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Infraestructure forecast modeling II

Policy planning via structural analysis and balanced scorecard. Electricity in Colombia case study

Daniel TORRES –GRACIA, PhD

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Infrastructure forecast modelling II;
Policy planning via structural analysis and balanced scorecard. Electricity in Colombia case study[1]

Daniel Torres-Gracia, PhD[2]

Abstract

Countless developments in forecasting models and processes have been developed in the last four decades, to support increasing demands in infrastructure services delivery and competitiveness. A wide range of these developments is available nowadays from highly detailed macroeconomic or technical forecasting models based on convergence of marginal functions, up to strategic business models supported on broad and soft methods of decision making modelling. Despite of this, it is surprising the little level of practical implementation of forecasting models within public infrastructure planning organisations involved in policy making and implementation processes that decide on short, medium and long term of important resources. Lacks on its practical approach, as well as the methodological complexity and high costs involved within its implementation processes, are among their major weaknesses reported in the literature. These models have been restricted to very specialized infrastructure planning units able to manage long term implementation process, involve highly qualified professional within the process and finance its related costs (private firms mostly). National and sub-national organizations with infrastructure planning functions, under tight schedules and financial restrictions, are applying softer focuses on forecasting modelling support on the social and institutional agreement on future goals as alternative method to replace complex analyses on future trends common in more complex models approaches. Although this “agreed” focus is valid under the assumption of the social acceptance premise, it is constraining technical validity to this validity, and reducing their trend’s analysis to any kind of technical assumption, whether rational or not, as long as it has been subjectively agreed. This focus has gained terrain within some national efforts in forecasting modelling in Colombia in the last years, reducing its technical analysis and quality in their practical results.

The PPCI2 programme, through the Sustainable Infrastructure and Energy Directorate and DNP, within its objective of improve technical capacity in project planning process under private and public initiatives, promoted a methodological proposal to develop an infrastructure forecasting model able to empower technical quality of decision making models, under a practical, reliable and doable implementation process across top level decision makers of the infrastructure planning units at national level in Colombia. The result of that effort is the Infrastructure General Forecasting model – IGF introduced in this document. The IGF is a quantitative-qualitative model supported in the structural analysis process – SAP to study interactions across forecasted variables and the Balanced Scorecard methodology – BSC to the support decision making processes. The underlined analytical method is the matrix analysis of probabilistic cross impacts. Its major outputs include trends and long term figures on forecasted variables as forecasting models traditionally offer, but additionally includes analyses on the role played by forecasted variables under a set of trends alternatives within the sector they affect. Basic modules of the IGF model includes historical trends analysis, analysis on current situation and short term effect of new PPPs and forecasting simulation analysis. The three modules combine the analyst criteria with secondary data under a systematic approach. This document explains IGF´s conceptual basis and methodology, as well as its structure across energy, telecommunications, transport and water supply sectors, and some pilot results on the coverage and market of the electricity service. Results show strong inputs to empower technical and strategic capacity across infrastructure planning units in Colombia useful to policy makers, sector planners, consultants, lectures and researchers on infrastructure planning.

Key words;
Colombia, forecast modelling, infrastructure strategic planning, balanced scorecard, structural analysis, scenarios planning, energy, telecommunications, transport, water supply.

JEL classification: C32 - C53 - O21 - R42

[1] Contents remain the opinion of the author and are not in any way intended to represent the views of DNP or IDB. Paper developed by the author as a consultant to the Private Participation and Concessions in Infrastructure Programme – PPCI2 (National Planning Department of Colombia, 2006). This paper is focused on modeling results to the electricity coverage and its market in Colombia. The project also included results in transport, telecommunications and water supply sectors.. Complimentary results in the Transport sector are available at *Revista Planeación & Desarrollo.* Vol. 37. No. 1. January – June 2006. Departamento Nacional de Planeación. Bogotá. Colombia

[2] PhD Infrastructure Planning. University of Bradford. United Kingdom.

