# Overview: steps in analysing transition risks for credit institutions

## Step 1: Scenario narrative
- **Climate scenarios** (temperature, CO2 emissions)
- **Pathway assumptions**: LCoE, energy mix composition, etc.

## Step 2: Scenario implications
- **Policy Impact**: CO2 price, ban on energy sources, etc.

## Step 3: Key step: Real-economy impact
- **Direct**: on businesses profitability/household finances
- **Indirect**: Macroeconomic

## Step 4: Impact on risk variables
- Probability of default
- LGD
- Risk weights
- Credit spreads
- Equity/bond prices
- Expected loss
- Capital requirements
- Solvency ratio
- CET1 impact

## Step 5: Output variables
- Primarily public sources
- Compliance: Directly from regulators, e.g., ECB
- Strategic, what-if scenarios: Global climate model
- Direct: partial sector microeconomic model or CGE
- Indirect: Standard macroeconomic model
- Mostly standard corporate finance
- Existing stress test framework

### Tools/methods
- Primarily public sources
- Compliance: Directly from regulators, e.g., ECB
- Strategic, what-if scenarios: Global climate model
- Direct: partial sector microeconomic model or CGE
- Indirect: Standard macroeconomic model
- Mostly standard corporate finance
- Existing stress test framework
A five step approach for mortgages

1. Scenario
2. Energy price
3. Collateral value
4. Risk weight
5. Results
Our case: average eu mortgage portfolio

- Initial housing value is EUR 200k with an LTV of 70%
- LTV is around 200%
- Average PD and LGD in Europe (based on paper by ECB)
- Energy mix of heating: average in EU
STEP 1
SCENARIO SELECTION
Estimating transition risks: carbon price as a tool

A carbon price scenario encapsulates many climate related risks

- Actual taxes on carbon emission.
- Indirect costs of carbon emissions, e.g. carbon credits, ban of certain energy types.
- Subsidies to low-emission technologies increasing the opportunity costs of emissions.
- Changing consumer behaviour.

We take starting point in a fixed USD shock in carbon price as in the recently announced ECB climate stress test.

Source: https://carbonpricingdashboard.worldbank.org/map_data
STEP 2
IMPACT ON ENERGY COSTS
Estimate impact on energy prices

For mortgages, the relevant credit risk driver under the climate transition is energy costs.

- This can be done at different levels of sophistication.
- No demand and general equilibrium effects in our example.

### Carbon intensity

<table>
<thead>
<tr>
<th>Source</th>
<th>g CO2e / kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal boiler</td>
<td>630</td>
</tr>
<tr>
<td>Oil boiler</td>
<td>320</td>
</tr>
<tr>
<td>Gas boiler</td>
<td>215</td>
</tr>
<tr>
<td>Electricity</td>
<td>234</td>
</tr>
<tr>
<td>Derived heat</td>
<td>249</td>
</tr>
<tr>
<td>Biofuels</td>
<td>0</td>
</tr>
</tbody>
</table>

### Energy mix

<table>
<thead>
<tr>
<th>Source</th>
<th>EU average %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>4%</td>
</tr>
<tr>
<td>Oil</td>
<td>14%</td>
</tr>
<tr>
<td>Gas</td>
<td>9%</td>
</tr>
<tr>
<td>Derived</td>
<td>11%</td>
</tr>
<tr>
<td>Biofuels</td>
<td>24%</td>
</tr>
<tr>
<td>EU average</td>
<td>38%</td>
</tr>
</tbody>
</table>

### Scenario impact: Average energy price increase

<table>
<thead>
<tr>
<th>Year</th>
<th>EUR cent / kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>2021</td>
<td>0</td>
</tr>
<tr>
<td>2050</td>
<td>5</td>
</tr>
</tbody>
</table>
STEP 3
ECONOMICS IMPACT: COLLATERAL VALUES
Estimate energy costs for individual buildings

Forecast increase in energy costs for property owners and discount to present value

Average household energy bill increase
EUR, nominal and discounted to 2021-level

EUR 6,600
Energy price increase over thirty-year horizon from today's perspective for a representative European household
Evidence: there is a clear correlation between energy costs and collateral value

Decrease in energy expenses by reaching the next better energy label

Relative to label G average pre-renovation energy expense, percent, percentage points

<table>
<thead>
<tr>
<th></th>
<th>Relative to label G average pre-renovation energy expense, percent, percentage points</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>10%</td>
</tr>
<tr>
<td>E</td>
<td>19%</td>
</tr>
<tr>
<td>D</td>
<td>16%</td>
</tr>
<tr>
<td>C</td>
<td>16%</td>
</tr>
<tr>
<td>B</td>
<td>12%</td>
</tr>
<tr>
<td>A</td>
<td>13%</td>
</tr>
<tr>
<td>Total</td>
<td>87%</td>
</tr>
</tbody>
</table>

