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1. Paradigm shift and innovative approaches

2. Results
   - Behaviours and technology
   - Urbanization and macro-economics
   - Transport decisions and Accessibility

3. Policy findings
PACT, PASHMINA: two inter-related FP7 research programmes as regard paradigm shifts in transport-energy-environment nexus in relation to urbanization.

**PACT: post-carbon transitions**

**PASHMINA: paradigm shifts**

**Innovative features:**
- Analysis
- Modelling
- EU Visions 2050

**Common focus:**
- City and urbanization
- Behaviours & lifestyles
- Innovation

PASHMINA Paradigm shifts in transport-energy-environment and urbanization
Assessing Paradigm shifts in transport – energy - environment nexus

• Innovative approaches to assess paradigm shifts in transport-energy-environment nexus in relation to urbanization, from global to local
  – Urbanization and macro-economics
  – Behaviours and technology clusters according to living areas
  – Mapping mobility and accessibility in specific connurbation case study

• Innovative visions of mobility, accessibility, energy and emissions in European urban areas according to PASHMINA scenarios
  – Apple: what technology can do, if basic trends in behaviours, urbanization and mobility mostly continue?
  – Orange: what can be expected from deep changes in behaviours « beyond tangibles », and more compactness in cities?
  – Potato: what might happen if physical limits are not anticipated and Europe experience recurrent crises?
Innovations in Analysis

• Main issues in relation to paradigm shifts
  – Which urban models for post-carbon EU? Which macro-economic impacts?
  – Which mobility models for post-carbon cities? What consequences on accessibility?
  – Which new technology clusters for new mobility models

• Innovative analytical approaches in PASHMINA WP2
  – Segmentation and description of urban reality versus carbon issues
  – Urbanization and macro-economics
  – Mobility behaviours and accessibility under constraints on speed and space use in various urban environments
  – New technologies and services for mobility, interaction with behaviours and city organization, new technology clusters
Progress in Modelling

• **IMACLIM-R**
  - Background: general equilibrium
  - Spatial dis-aggregation into a system of cities
  - Attractiveness of cities and migrations of firms, jobs and population

• **VLEEM-TILT**
  - VLEEM model, dedicated to address energy issues over one century
  - Urbanization pattern development and related speed, time-use and car equipment dimensions in mobility modelling
  - Technology clusters development according to urbanization pattern

• **GIS**
  - Mapping impacts of paradigm shifts on urban development
  - Impacts of speed and other complex factors on dwelling location
  - Impacts of transport systems decisions on accessibility
Progress in EU-2050 visions

• Weaknesses in EU-2050 visions
  – Very few ruptures in the existing socio-economic model and related mobility pattern
  – Mostly focussed on individual technologies, not on new clusters
  – No interactions between new technologies and behaviours and social organization

• Progresses thanks to PASHMINA
  – Much more robust visions of mobility and accessibility dynamics in case of ruptures in the existing socio-economic model
  – Much better assessment of the conditions and consequences of the development of new technologies and services for transport
    • Path of development of these technologies in relation to urban development
    • Impacts on energy and emissions
    • Drawing effect on new technology clusters in relation to renewables
Lessons on knowledge

- **Positive lessons**
  - Much better equipped to assess the consequences of deep changes in the society on mobility and related energy and emissions
  - Much better insights in the conditions of change in transport technologies, its inter-action with mobility and its potential key role in new technology clusters around renewables
  - Much better understanding interactions between transport decisions, mobility and accessibility

- **Negative lessons**
  - Still very poor in metrics for welfare « beyond tangibles »
  - Unsuccessful to progress on the « value of time » , in particular in view of macro-economic feed-backs of speed constraints
1. Paradigm shift and innovative approaches

2. Results
   - Behaviours and technology
     - Urbanization and macro-economics
     - Transport decisions and Accessibility

3. Policy findings
“Apple” : a paradigm shift in the transport-energy technology system, the wedding of speed and centralized technology in the EU

- Main features as regard transport-energy-environment nexus
  - Led by governments and big stakeholders, minor role of local actors, very centralized, technology focus
  - Little change in behaviours and city organization
  - Urban sprawl controlled, small/medium cities, in particular close to big cities, expand rapidly
  - Spatial networking among cities; fast rail infrastructures, regional and long distance
  - Hybrids, electric vehicles and biofuels: gCO2/car-km down by 85%
  - Large development of wind power and CSP, smart grids and centralized management of cars batteries
“Orange" : a paradigm shift in behaviours, social preferences and life-styles, a bottom-up transition process relying on social networking in the EU