List of acronyms

BRS	Bus Rapid Transit Systems
BSC	Balanced scorecard
COLOMBIA 2019	National Programme describing major Colombian trends 2006 - 2019
CONPES	National council of Economics and Social Policy
CAF	Andean Development Corporation
CRA	Regulatory Commission for Water and Sanitation
CREG	Regulatory Commission for Electricity and Gas
CRT	Regulatory Commission for Telecommunications
DANE	National Administrative Department of statistics
DIES	Sustainable Infrastructure and Energy Directorate. DNP
DNP	National Planning Department of Colombia
FAER	Rural electrification Fund
FAZNI	Non-Interconnected Zones Fund
FONADE	National Fund for Development projects
GDP	Gross Domestic Product
GNV	Natural gas for vehicles
Gwh	Giga Watts per hour
IAPC	Internal Agenda to Productivity and Competitiveness
ICTs	Information and communications technologies (TICs)
IDB	Inter-American Development Bank
IGF	Infrastructure general forecasting model
IIRSA	Initiative for the integration of regional infrastructure in South America
ISA	National Electric Transmission Utility
ISAGEN	National Generation Utility
KPI	Key Performance Indicator
LDN	Telecommunications system for National long distance calls
LDI	Telecommunications system for International long distance calls
MICT	Ministry of industry commerce and tourism
MC	Ministry of Communications
MME	Ministry of Mining and Energy
MT	Ministry of Transport
OECD	Organization for Economic Co-operation and Development
PEST	Analysis model of political, economical, social and technological trends
PPCI2	Programme for Private participation and concessions in infrastructure – Second phase-. DNP
PPP	Policies, programmes or projects
SAP	Structural Analysis Process
SAPSB	Water and Sanitation office. DNP (Urban Development and Environmental Policy Directorate)
$COL Mill	Millions of Colombian Pesos
$USD Mill	Millions of American Dollars
SIN	National Electricity Interconnected System
SPR	Regional Port Society
SSPD	Superintendence of Public Utilities
SWOT	Analysis model of strengths, weaknesses, opportunities and threats
UPME	Mining and Energy Planning Unit
ZNI	Electricity Non-interconnected Zones (uncovered by the SIN)

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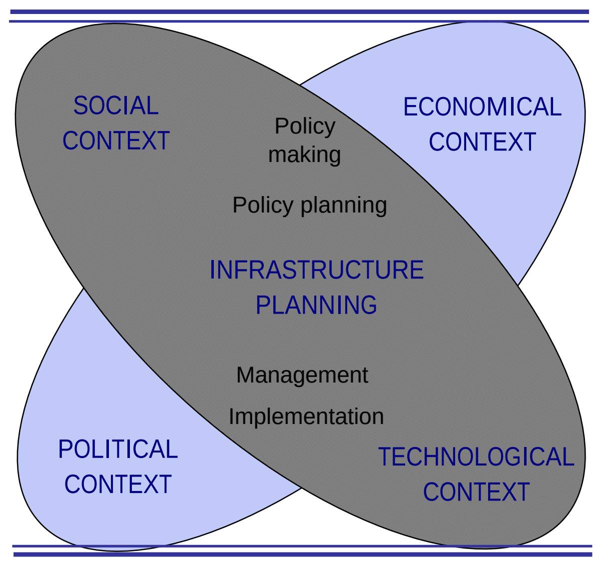
1. Empirical approach to an integrated planning and forecasting model

1.1 The planning point of view.

Investment flows in Colombia's public infrastructure have played a relatively stable role in the last twenty years compared to its peers in the Latin-American context (World Bank, 2004b). After fifteen years of major institutional, regulatory and financial reforms, and despite of its positive results on selected sectors, infrastructure in Colombia keeps confronting strong pressures on decentralization, globalization, and private sector participation. It has been demonstrated how the dynamic of these forces, have impacted long term performance of several infrastructure sectors including transport, energy and telecommunications. Effects are evident either on reduction of investments flows (public and private), and on deterioration of performance indicators including stock, financial and operational aspects.

By analysing dynamics of dominant forces over infrastructure performance in Colombia, strong impacts have emerged focused on limitations of the planning approach applied. In this sense, a structured and mature planning focus may have positive effects on some transport sectors, while be related with negative performance on some telecommunications services. The effect of the planning approach will depend not only on the planning focus by itself but also on the dynamic of external forces that may affect the infrastructure planning process, from policy making to implementation levels (Figure 1). Even under stable contexts and mature infrastructure sectors, flexible approaches to plan are better related with higher levels of performance of those sectors (Torres-Gracia, 2002).

Figure 1.
A conceptual relating infrastructure planning and its context.



