Motivations and aims

- Equity and Sustainability

Our socio-economic system will experience deep changes that have to be investigated in their systemic interactions (co-evolution of environmental, social and economic factors).

Twofold purpose:

- To propose a model able to evaluate the impact of energy transition policies and initiatives (e.g. SEN, 2017) on macroeconomic and social indicators and vice versa.
- To investigate whether policies that tend to increase equity can be complementary to the achievement of environmental and energy targets.

RQ: how does the implementation of low-carbon policies impact current trends toward industrial automation and technological unemployment?
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- **Growth and inequality increases** may contribute to the failure to meet EU emissions target.

- The introduction of policies directly aimed at **improving equity and sustaining employment** can instead help to meet EU targets.

- **No win-to-win strategy** $\implies$ there are still several *tradeoffs* between economic, social and environmental indicators.
Ecological Macroeconomics

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Keynesian approach $\implies$ Demand driven model.
Theoretical starting point

Focus on issues still relatively unexplored in this literature:
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Ecological macroeconomic modelling to better address these issues and the challenges they represent. This means to include a multiplicity of feedbacks and interactions. System dynamics $\Rightarrow$ complexity. This approach has been developed since the seminal work by Meadows et al. (1972), *The Limits to Growth*. 
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A macro view of the model
Analytical Framework

Distribution and aggregate demand

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- Distributed profits allow for an investigation of the functional distribution and its influence on aggregate demand:
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Capital Accumulation

4 sectors: standard goods ($s$), social and local goods ($s$), thermoelectric energy ($th$) and renewable energy ($ren$).
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Potential sectorial output \((z = c, s, th)\):

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y_{fc,z} = \epsilon_z k_z. \tag{1}
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and

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Labour productivity and energy efficiency

- Labour productivity ($\lambda$) depends on: physical capital growth rate (+), public and private investment in automation (+), wage (+) (efficiency wage), working time (−), and an exogenous positive rate (in the standard goods sector about 0.2% per year).

- Energy efficiency depends on: public and private specific investments (+), rate of growth of physical capital (+), and relatively price of energy (+).

- Improvements in energy efficiency become always more difficult = more expensive (decreasing marginal productivity).
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- Labour productivity ($\lambda$) depends on: physical capital growth rate (+), public and private investment in automation (+), wage (+) (efficiency wage), working time (−), and an exogenous positive rate (in the standard goods sector about 0.2% per year).

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Feedback loops

An example
Data and calibration

The model is applied to Italy. Data sources:

Macroeconomic variables (labour and pension income, unemployment benefits, consumption, investment, employment): ISTAT, Conti Nazionali
Population and demographic variables: ISTAT, variabili demografiche
Energy and energy efficiency: Energy Balance Eurostat – EUCO/PRIMES
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Initial year 2010, scenarios 2010-2050
Scenarios

- **Business as usual - BAU**
  Our reference scenario based on current policies on energy, labour market and other socio-economic aspects. For energy and decarbonization it partially replicates PRIMES scenarios, e.g. **EURO30**, while there are differences on GDP estimates.
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▶ **DeGrowth - DG**
This scenario keeps the energy policies defined in **GG** – slightly reducing the resources mobilised – and it includes significant changes on fiscal and social policies (coherent with national and international degrowth movement).
Features of the Scenarios

- 12 policy changes between GG and BAU (on the path of exogenous variables).
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Degrowth Policies

Policies in DG include:

- working time reduction, about 30% less in 2050 (i.e. annual average reduction by about 1%);
- decreasing labour market flexibility;
- changes in the composition of the demand by households and government in favor of social and local economy;
- increasing average taxation on distributed profits from 42% to 52% in 15 years;
- slightly increase in the government expenditure to GDP ratio, from 21% to 24% (in 2050);
- decline in the public incentives to automation.
- lower decline in the wage to pension ratio from about 70% to 62% vs 53,2% in BAU and GG.
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$CO_2$ Emissions (2010=90)

![Graph showing $CO_2$ emissions over time with lines for Business as Usual, Green Growth, and Degrowth scenarios.](image)
REN share on gross final consumption of energy (%)

