\_IGEO*  
*FCARBONTAX\_IGEO*  
*FCARBONREV\_IGEO*  
*FCOALREV\_IGEO*  
*FNGASREV\_IGEO*  
*FPETREV\_IGEO*

## Energy Prices

1. Coal
2. Natural gas
3. Oil

### Mnemonics

*FPCCOALDOM\_IGEO*  
*FPCNGASDOM\_IGEO*  
*FPCOILDOM\_IGEO*

## Energy Consumption

1. Coal
2. Natural gas
3. Petroleum and othe liquid

### Mnemonics

*FCOALCONQ\_IGEO*  
*FNGASCONQ\_IGEO*  
*FPETCONQ\_IGEO*

## CO2 Emissions

1. Coal
2. Natural gas
3. Oil and petroleum products

### Mnemonics

*FCOALCO2EQ\_IGEO*  
*FNGASCO2EQ\_IGEO*  
*FPETCO2EQ\_IGEO*

## Government Finances

1. Total revenue
2. Total expense
3. Expenditure intermediate term
4. Expenditure residual

### Mnemonics

*FGGREV\_IGEO*  
*FGGEXP\_IGEO*  
*FGGEXP\_I\_IGEO*  
*FGGEXP\_RESID\_IGEO*

# Chronic Physical Risk



Energy Demand



Tourism



Sea Level Rise



Heat & labour  
Productivity



Human Health

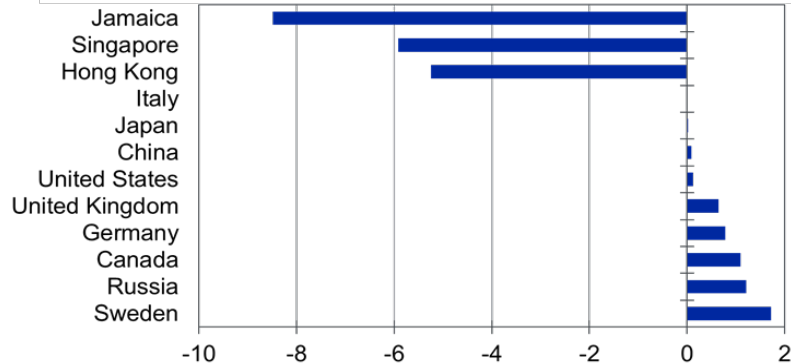


Agricultural  
Productivity

Moody's Analytics physical risk assessment is based on:

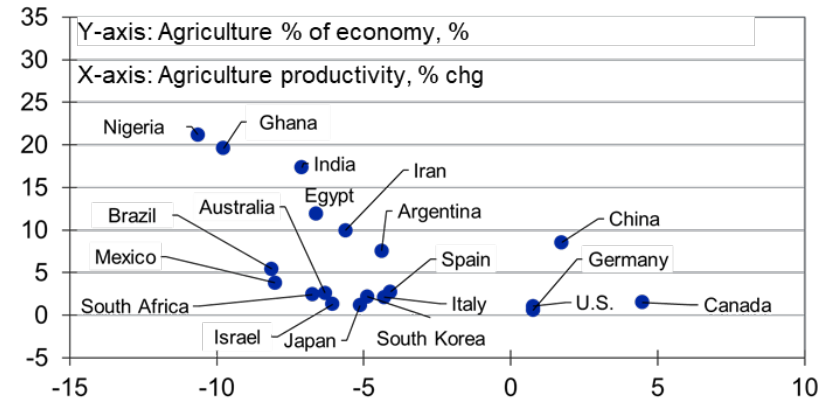
- » Combined output delta
- » Temperature pathways from NGFS Scenarios
- » Chronic physical risk (vs acute)
- » Forecasting horizon from 2050 to 2100
- » Transition risk added later
- » Moody's Global Macroeconomic Model.

**Colder Countries Benefit, 3°C increase on Tourism**



## Possible outcome

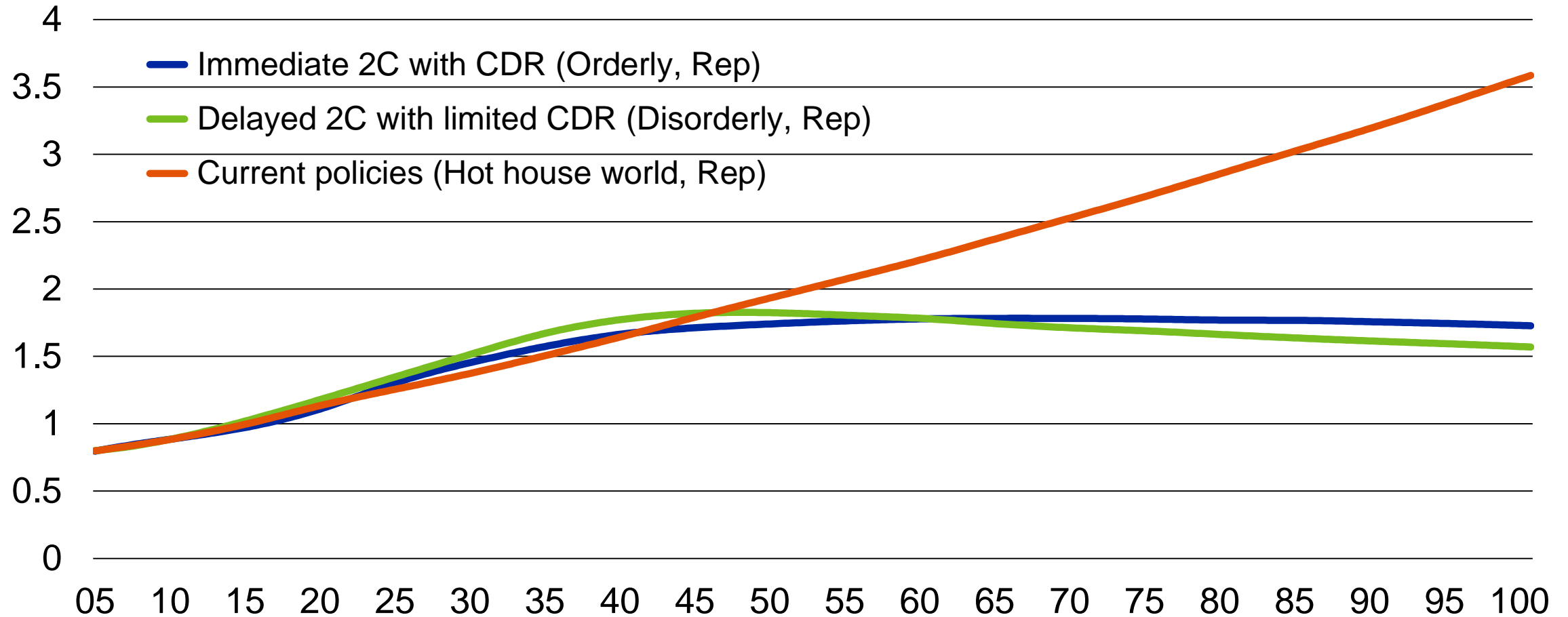
**Ag Hit to Hot, 3°C increase on Agriculture**