Source: own elaboration from Torres-Gracia (2002)

1.2 The forecasting point of view.

From the prospective forecasting in infrastructure approach, research keeps highlighting on positive relationships between improved forecasting methodologies and enhanced performance of economic, managerial and physical aspects of the infrastructure. In the Colombian and Latin-American context, recent economic studies (World Bank and IADB), have repeatedly proposed the development of infrastructure planning tools such as modelling tools as means to incentive private investment via institutional empowerment[3]. See Figure 2.

[3] In a review of more than 50 studies on economic efficiency of infrastructure investments across Europe, Asia, North and South America, Torres-Gracia, 2001 highlights a positive role played by enhanced modelling processes because of its effects on production, consumption, quality of life and the environment. See annexe 1. Se also World Bank 2004b y 2005a.

Infrastructure is the factory over which a nation, its productive relationships and its social welfare is supported. As a way to facilitate the development of planning tools, recent studies in the Colombian context, promoted by some planning agencies, multilateral agencies and the private sector, have helped in the development of strategic long term visions across several infrastructure sectors[4]. They have highlighted the necessary improvement of institutional planning capacity as a challenge for infrastructure public agencies, in order to improve technical and sustainable aspects within the design of their infrastructural policies[5]

Figure 2.
Approaches on infrastructure modelling towards investments forecasting.

	"Benchmarkig"	Set target
Costing exercise	**Ex:**	**Ex:**
	-Stock target: what would it cost to get Mexico´s infrastructure (per capita; per unit of GDP; per km2) to the level of the LAC leader; or to the level of the East Asia median?	What would it cost for Mexico to achieve universal service coverage in water and sanitation, electricity and acces to year round roads?
	-Flow target: how does Mexico´s expenditures on infrastructure compare to peers	
Model	**Econometric:**	**Engineering-economic models:**
	Growth: What level of infrastructure coverage ins needed to achieve x% level of growth and reduce inequality by z% . Model developed by Calderon and serven (2004) could be used for this	These are "set" targets inasmuch as the target is a particular level of coverage and quality as defined through enegineering-economic models. **Power sector:** well defined international methodology, applied by CFE in Mexico, which estimates the investment needed to maintain the integrity of the network and satisfy predicted expansion in demand. **Water sanitation:** financial model that estimates investment needed to attain the coverage goals set in National Hydraulic Plan. **Roads**: well defined methodology for rehabilitation/maintenance expenditures: combined with road sector expert opinion on definition of major corridors and investment needs fo their completion.
	Demand: What level of infrastructure coverage will be demanded by firms and consumers, for given growth projections. This is the approach followed in Fay and Yepes, 2003.	

Source: World Bank, 2005a

4 Some related studies include; DNP 1997a, 2004a, 2004b, 2005a, 2005b, 2005d, 2005m, 2006a to 2006o, and Torres-Gracia 2001, 2002, 2007.

5 In a study across ten sectors, Torres-Gracia, 2001 designed a set of balanced scorecards and developed a performance evolution index –PEI which relates negative trends in the infrastructure performance with weaknesses in the planning capacity of the public agencies responsible.

2. What is it and why an IGF model to the Colombian infrastructure?

The major objective of this study is to support the improvement on long term planning capacity of the DIES and SAPSB at DNP, through the design and implementation of an integrated scheme of balanced scorecard and prospective forecasting. Its scope includes energy, telecommunications, transport and water supply sectors. Scorecards simulate strategic policies, programmes and projects dynamics using three general modules:

- Module 1. Historical trends: it explains dynamics on historical trends, as a conditional input to explain today's situation of a policy, programme or project- PPP. It is based in:
  - A clear identification of variables that better describe the PPP,
  - Analysis of cause-effect relationships between those variables and
  - Study of historical trends forces affecting them.
- Module 2. Current situation and short term effects: it explains changes over current dynamics of a sector, due to the implementation of a new PPP. It is based in:
  - A qualitative-quantitative characterization of the sector and the PPP to be implemented,
  - Identification of functions describing current sector's situation and
  - A matrix-based comparative analysis before and after the PPPs implementation.
- Module 3. Forecasting module: it generates qualitative and quantitative data as inputs to the design and recommended implementation strategies of probable, feasible and doable future scenarios in a particular infrastructure sector. It is based in:
  - Identification of key performance indicators - KPIs to the sector and the PPP analyzed
  - Definition of the role that each KPI may play over a set of future scenarios
  - Development of a systematic process to the design of future development scenarios and
  - Construction of trends typologies for each scenario and each KPI included within the analysis.

