Consequential environmental Life Cycle Assessment and socio-economic analysis

Hybridization test on a Parisian project of Bus Rapid Transit

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CONTEXT
Decision-making support and transportation assessments in France
Transportation development process

GLOBAL DEVELOPMENT POLICY

PROJECT PROCESS

MASTER PLAN

CONCEPT DESIGN
(Opportunity study & Feasability study)

PRELIMINARY DESIGN

PROJECT EXECUTION

Assessments

CBA
EIA

PUBLIC INQUIRY

Declaration of public utility

Life Cycle Thinking for leading managers
Socioeconomic appraisal

= Cost-benefit analysis

Method coming from economics

Measure the utility of a project:

- Financial rentability
- Social and environmental externalities

Insertion in decision-making:

- USA: The New Deal’s public works program, Roosevelt, 36
- FR: road project investments (58-59)
  - compulsory in 1982 (LOTI)
Cost-benefit analysis of infrastructure in France

- **Compulsory for public-funded infra** (Instruction of 2014, June 16th)
- **Indicator**: socio-economic Net Present Value (IRR):
  \[
  SE-NPV = \text{CapEx} + \left[ \sum_{i,t} \text{OpEx}_{i,t} + \sum_{j,t} \text{Monetized Externalities}_{j,t} \right]_{\text{discounted}}
  \]

- **Current CBA is « light » on environmental externalities**
  - Perimeter mostly restricted to operation
  - Compulsory environmental externalities*:
    - C02eq emissions
    - Effect of air pollution on health

*Because we know how to monetize them*
Cost-benefit analysis of infrastructure in France

**SOCIOECONOMIC INTEREST**

- **OF THE PROJECT**: $\text{SE-NPV (P)} > \text{SE-NPV (R)}$
- **BEST VARIANT**: 
  - global vision: $\max \left[ (\text{SE-NPV (P(A))} - \text{SE-NPV (R)}, \text{SE-NPV (P(B))} - \text{SE-NPV (R)}) \right]$
  - Project vision: $\max \left[ \text{SE-NPV (P(A)), SE-NPV (P(B))} \right]$
Life Cycle Assessment as a support for transportation decision-making in France

- Not compulsory => voluntary actions
- Special interest after the Grenelle Roundtable (2009) mostly for roads

⇒ French volunteer convention for public works sustainability (de Bortoli 2015)
⇒ Road eco-comparators: Ecorce, Seve, Variways...
⇒ Road LCA (CEREMA and ENPC 2016)

- Other transport systems: rare punctual approaches:
  - Ademe LCA comparison: electric veh Vs conventional veh
  - ENPC: LCA of a BRT line (de Bortoli et al 2016)
  - Mines ParisTech: software NovaEquer for district LCA + Efficacity work (R&D centre for energy transition)
  - Conurbation mobility LCA (Le Feon 2014)
METHODOLOGIES

Comparison of CBA and LCA
Approach

Cost-Benefit Analysis

CONSEQUENTIAL
- A situation at T0
- Two evolutive scenarios

Project Scenario Vs Reference scenario

Life Cycle Assessment

ATTRIBUTIONAL
- Comparison of two variants
  Mode A Vs Mode B

or CONSEQUENTIAL
- Assessment of the consequences of a decision (« marginal » data)

« I do the project » Vs « I don’t do it »
Impacts and indicators

Cost-Benefit Analysis
Socio-Economic Net Present Value (\(=\text{SE-NPV}\)) includes:
- Expenses and incomes
- Mandatory externalities
  - GHG emissions
  - Traffic noise
  - Traffic safety
  - Air pollution
  - Travel time

Optional externalities: travel time, reliability, comfort, energy, macroeconomic & urban effects, rare resources.

Life Cycle Assessment
ENVIRONMENTAL INDICATORS
- No standardized list for transport (for built structures: NF EN-15804)
- Example of set of indicators for transport

<table>
<thead>
<tr>
<th>Mid-point indicators</th>
<th>Characterization methods</th>
<th>Unit</th>
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<tbody>
<tr>
<td>Energy consumption</td>
<td>CML</td>
<td>MJ eq</td>
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<tr>
<td>Climate change (100 years)</td>
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<td>Kg CO2 eq</td>
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<tr>
<td>Depletion of abiotic resources</td>
<td>CML</td>
<td>Kg Eq antimony</td>
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<tr>
<td>Solid waste</td>
<td>Recipe</td>
<td>kg</td>
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<tr>
<td>Radioactive waste</td>
<td>Recipe</td>
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<td>Acidification potential – generic</td>
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<td>Kg SO2 eq</td>
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<td>Stratospheric ozone depletion</td>
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<td>Kg CFC11 eq</td>
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<tr>
<td>Photochemical oxidation</td>
<td>CML</td>
<td>kg EthyleneEq</td>
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<tr>
<td>Eutrophication – generic</td>
<td>CML</td>
<td>kg PO4(^3) eq</td>
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<td>Freshwater aquatic ecotoxicity (100 years)</td>
<td>CML</td>
<td>kg 1.4DCBeq</td>
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<td>Marine aquatic ecotoxicity (100 years)</td>
<td>CML</td>
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<tr>
<td>Terrestrial ecotoxicity (100 years)</td>
<td>CML</td>
<td>kg 1.4DCBeq</td>
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De Bortoli et al 2016
Cost-Benefit Analysis