Example

# NGFS Scenarios

## World Temperature Pathway (°C rel. to 1850-1900)



Sources: Network for Greening the Financial System

# NGFS Consistent Scenarios

## Energy Consumption

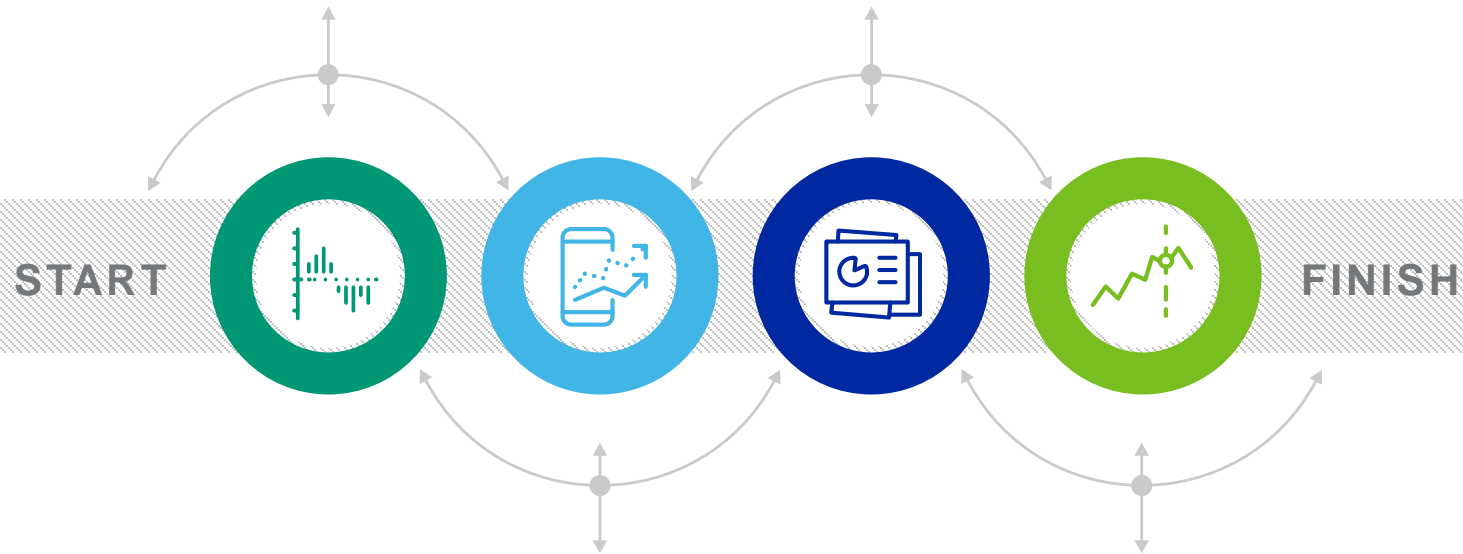
REMIND IAM

Translate into fuel emissions by source

## Energy Prices & Price Indices

CO2 tax set to match emissions

Prices reflect the taxes



## Physical Risk

MA Approach

MA population and GDP assumptions

## Output

GDP paths consistent with assumptions regarding physical and transition risk  
Industrial detail projections