Business as Usual
Green Growth
Degrowth

Quota FER su consumi finali di energia (%)
90
71.25
52.5
33.75
15
2010 2016 2022 2028 2034 2040 2046

Time (Year)
Per-capita GDP (2010=100)
Wage differential (standard/local, 2010=100)

<table>
<thead>
<tr>
<th>Year</th>
<th>2010</th>
<th>2016</th>
<th>2022</th>
<th>2028</th>
<th>2034</th>
<th>2040</th>
<th>2046</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wage Differential (standard/local)</td>
<td>100</td>
<td>112.5</td>
<td>125</td>
<td>137.5</td>
<td>150</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Time (Year)

Business as Usual
Green Growth
Degrowth
Concluding Remarks

- 2METE aims at analysing the strategic challenges associated to the transition to a sustainable and equitable society.
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- **2METE** aims at analysing the strategic challenges associated to the transition to a sustainable and equitable society.

- The *Degrowth* scenario is the only one to succeed in achieving the emissions target together with a decline in unemployment rates and inequality (in terms of income inequality and wage polarization).

- This study is a case to illustrate the potential of ecological macroeconomics to contribute to much-needed innovative strategies for addressing current pressing challenges.

- Our ambition is to build a network to develop knowledge and capacity-building necessary to use ecological macroeconomics to timely advise policy decisions.
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**Scenari: CO₂**

- **Emissioni di CO₂ (2010=90)**
  - Business as Usual
  - Green Growth
  - Degrowth

- **Emissioni di CO₂ (kton)**
  - Business as Usual
  - Green Growth
  - Degrowth

- **Emissioni di CO₂ pro-capite (ton)**
  - Business as Usual
  - Green Growth
  - Degrowth

- **Intensità emissioni di CO₂ (emissioni di CO₂/PIL, 2015=100)**
  - Business as Usual
  - Green Growth
  - Degrowth
Scenari: Consumi Energetici ed Efficienza

Consumo di energia pro capite (Gw/h)

<table>
<thead>
<tr>
<th>Year</th>
<th>Business as Usual</th>
<th>Green Growth</th>
<th>Degrowth</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>28</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td>23.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2022</td>
<td>19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2028</td>
<td>14.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2034</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2040</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2046</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

Time (Year)

Quota rinnovabili su produzione di energia elettrica (%)

<table>
<thead>
<tr>
<th>Year</th>
<th>Business as Usual</th>
<th>Green Growth</th>
<th>Degrowth</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td>83.75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2022</td>
<td>67.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2028</td>
<td>51.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2034</td>
<td>35</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
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<tr>
<td>2046</td>
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Time (Year)

Consumo lordo di energia (kton)

<table>
<thead>
<tr>
<th>Year</th>
<th>Business as Usual</th>
<th>Green Growth</th>
<th>Degrowth</th>
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</thead>
<tbody>
<tr>
<td>2010</td>
<td>180,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td>157,500</td>
<td></td>
<td></td>
</tr>
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<td>2022</td>
<td>135,000</td>
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<td></td>
</tr>
<tr>
<td>2040</td>
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<td></td>
</tr>
<tr>
<td>2046</td>
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</tbody>
</table>

Time (Year)

Quota FER su consumi finali di energia (%)

<table>
<thead>
<tr>
<th>Year</th>
<th>Business as Usual</th>
<th>Green Growth</th>
<th>Degrowth</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>90</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td>71.25</td>
<td></td>
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</tr>
<tr>
<td>2022</td>
<td>52.5</td>
<td></td>
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<tr>
<td>2028</td>
<td>33.75</td>
<td></td>
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<tr>
<td>2034</td>
<td>15</td>
<td></td>
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</tr>
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<td>2040</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>2046</td>
<td></td>
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</tbody>
</table>