FINANCIAL ANALYSIS

Project: Capex + Opex

Mobility area: difference of global Opex

EXTERNALITIES ANALYSIS

Mobility area: Effects of mode shift on operation impacts: GHG, road safety, noise, air pollution, travel time

Life Cycle Assessment

ENVIRONMENTAL ANALYSIS

Most of the time, entire life cycle:

- Construction
- Operation
- Maintenance
- End-of-life
Cost-Benefit Analysis

FINANCIAL ANALYSIS

- **Project**: Capex + Opex

EXTERNALITIES ANALYSIS

- **Mobility area**: difference of global Opex

Life Cycle Assessment

ENVIRONMENTAL ANALYSIS

Most of the time, entire life cycle:

- Construction
- Operation
- Maintenance
- End-of-life

OBJECTIVES: adding whole life cycle environmental impacts (project and modal shift)
Proposal of a new methodology to assess transportation project impacts

\[ [\text{Project benefits}]_{\text{pkm}} = [\text{Impact without project}]_{\text{pkm}} - [\text{Impact with project}]_{\text{pkm}} \]

**A - ENVIRONMENTAL IMPACTS**

**Calculating:**

1. average transport impact per pkm without the project
2. new project transportation mode impacts per pkm
3. average transport impact per pkm with the project
4. The difference with/without

**B - SOCIAL & ECONOMIC IMPACTS**

**ECONOMIC IMPACT**

**Calculating:**

1. Public CapEx of the project
2. Public OpEx with & without project (/pkm)
3. User cost difference
4. Public and user cost differences /pkm

**SOCIAL IMPACTS**

1. Time savings (/pkm)
2. Safety savings (/pkm)
Case study
Design on the road section
LCA of the project

Subsystem modeling of the BRT line

Recipe
CML
CED
EDIP
Some figures are from preliminary design, others are extrapolated: the aim of the presentation is to discuss methodology, not results.
Traffic simulation and assumptions

ASSUMPTIONS

- No induced trips (neither motorized nor non-motorized)
- Constant demand: trips on removed bus lines are totally replaced by BRT trips

⚠️ Some figures are from preliminary design, others are extrapolated: the aim of the presentation is to discuss methodology, not results
Holistic comparison of the road section with and without the project on one year.

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Holistic consequential assessment of the project implementation

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CONCLUSION AND PERSPECTIVES
Some limits to method implementation

- **Limit 1**: EcoInvent average processes not specific to France
  - Contextualisation work to do for average impacts (especially on infrastructures)

- **Limit 2**: consumptions and emissions of the BRT based on WHSC measures (different from real emissions)

- **Limit 3**: no speed effect consideration (consumption, emissions)
  - Coupling traffic dynamic simulation with LCA?

- **Limit 4**: defining robust evolution scenarios
  - Transportation offer and demand
  - Mode performances
  - Prices (per market)
Some questions on the methodology

- **Question 1**: decision-making support and indicators
  - Monetization?
    - Proposing a set of non-monetized indicators?
    - + the standard SE-NPV?
  - Public cost indicator: infrastructure works are done from one side to another side of the street...

- **Question 2**: what perimeter?
  - Physical: traffic network effects...
  - Usage: consideration of non-motorized trips (induced or modal shift) with new street design? Model?

- **Question 3**: considering uncertainty?
  - Sensitivity analysis
  - Scenarios
  - Others?
THANK YOU FOR YOUR ATTENTION

Special thanks to

Zakaria SEFRI

And

Jonathan NG YUK SHING

who conducted the first LCA of TZen3 infrastructure (students at Ecole des Ponts et Chaussées)
Socio-economic results

ECONOMIC IMPACT
2. Public OpEx (with - without project) : +0,7M€2012/year
3. User cost savings: +0,29 M€2012/year (car operation, parking, street maintenance and police)
4. Public and user cost difference /pkm

SOCIAL IMPACTS
1. Time savings :+23,2M€2012/an
2. Safety savings : + 0,01M€2012/an

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Life cycle comparison of modes

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Life cycle comparison of modes

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European emission standards: « Euro norms »

- NOx
- HC
- CO

<table>
<thead>
<tr>
<th></th>
<th>Euro 0</th>
<th>Euro I</th>
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