# Industrial Coverage

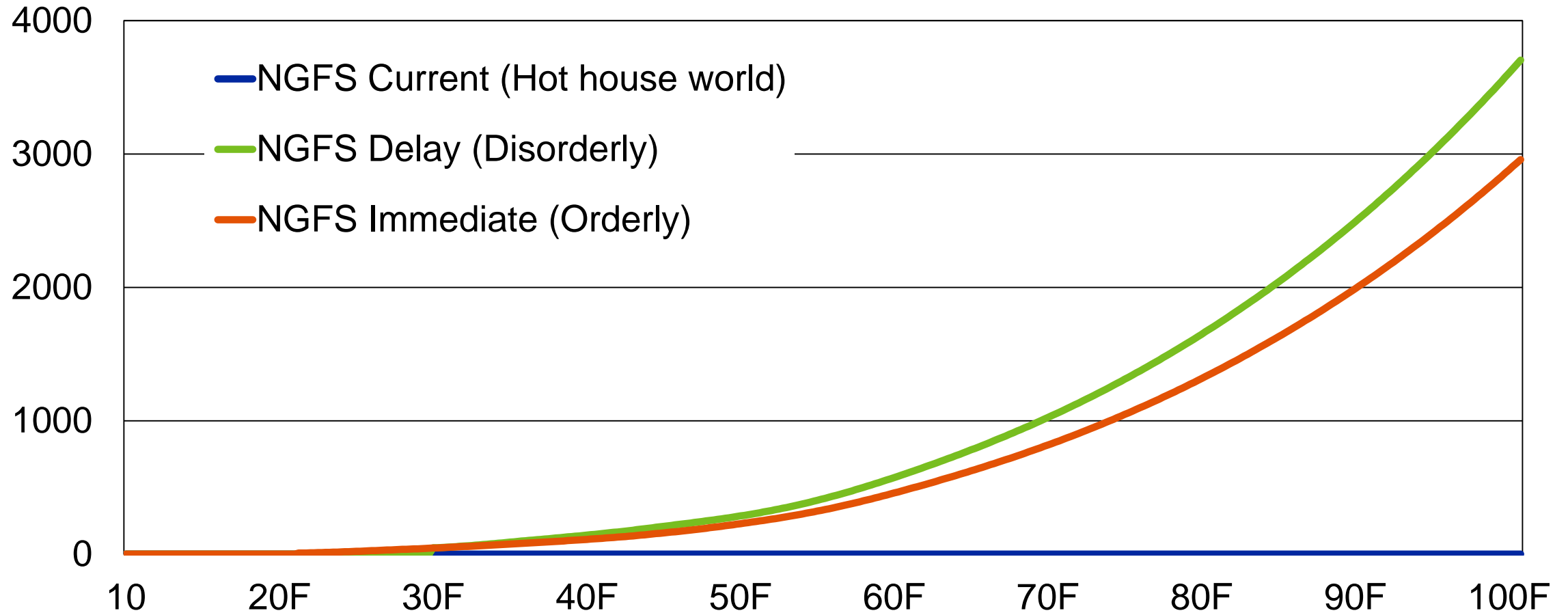
TCFD Recommendation	PRA General Insurance Stress Test 2019	Moody's Global Model Coverage: Europe & Asia Moody's Global Macro model currently forecasts:	
<p>Eight higher-risk sectors to have more detailed climate-related financial disclosures.</p>	<p>Nine sectors to provide factors to assess the potential impact on the market of investments from transition and physical risks in each of the climate scenarios</p>	<ul style="list-style-type: none"> <li>• Employment and Gross Value Added by industry for most European countries and some Asian countries</li> <li>• 20 industries according to NACE classification (seven in the goods-producing sector and 13 in the service-providing sector)</li> </ul>	
<p><b>TCFD Higher-Risk Industries</b></p> <ul style="list-style-type: none"> <li>» Energy</li> <li>» Transportation</li> <li>» Materials &amp; buildings</li> <li>» Agriculture, food &amp; forest products</li> <li>» Banks</li> <li>» Insurance companies</li> <li>» Asset owners</li> <li>» Asset managers</li> </ul>	<p><b>PRA Higher-Risk Industries</b></p> <ul style="list-style-type: none"> <li>» Fuel extraction</li> <li>» Power generation</li> <li>» Transport</li> <li>» Energy-intensive ind. (materials/metals)</li> <li>» Agriculture &amp; food security</li> <li>» Water utilities</li> <li>» Real estate assets (incl. CRE, rental &amp; leasing, construction, infrastructure)</li> <li>» Sovereign &amp; municipal bonds</li> <li>» Others</li> </ul>	<p><b>Moody's Higher-Risk Industries</b></p> <ul style="list-style-type: none"> <li>» Mining &amp; quarrying</li> <li>» Electricity: gas, steam &amp; air cond. supply</li> <li>» Transportation &amp; storage</li> <li>» Manufacturing</li> <li>» Agriculture, forestry &amp; fishing</li> <li>» Water supply; sewerage, waste management &amp; remediation</li> <li>» Construction</li> <li>» Real estate</li> <li>» Financial &amp; insurance</li> <li>» Public administration &amp; defense</li> </ul>	<p><b>Moody's Higher-Risk Industries</b></p> <ul style="list-style-type: none"> <li>» Wholesale &amp; retail trade</li> <li>» Accommodations &amp; food service</li> <li>» Information &amp; communication</li> <li>» Professional: scientific &amp; technical</li> <li>» Administrative &amp; support service</li> <li>» Education</li> <li>» Human health &amp; social work</li> <li>» Arts: entertainment &amp; recreation</li> <li>» Other services</li> <li>» Activities of household as employers</li> </ul>