Increase in property price by reaching the next better energy label

Relative to label G average pre-renovation house price, EUR

<table>
<thead>
<tr>
<th></th>
<th>Relative to label G average pre-renovation house price, EUR</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>9,400</td>
</tr>
<tr>
<td>E</td>
<td>8,900</td>
</tr>
<tr>
<td>D</td>
<td>5,000</td>
</tr>
<tr>
<td>C</td>
<td>6,000</td>
</tr>
<tr>
<td>B</td>
<td>4,400</td>
</tr>
<tr>
<td>A</td>
<td>3,700</td>
</tr>
<tr>
<td>Total</td>
<td>37,400</td>
</tr>
</tbody>
</table>

**EUR 6,600**
Average theoretical price impact

**58%**
Empirical adjustment

**EUR 3,900**
Average actual price impact
STEP 4
IMPACT ON RISK WEIGHTS
4. Update LTV

Impact on risk weights for IRB banks
% of REA

- Initial risk weight: 17.3%
- Higher LGD: 70 bp.
- Higher PD: 60 bp.
- New risk weight: 18.6%

Higher LTV-ratio implies a higher LGD by definition.
Higher LTV-ratio implies a higher PD through incentives.

1.3pp
STEP 5
RESULTS
Importance of energy efficiency: impact on capital ratio

Impact on CET1 depends on energy efficiency of the buildings

Decline in CET1 buffer for a generic mortgage institute in transition risk stress

Risk-based approach for regulation?

- Label D: 0.9
- Label B: 0.4
- Label G: 2.0
- Label G + oil boiler: 3.1

Copenhagen Economics
A risk-based approach to integrate climate considerations in prudential regulation?

Current perspective:
One-sided – Higher energy efficiency leads to higher collateral

Forward looking perspective:
Two-sided – higher risks for inefficient mortgages – lower for efficient mortgages.
Be cautious with the one carbon price impact approach

**Implicit carbon tax on energy across EU (selected countries)**

<table>
<thead>
<tr>
<th>Country</th>
<th>EUR per ton CO2</th>
</tr>
</thead>
<tbody>
<tr>
<td>NL</td>
<td>209</td>
</tr>
<tr>
<td>DK</td>
<td>156</td>
</tr>
<tr>
<td>SE</td>
<td>150</td>
</tr>
<tr>
<td>FI</td>
<td>101</td>
</tr>
<tr>
<td>IT</td>
<td>91</td>
</tr>
<tr>
<td>FR</td>
<td>43</td>
</tr>
<tr>
<td>HR</td>
<td>38</td>
</tr>
<tr>
<td>PT</td>
<td>38</td>
</tr>
<tr>
<td>DE</td>
<td>27</td>
</tr>
<tr>
<td>IE</td>
<td>25</td>
</tr>
<tr>
<td>PL</td>
<td>22</td>
</tr>
<tr>
<td>SK</td>
<td>17</td>
</tr>
<tr>
<td>RO</td>
<td>15</td>
</tr>
<tr>
<td>HU</td>
<td>10</td>
</tr>
<tr>
<td>LV</td>
<td>9</td>
</tr>
<tr>
<td>BG</td>
<td>9</td>
</tr>
<tr>
<td>CZ</td>
<td>6</td>
</tr>
<tr>
<td>LT</td>
<td>6</td>
</tr>
</tbody>
</table>

Copenhagen Economics
Data: Energy mix and energy efficiency are key inputs

Share of energy efficient buildings (label A or B)

Note: Data was only available for a subset of European countries. Data for Germany are from 2014.

Source: BPIE (2020); DENA (2016)
Also worth considering: Macroeconomic transmission channel

**A typical macroeconomic stress test**

Market participants will also be affected indirectly: higher carbon prices can lead to a macroeconomic shock, which in turn impact financial risk factors.

**This is basically a typical stagflation shock:**

Can be estimated in a simple macro-economic model or based on parameters from existing papers

### Simplified illustration of a macroeconomic Co2 price shock

<table>
<thead>
<tr>
<th>Higher Co2 prices</th>
<th>Macroeconomic price shock = inflation</th>
<th>To curb inflationary pressure, central banks raise interest rates.</th>
<th>GDP decline</th>
<th>Impact financial markets</th>
</tr>
</thead>
</table>

- **GDP decline**
- **Impact financial markets**

![Graph showing the impact of Co2 price shock on inflation and GDP](image)

- **Inflation**
- **Supply**
- **Aggregate demand**
- **GDP**
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