- Main features as regard transport-energy-environment nexus
  - Local transitions essential, driven by local authorities, citizens and NGOs
  - Deep changes in behaviours toward thriftiness
  - Urban sprawl regresses; 1st rings of core cities densified
  - Spatial networking among big cities and with medium cities nearby
  - Hybrids, electric vehicles and biofuels: gCO2/car-km down by 75%
  - Zero-energy and +energy building concepts generalized
  - New technology clusters around photovoltaics and smart grids
"Potato" : BAU scenario, that account for development/adjustment through violent/brutal crises

- Main features as regard transport-energy-environment nexus
  - High tensions on oil/gas markets, possible shortages
  - Economic recession, then stagnation in the EU
  - No change in behaviours and life-styles
  - Urban sprawl continues, spatial networking limited to big cities only
  - Innovation slow, few new capital intensive infrastructures
  - Lack of reliability of centralized energy systems favouring supply/demand of local solutions
  - Hybrids, electric vehicles and biofuels: $gCO2/\text{car-km}$ down by 70%
  - High oil/gas prices drive decentralized renewables

PASHMINA Paradigm shifts in transport-energy-environment and urbanization
The European demographic structure will change deeply in all scenarios by 2050

- **Population:**
  - stabilization / slow growth
  - aging: >75 from 6% to around 15%

- **Households:**
  - singles around 50%
  - reduced size

PASHMINA Paradigm shifts in transport-energy-environment and urbanization
Changes in behaviours and life-styles are expected to have drawbacks on the GDP growth

- **Time-use preference**: a key indicator of life-styles preferences

- **Economic outlook**:  
  - strong discrepancy in GDP/capita  
  - but lack of measurement of welfare « beyond GDP »
Urban sprawl versus density: more energy intensive, but more favourable for renewables

PASHMINA Paradigm shifts in transport-energy-environment and urbanization
Contrasted visions of mobility development in the EU up to 2050

- Motorization impacted by
  - urbanization
  - households structure
  - life styles

- Drivers of pass. traffics
  - elasticity speed / GDP
  - transport time budget
  - motorization
Visions of urban traffics, 1st rings

- **Apple**
  - Gpas-km
  - 2000: 600
  - 2025: 700
  - 2050: 800

- **Potato**
  - Gpas-km
  - 2000: 600
  - 2025: 700
  - 2050: 800

- **Orange**
  - Gpas-km
  - 2000: 600
  - 2025: 700
  - 2050: 800

- **Legend**
  - **Slow modes**
  - **Public transport**
  - **Cars**
Visions of urban traffics, other cities

Apple

Orange

Potato

Slow modes
Public transport
Cars

PASHMINA Paradigm shifts in transport-energy-environment and urbanization
Penetration of new electric technologies for road mobility

A) Market shares of technologies in sales of new cars

**Apple**

**Orange**

**Potato**

- **Electric vehicles**
- **Plug-in hybrids**
- **ICE**
Penetration of new electric technologies for road mobility
B) market shares of technologies in car fleet

Apple

Orange

Potato

Electric vehicles
Plug-in hybrids
ICE

PASHMINA Paradigm shifts in transport-energy-environment and urbanization
Penetration of new electric technologies for road mobility: C) market shares of electric drive in car traffic (veh-km)

**Apple**

- 2025: Electric vehicles, regional trips - Electric vehicles, urban trips - Plug-in hybrids, regional trips - Plug-in hybrids, urban trips
- 2050: Electric vehicles, regional trips - Electric vehicles, urban trips - Plug-in hybrids, regional trips - Plug-in hybrids, urban trips

**Orange**

- 2025: Electric vehicles, regional trips - Electric vehicles, urban trips - Plug-in hybrids, regional trips - Plug-in hybrids, urban trips
- 2050: Electric vehicles, regional trips - Electric vehicles, urban trips - Plug-in hybrids, regional trips - Plug-in hybrids, urban trips

**Potato**

- 2025: Electric vehicles, regional trips - Electric vehicles, urban trips - Plug-in hybrids, regional trips - Plug-in hybrids, urban trips
- 2050: Electric vehicles, regional trips - Electric vehicles, urban trips - Plug-in hybrids, regional trips - Plug-in hybrids, urban trips
Penetration of new electric technologies for road mobility

D) Energy consumption of cars

Apple (Mtoe)

Orange (Mtoe)

Potato (Mtoe)

- electricity
- biofuels
- diesel
- gasoline

PASHMINA Paradigm shifts in transport-energy-environment and urbanization
New technology clusters
C) Impacts of clusters deployment

Apple

Inputs for car electricity, TWh

A: minimum development of decentralized PV cluster
B: maximum development of decentralized PV cluster

- Decentralized PV electricity
- Wind power and CSP*
- Other inputs*

PASHMINA Paradigm shifts in transport-energy-environment and urbanization
New technology clusters
C) Impacts of clusters deployment

Orange

Inputs for car electricity, TWh

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<tr>
<th></th>
<th>2025</th>
<th>2050</th>
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<tr>
<td>A</td>
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<td>B</td>
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A: minimum development of decentralized PV cluster
B: maximum development of decentralized PV cluster