# 3

## UK & US Climate Change Scenarios

# U.K. Carbon Dioxide Tax Rate

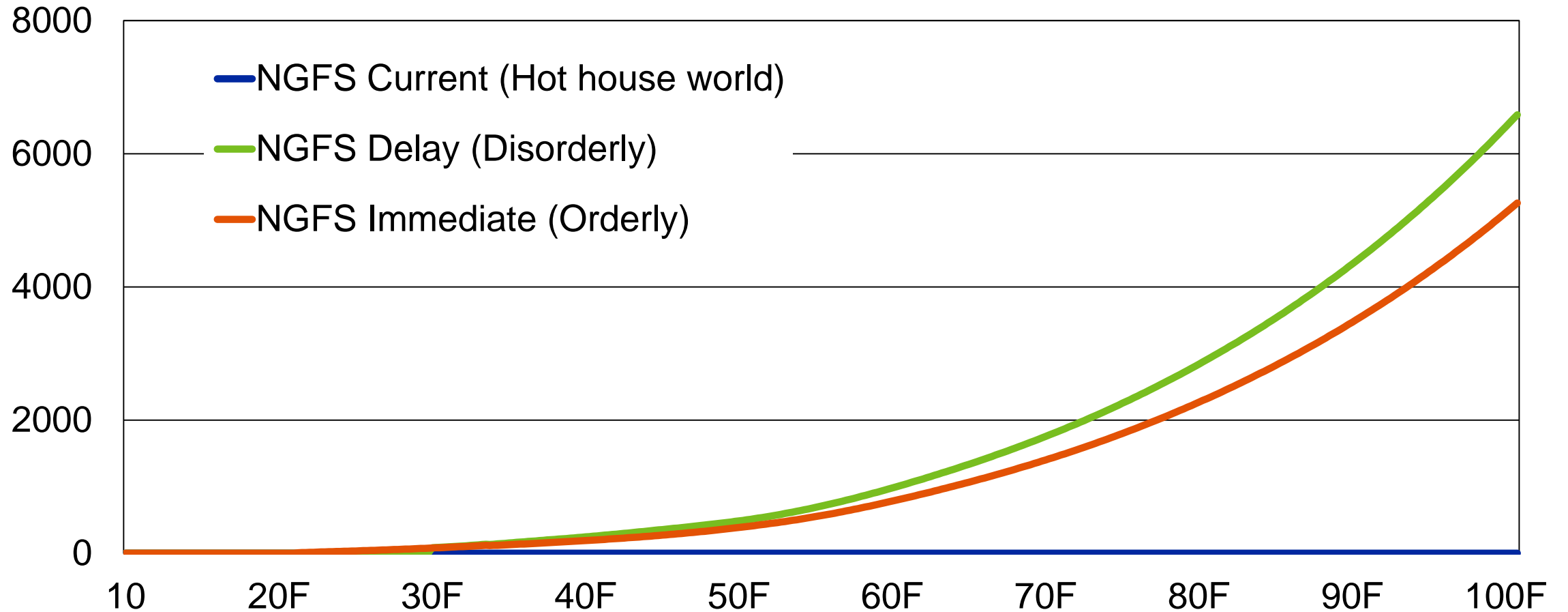
GBP per metric ton, NSA



Sources: Network for Greening the Financial System; Moody's Analytics

# U.S. Carbon Dioxide Tax Rate

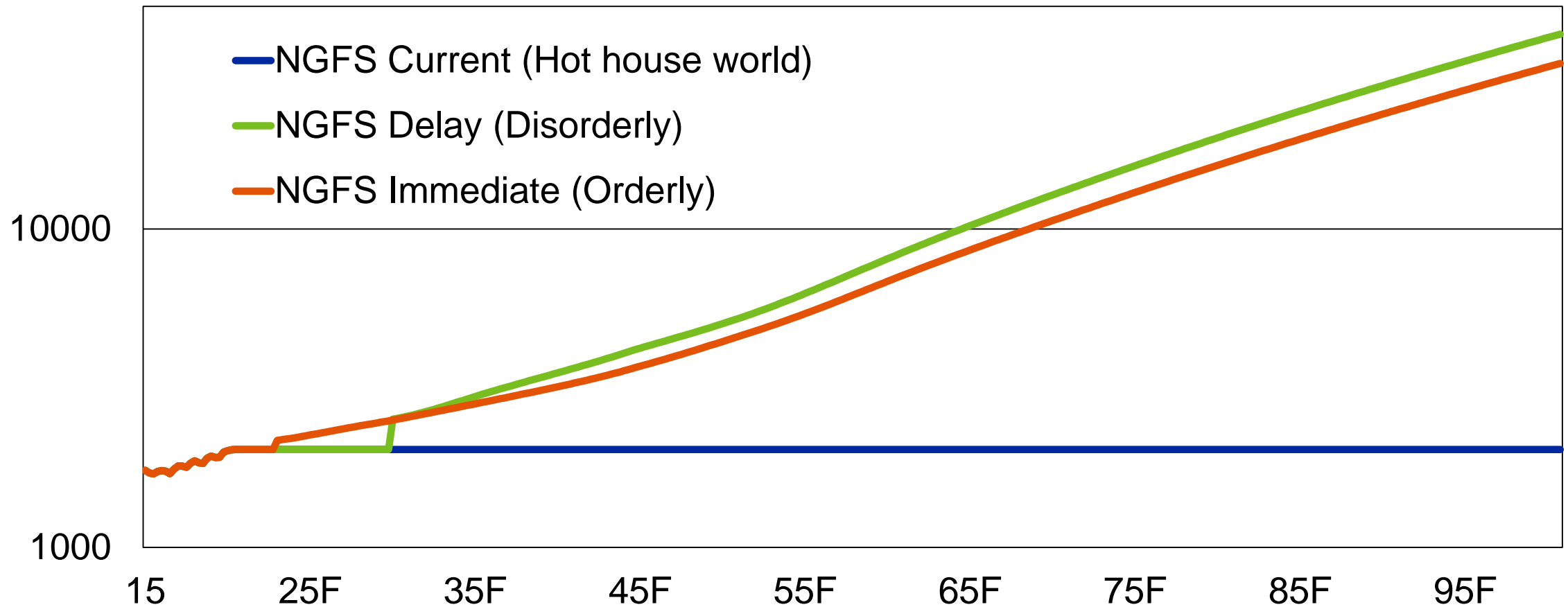
USD per metric ton, NSA



Sources: Network for Greening the Financial System; Moody's Analytics

# U.K. Effective Domestic Price: Coal

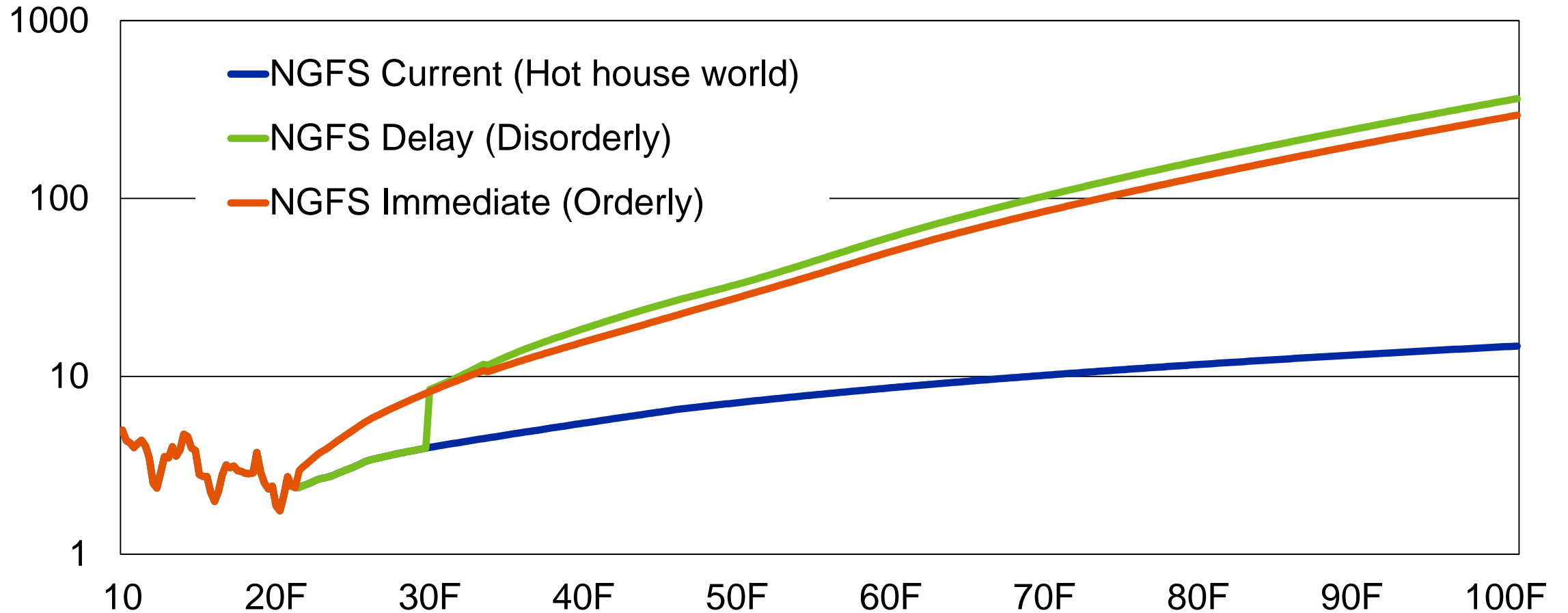
1/100 GBP per #, NSA (Log scale)



Sources: U.K. Department for Business, Energy & Industrial Strategy; Moody's Analytics