Time (Year)
**Scenari: PIL e Investimenti**

**Pil pro-capite (2010=100)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Business as Usual</th>
<th>Degrowth</th>
<th>Green Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>90</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td>107.5</td>
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<tr>
<td>2022</td>
<td>125</td>
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<tr>
<td>2028</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>2046</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Spesa per investimenti (milioni di euro)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Business as Usual</th>
<th>Degrowth</th>
<th>Green Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>200,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td>250,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2022</td>
<td>300,000</td>
<td></td>
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<tr>
<td>2028</td>
<td>350,000</td>
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<tr>
<td>2034</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>2046</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**PIL (milioni di euro)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Business as Usual</th>
<th>Degrowth</th>
<th>Green Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>1.3 M</td>
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</tr>
<tr>
<td>2016</td>
<td>1.625 M</td>
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<tr>
<td>2022</td>
<td>1.95 M</td>
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<td>2028</td>
<td>2.275 M</td>
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<td>2034</td>
<td>2.6 M</td>
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<td></td>
</tr>
<tr>
<td>2040</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2046</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Quota investimenti verdi su investimenti totali (%)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Business as Usual</th>
<th>Degrowth</th>
<th>Green Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td>1.25</td>
<td></td>
<td></td>
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<tr>
<td>2022</td>
<td>2.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2028</td>
<td>3.75</td>
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<td></td>
</tr>
<tr>
<td>2034</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2040</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2046</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Scenari: Mercato del Lavoro

**Tasso di disoccupazione (%)**

- Business as Usual
- Green Growth
- Degrowth

**Salario medio annuale (migliaia di euro)**

- Business as Usual
- Green Growth
- Degrowth

**Produttività media del lavoro (2010=100)**

- Business as Usual
- Green Growth
- Degrowth

**Salario orario medio (euro)**

- Business as Usual
- Green Growth
- Degrowth
Scenari: Distribuzione del reddito

Quota profitti distribuiti su PIL (%)

Quota salari (reddito da lavoro/PIL) (%)

Quota settore locale (%)
Scenari: Settore Pubblico

Saldo del bilancio pubblico (milioni di euro)

<table>
<thead>
<tr>
<th>Anno</th>
<th>Business as Usual</th>
<th>Green Growth</th>
<th>Degrowth</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>-45,000</td>
<td>0</td>
<td>-70,000</td>
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<tr>
<td>2016</td>
<td>-20,000</td>
<td>-1.75</td>
<td>-3</td>
</tr>
<tr>
<td>2022</td>
<td>5,000</td>
<td>-0.5</td>
<td>147.5</td>
</tr>
<tr>
<td>2028</td>
<td>30,000</td>
<td>0.75</td>
<td>161.25</td>
</tr>
<tr>
<td>2034</td>
<td>410,000</td>
<td>1.75</td>
<td>175</td>
</tr>
<tr>
<td>2040</td>
<td>455,000</td>
<td>2</td>
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<tr>
<td>2046</td>
<td>500,000</td>
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</tbody>
</table>

Spesa pubblica per acquisto di beni e servizi (milioni di euro)

<table>
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<th>Business as Usual</th>
<th>Green Growth</th>
<th>Degrowth</th>
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<tbody>
<tr>
<td>2010</td>
<td>320,000</td>
<td>0</td>
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<td>2016</td>
<td>365,000</td>
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<tr>
<td>2022</td>
<td>410,000</td>
<td>-1.75</td>
<td>147.5</td>
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<tr>
<td>2028</td>
<td>455,000</td>
<td>-0.75</td>
<td>161.25</td>
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<tr>
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<td>-0.25</td>
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<td>555,000</td>
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<tr>
<td>2046</td>
<td>610,000</td>
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Rapporto deficit PIL (%)

<table>
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<th>Green Growth</th>
<th>Degrowth</th>
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<tbody>
<tr>
<td>2010</td>
<td>-3</td>
<td>-1.75</td>
<td>-3</td>
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<tr>
<td>2016</td>
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<td>-0.5</td>
<td>-3</td>
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<td>-1.75</td>
<td>147.5</td>
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<td>1.75</td>
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Rapporto debito PIL (%)

<table>
<thead>
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<th>Green Growth</th>
<th>Degrowth</th>
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<tbody>
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<td>2010</td>
<td>120</td>
<td>133.75</td>
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<td>175</td>
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<td>147.5</td>
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