- Decentralized PV electricity
- Wind power and CSP*
- Other inputs*

PASHMINA Paradigm shifts in transport-energy-environment and urbanization
Oil resources and prices in PASHMINA scenarios

- Current **URR from ASPO**, developing with possible EOR in S1 and S2 (technological progress), supposed not possibly increasing in S3
- **Oil price lower in S2** (strong climate change regime)
- Oil price similar in S1 and S3 by 2030 (not for the same reasons), but then becomes very unstable: resource scarcity

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**Oil URR**

**Oil Price**
EU27 primary energy

- Increasing total energy demand in S1
- Decreasing total energy demand in S2 and S3
- Very different prospects for nuclear
EU27 power generation

**Scenario 1: Apple**

- Very different levels of power generation (economic growth + prices + carbon constraint effects)
  - S1: very capital intensive
  - S2: capital intensive
  - S3: low capital intensive
European CO2 emissions: total emissions paths

- Emission paths are more contrasted in Europe across scenarios than at World level

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Short-term (2020)</th>
<th>Longer-term (2050)</th>
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<tbody>
<tr>
<td>S1 - Apple</td>
<td>-21% CO2 emissions</td>
<td>Factor 2 (-46%)</td>
</tr>
<tr>
<td>S2 - Orange</td>
<td>-33% CO2 emissions</td>
<td>Factor 3 (-69%)</td>
</tr>
<tr>
<td>S3 - Potato</td>
<td>-28% CO2 emissions</td>
<td>Factor 3 (-66%)</td>
</tr>
</tbody>
</table>

Total EU27 CO2 emissions

PASHMINA Paradigm shifts in transport-energy-environment and urbanization
1. Paradigm shift and innovative approaches

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3. Policy findings
Objectives

- Describing location choices inside a system of cities in interaction
- Assessing the impact of those location choices on climate through CO$_2$ emissions
Approach (1)

- Describing location choices inside a system of cities in interaction
  - New Economic Geography (Krugman)
    - Migration of economic activity among a number of locations accounting for agglomeration benefits and costs
  - Urban economy:
    - Location of agents inside a urban system as a result of microeconomic tradeoffs
Approach (2)

- Assessing the impact of those location choices on climate through CO$_2$ emissions
  - Computable General Equilibrium (CGE) model
    - Macroeconomic interplay + Quantified assessment
  - Energy

PASHMINA Paradigm shifts in transport-energy-environment and urbanization
Approach (2)

- Assessing the impact of those location choices on climate through CO$_2$ emissions

  - IMACLIM-R
    - Computable General Equilibrium (CGE) model
      - Macroeconomic interplay
      - Quantified assessment
    - Energy
Method: the IMACLIM-R model

- Long-Term (2050), 1 year time step
- 12 regions, 12 sectors
- Double accounting: physical and monetary (Mtoe, p-km)
- A recursive and modular architecture with a succession of:
  - Static equilibria (macroeconomic consistency)
  - Linked by dynamic relationships (reduced forms of detailed bottom-up models)
Method: the IMACLIM-R model

Static equilibrium (t) under constraints

Modification of constraints

Static equilibrium (t+1) under constraints

Price, Quantities, Investments

Population, Productivity Equipments, Technologies, Preferences

Industry, Electricity, Oil, Transport

PASHMINA Paradigm shifts in transport-energy-environment and urbanization
Method: the IMACLIM-R model

- Static equilibrium (t) under constraints
- Modification of constraints
- Static equilibrium (t+1) under constraints

- Industry
- Urban Systems
- Oil
- Transport

- Price, Quantities, Investments
- Population, Productivity, Equipments, Technologies, Preferences

PASHMINA Paradigm shifts in transport-energy-environment and urbanization
1. Disaggregate the national economy into a system of cities in interaction

2. Represent geographic movements of production
Step 1: Spatial disaggregation into a system of cities

Step 2: Migration of firms and population

Spatial dynamics in 2 steps

Energy Variables

Aggregate Economic variables:
- Price, Wage,
- Profit,
- Production,

Static Equilibrium $t$

Static Equilibrium $t+1$

Re-aggregation of technical coefficients
- Transport needs,
- Productivity, investment costs

PASHMINA Paradigm shifts in transport-energy-environment and urbanization
System of cities in interaction

- Spatial structure of cities:
  - Monocentric and axisymmetrical
  - The Firms are clustered into the adimensionnal centre
  - Spatial distribution of households/workers
    - Housing surface, Distance to centre (commuting)

- Urban development accounts for the consequences of agglomeration
  - Benefits: scale economies (firms), income and goods’ diversity (households)
  - Costs: wages (firmes), housing and transport costs (households)
Relocation of production