# U.S. Effective Domestic Price: Natural Gas

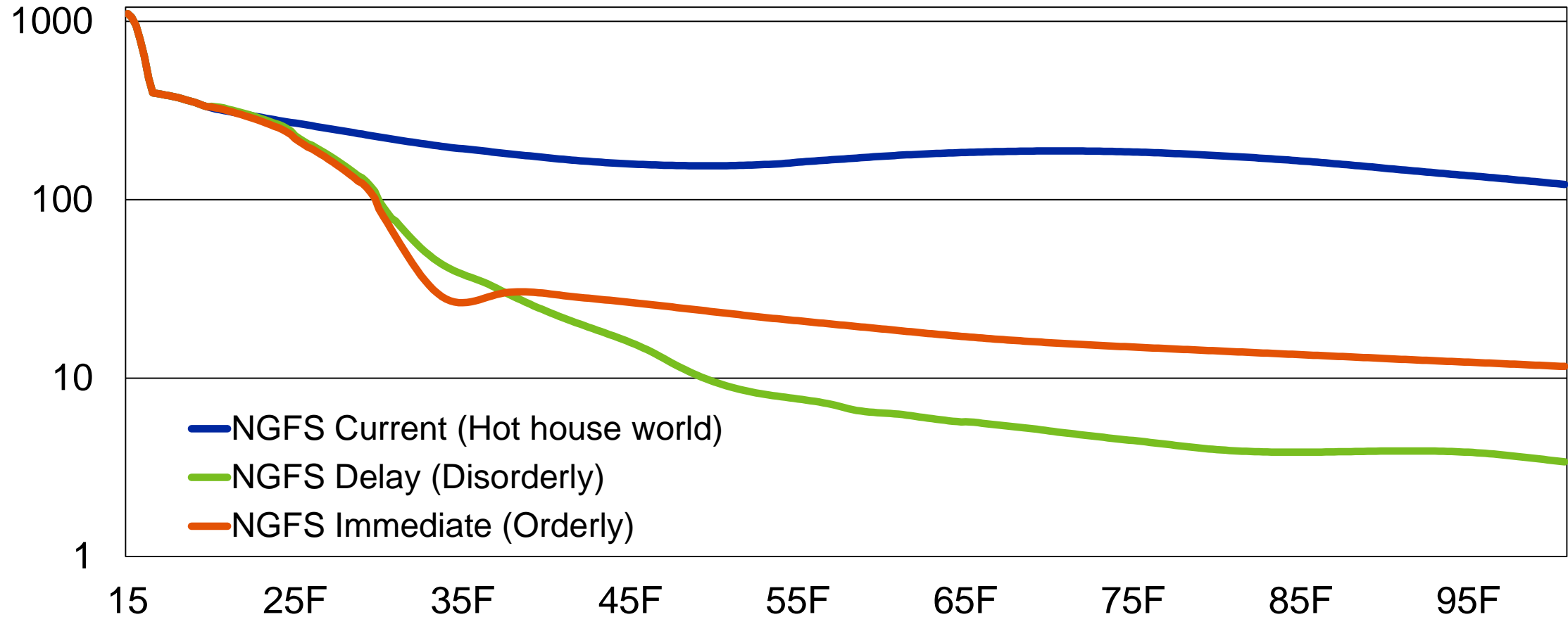
USD per MMBtu, SA (LOG scale)



Sources: Network for Greening the Financial System; Moody's Analytics

# U.K. Energy Consumption: Coal

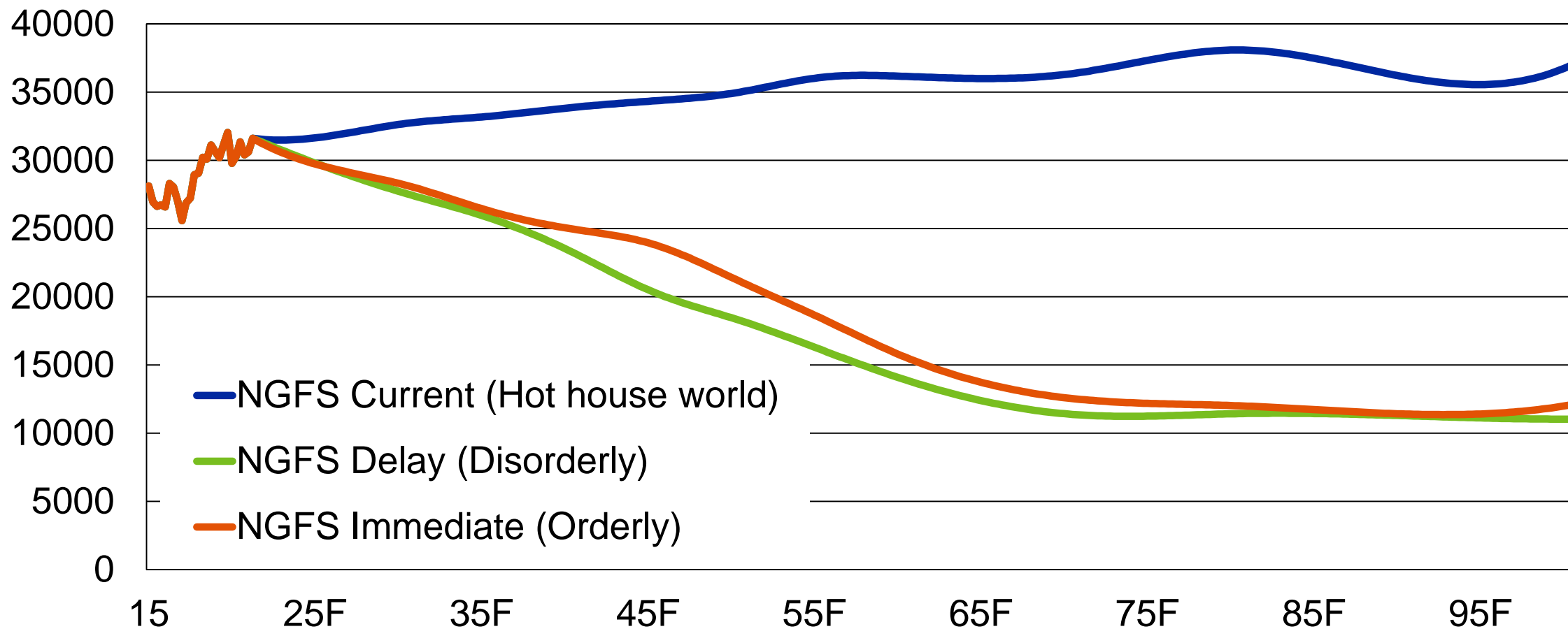
Tril. BTU, SAAR (Log scale)



Sources: U.S. Energy Information Administration; Moody's Analytics

# U.S. Energy Consumption: Natural Gas

Ths. Short Tons, SAAR

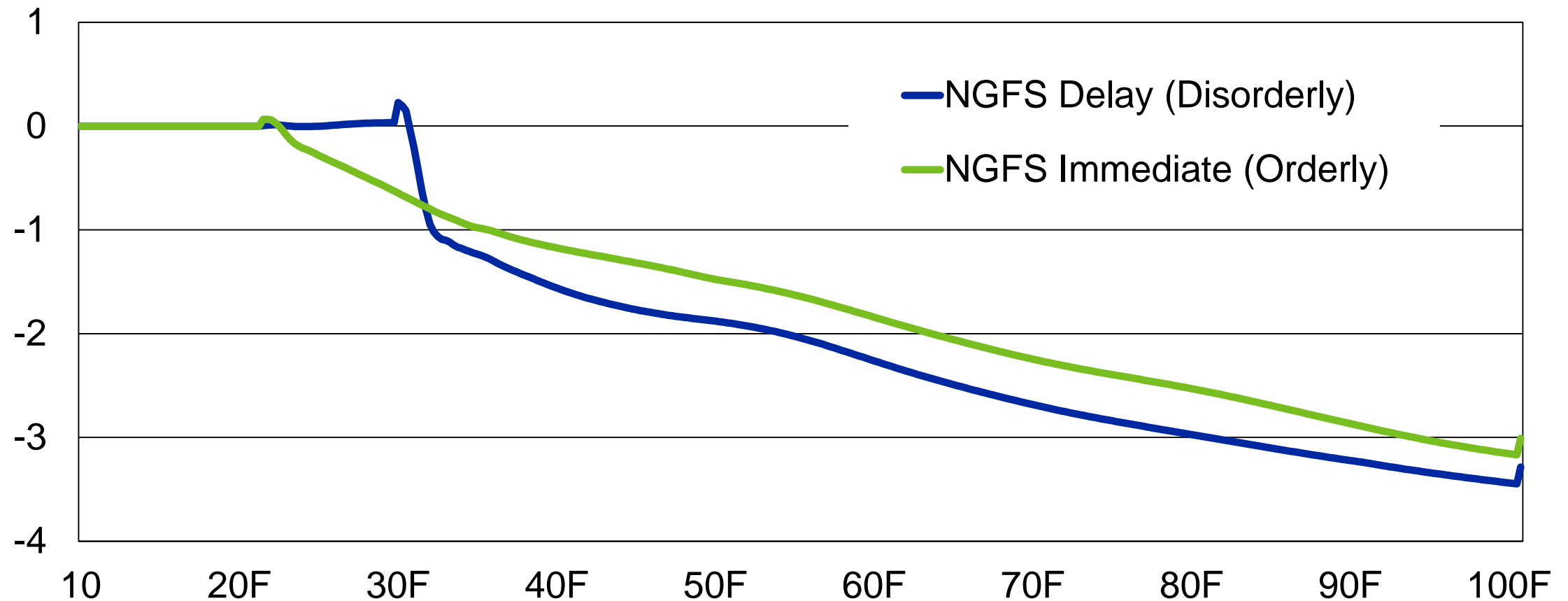


Sources: Network for Greening the Financial System; Moody's Analytics



# U.K.: Real GDP Scenario Comparison

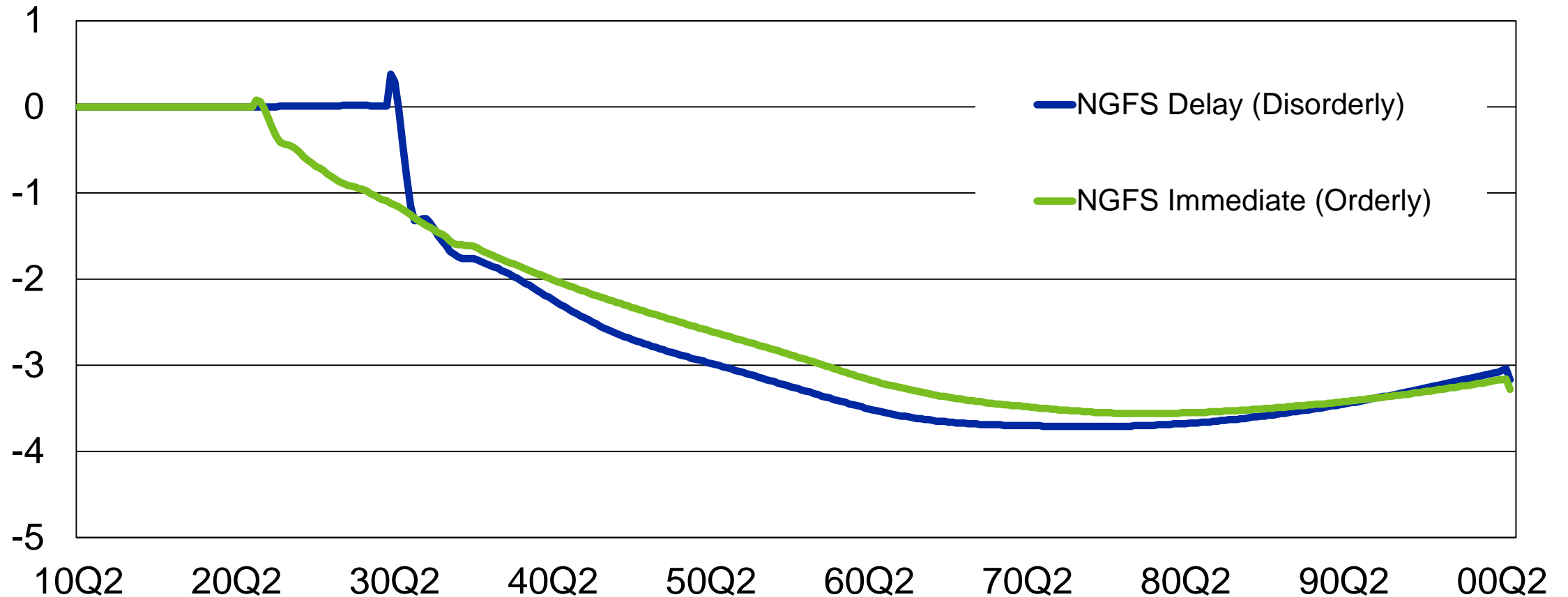
% deviation from NGFS Current



Sources: Network for Greening the Financial System; Moody's Analytics

# U.S. Real GDP Scenario Comparison

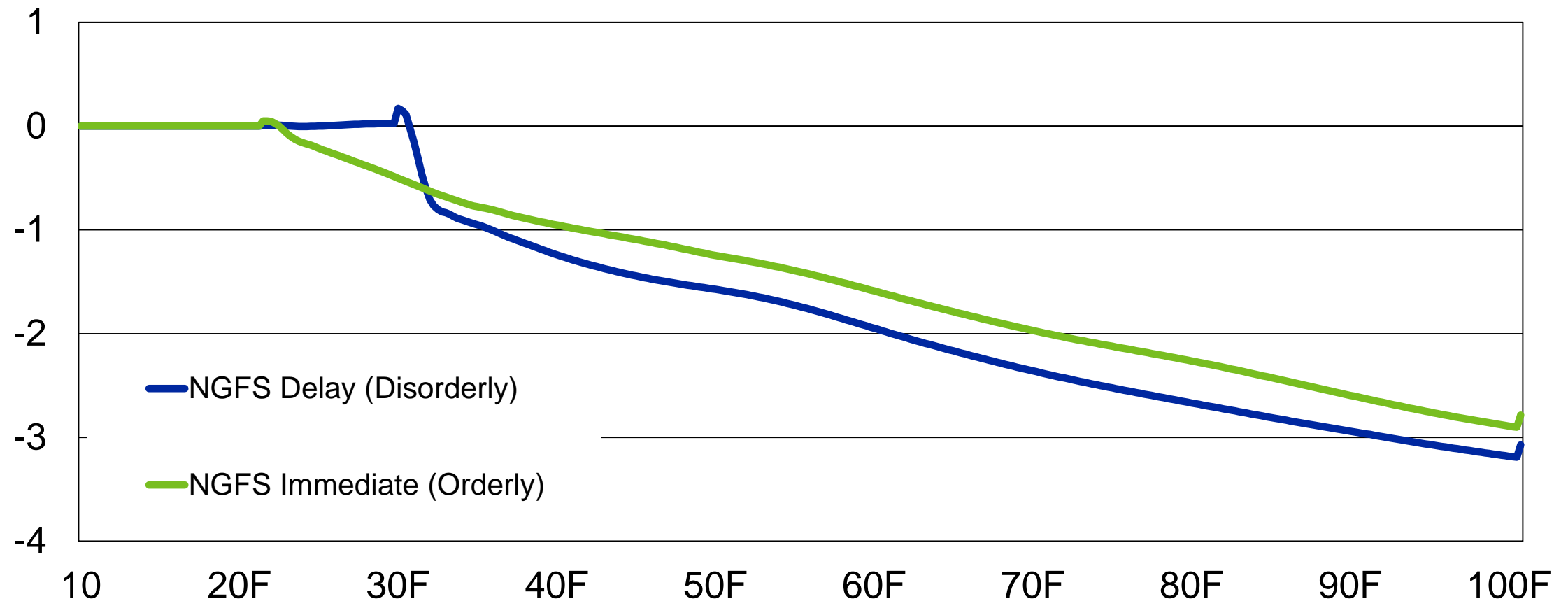
% deviation from NGFS Current



Sources: Network for Greening the Financial System; Moody's Analytics