- Differentiated Attractiveness of cities
  - Investment profitability

- Migration of productive capital towards the most attractive cities

- Migration of productive firms
1. Paradigm shift and innovative approaches

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3. Policy findings
Capturing Paradigm shifts: Innovative approach

• Analysis of the future scenarios following different pathways – the pear, the apple, the orange
  – Linking land use models of settlement structures and accessibility with strategic transport planning
  – Linking the option for transport with transport habits

• Showing future accessibility when strategic transport decisions are realised, relative to the four scenarios
  → indicating the transport planning that will open for sustainable transport futures (apple and orange)
Capturing paradigm shifts: Innovative approach

• Stresses a key role for *travel time* in the localisation patterns of housing areas
  – Public transportation: Access to train stations and bus stops
  – Private road transport: Access to main roads

• Includes complex local-regional factors that determine localisation of housing areas
  – Travel habits, congestion, workplaces, cultural activities
  – Showing future urban sprawl, densification
Example: Access to recreation
Main results

• The model used on the case area of Copenhagen City-Region, Denmark
  – Based on the basic spatial principles of the Finger Plan and strategic transport/spatial plans until 2040
  – Increased urbanisation and densification, i.e. Cph and connected towns increase in size and density, in all four scenarios
  – Hot spot areas where densification are expected regardless of scenario

• Accessibility to seamless travel influence strongly localisation of housing, leisure and business
  → the choice of transport mode dependent on localisation relative to access to main transport
Accessibility, private and public transport

Private transportation

Public transportation
Accessibility and implementation of transport planning

Scenario Implementation overview

**Pear**
- No planning zones incorporated
- General accessibility is focused on road transportation through main roads and motorways
- Property value used as important locational factor
- Proximity and suitability has low influence
- Accessibility to jobs is focused on road transportation

**Apple**
- Focus on developing the 'Fingerplan' frame
- Direct implementation of the 'closeness to stations' principle
- Accessibility to jobs by public transportation is main accessibility factor
- Reduced focus on road network accessibility
- Effects of urban density and proximity is increased

**Orange**
- Planning zones favour urban compactness
- Focused on balancing transportation to work and recreation
- Uses a combined distance indicator for forests, lakes, coast and shopping
- Urban density is key locational driver
- Urban density and proximity are highly weighted
1. Paradigm shift and innovative approaches

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3. Policy findings
Major policy findings

• **Opportunities and risks**
  – In any case, decided or forced, the EU consumption of fossils in the next 40 years, and therefore its CO2 emissions, will decrease a lot
  – but the social, economic and policy costs would be very high if this transition is not properly planned and implemented

• **Radically different economic pathways are possible**
  – Social forces are currently pushing in two very different directions: reproducing the old recipes for economic growth or fighting for a new "beyond tangibles" socio-economic model.
  – Depending on which social forces will become predominant, who will take the lead and with which socio-economic objectives, the transition pathways will be very different.
Technology innovation

• **Technology innovation alone will not save the World...**
  – If mobility pattern does not change, new technologies and services could, at best, halve direct and indirect GHG emissions by 2050.
  – this "factor 2" reduction could only be achieved in case of a rapid penetration of electricity in short distance mobility, with an electricity generated from non-CO2 emitting technologies, renewables and nuclear.

• **...but it can generate very positive feed-backs**
  – if the EU is able to master the paradigm shift in transport technologies, in particular from the industrial point of view, this may well contribute to sustain the economic growth in Europe
  – complementarities between electro-mobility and renewables do exist, and new technology clusters could emerge in Europe, as win-win solutions.
Behaviors and social innovations

• **Changes in mobility pattern unavoidable by 2050**
  – Mobility pattern will have to change if CO2 emissions of transport must cope with 2°C / 450 ppmv target by 2050.
  – Or it will change as a direct consequence from broader changes in social priorities (“beyond tangibles”, Orange scenario)
  – Or it will be painly forced by oil scarcity (Potato)

• **Social innovations for thrift mobility behaviours**
  – Re-shaping core cities and suburbs to increase accessibility with less distances
  – Favouring zero energy and + energy building concepts in new constructions to foster new decentralized transport-energy clusters
  – Rationalizing mobility needs thanks to new technology clusters and new services, through reduced autonomy requirement
• **No free lunch!**
  - Broad changes in social priorities towards “beyond tangibles” may result in a lower – but better distributed - GDP growth
  - If nothing change deeply in mobility and technology, the oil shock will be very painful, and the loss in GDP important
  - Solving the problems through huge public investment in public transportation may reduce drastically future GDP growth because of the public debt

• **Suffer or manage economic threats?**
  - A risk of increasing social inequality: more people close or below the poverty threshold, and a small class of people capturing an increasing share of the global wealth
  - Aggravation of the risk because of oil prices if poor people cannot afford to purchase new efficient technologies
Merci pour votre attention!

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