# U.K. GVA-Services Prod. Industry Scenario Comparison

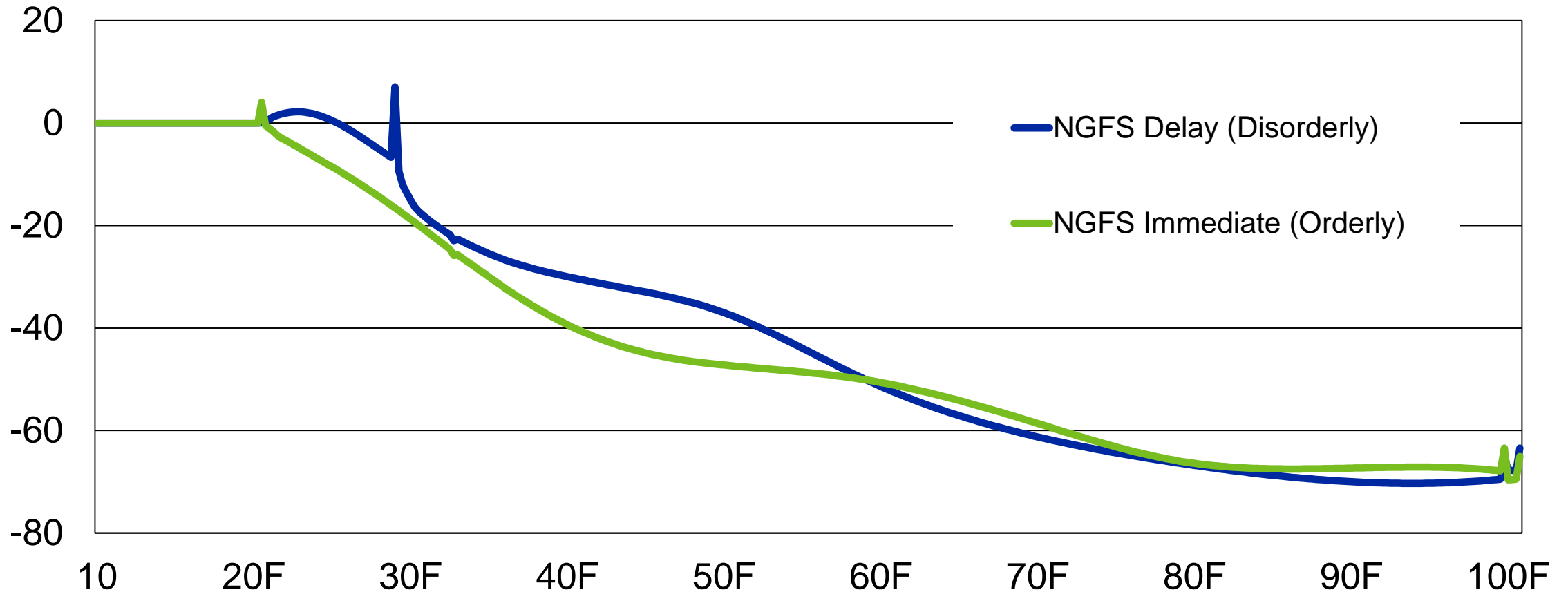
% deviation from NGFS Current



Sources: Network for Greening the Financial System; Moody's Analytics

# U.S. GPO-Mining Industry Scenario Comparison

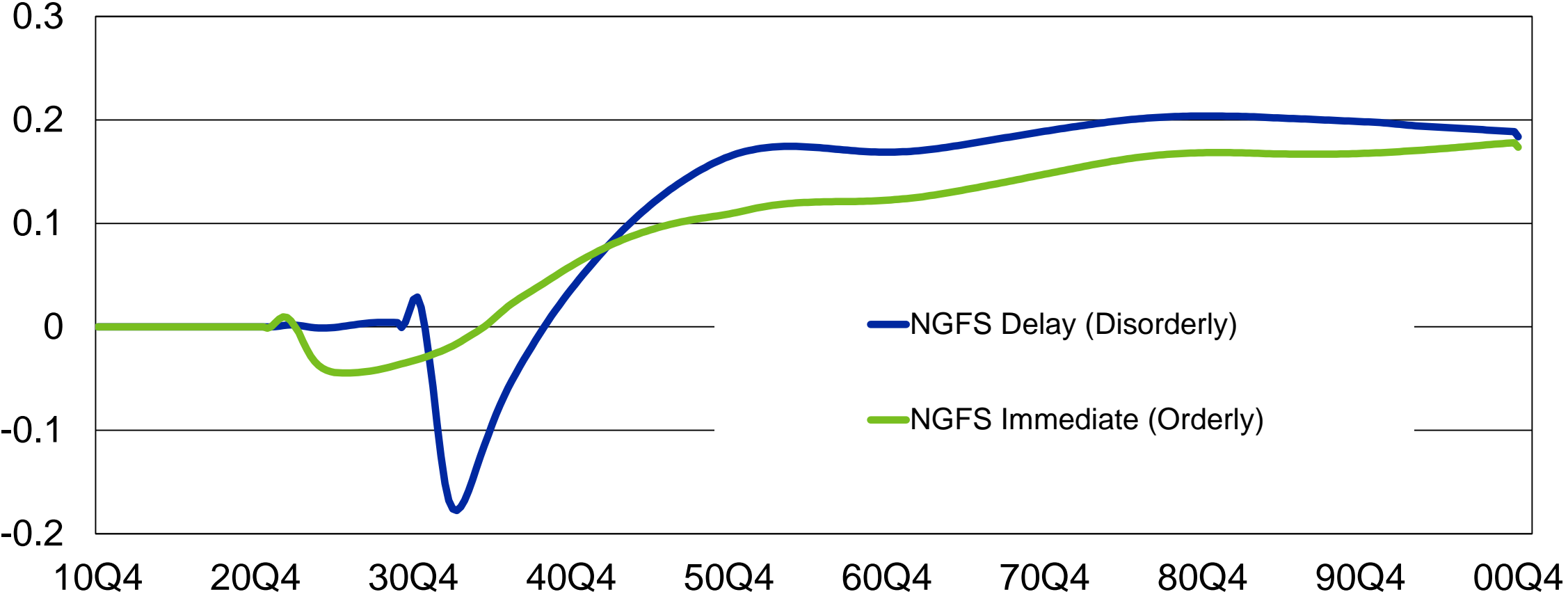
% deviation from NGFS Current



Sources: Network for Greening the Financial System; Moody's Analytics

# U.K. Employment-Services Prod. Industry Scenario Comparison

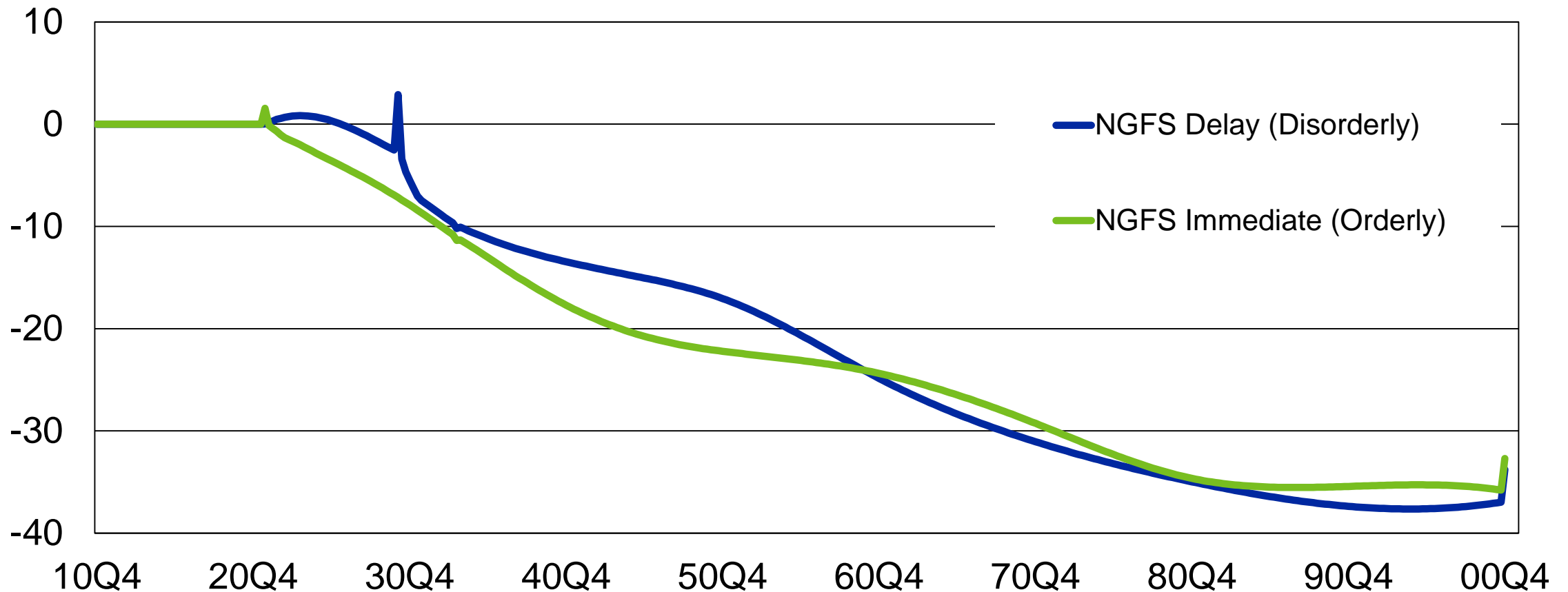
% deviation from NGFS Current



Sources: Network for Greening the Financial System; Moody's Analytics

# U.S. Employment-Mining Industry Scenario Comparison

% deviation from NGFS Current



Sources: Network for Greening the Financial System; Moody's Analytics

# Key Takeaways

1. Regulatory pressure to quantify climate risk has increased.
2. Generating NGFS consistent scenarios will require target prioritization.
3. Transition risk will be critical for countries such as the U.K. and the U.S, and its impacts will vary substantially across industries.

## Q&A

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