3. Rationale to the integration of BSC and SAP methodologies into an IFG model.

3.1 The structural analysis tool

The Structural Analysis Process-SAP is used to systematically analyze relationships over KPIs that describe a particular infrastructure PPP[6]. It helps to identify the role played by each KPI to the achievement of predefined goals associated with the PPP under analysis. These goals may be defined to the short, middle or long term. It includes the following steps; i) construction of a quantitative-qualitative relationships matrix, ii) mathematical processing of matrixes, and iii) outputs analysis process. Results of the SAP are represented by two parameters; dependency and influence of each KPI. These parameters are key inputs to define the role of each KPI within the PPP analyzed. Construction of qualitative and quantitative matrixes involves the following fourth steps:

a. KPIs identification:

KPIs should be those that better characterize the PPP under study and the environment (internal as well as external variables). This phase should be as thorough as possible and initially should have a comprehensive focus. Workshops and unstructured interviews with teams of experts are strongly recommended to define the list of KPIs, which should not exceed 70 variables.

b. Description of relationships between KPIs:

Relationships between KPIs are systematically discovered in a dual-entry table called structural analysis matrix. The first task is to build a qualitative matrix. By answering the following question, the group who have previously defined KPIs, fills in the structural analysis matrix for each pair of KPIs

¿Is there a relationship of direct influence between variable 1 and variable 2?

If there is not, one puts 0. If there is, one must ask if this relationship of direct influence has a low (1), medium (2) or high (3) level. The result is the first qualitative matrix (matrix 1 at figure 3). The second task is to build the quantitative matrix. To build it, preview questions are replaced by the relation between the variance of the time-series for variable *1* in respect to variable *2*. Consequently the 0-3 scaling values from the qualitative matrix are replaced in the quantitative matrix by the correlation coefficient between *1* and *2*. A correlation coefficient is the better proxy to the cause-effect relationship analysis made through the qualitative analysis. All limitations on this coefficient regarding to its cause-effect use should be considered. Calculus should be consistent with the time frame analyzed qualitatively (today, past, future). The result of the second task is the first quantitative matrix (matrix *2* at Figure 3).

Finally the third task is the building process of a weighted average between matrixes 1 and 2 (matrix 3 at Figure 3). This matrix allows the analyst to define an integrated qualitative-quantitative analysis tool, where weights given to both qualitative and quantitative data represent the importance level of qualitative and quantitative analysis within the PPP studied. Weights are defined upon the following aspects:

[6] Broadly defined by Godet (2004) as a tool that structures the pooling of ideas and helps to identify the main variables which are both influential and dependent to a system. Those which are essential to the evolution of the system. While this is a definition for a qualitative driven SAP, the original SAP designed by Godet has been adapted for this study purposes in order to apply a qualitative-quantitative SAP new version within the analysis.

- Qualitative or quantitative focus desired to the analysis.
- Quality, validity, reliability and influence of the qualitative relationships (matrix 1) within the PPP analyzed.
- Sustainability of quantitative data used as input to the matrix 2.

Finally, by adding all columns on each row of the matrix 3, a value regarding the level of influence for each KPI is obtained. By adding all rows on each column, a value regarding the level of dependence for each KPI is obtained. Influence and dependence levels are defined in the context of the PPP analyzed. These values are showed within ellipses at Figure 3.

Figure 3.
Structural analysis matrixes.

Matrix 1. Qualitative analysis

¿is there a relationship of direct influence between variable i and variable j ?

- 0 = no
- 1 = yes, and it is low
- 2 = yes, and it is medium
- 3 = yes, and it is strong

KPI code	1	2	3	4	5	6	7	8	9
1	3	3	3	2	1	2	2	2	1
2	3	3	0	1	2	0	0	1	3
3	2	2	3	2	3	1	2	2	2
4	1	1	0	3	1	1	2	1	2
5	1	0	1	1	3	0	2	2	2
6	0	3	2	1	1	3	2	2	1
7	0	2	3	1	1	2	3	2	3
8	2	2	0	2	1	2	3	3	2
9	3	1	2	2	3	0	2	2	3

Matrix 2. Quantitative analysis

Correlation coefficient (Pearson^2)

KPI code	1	2	3	4	5	6	7	8	9
1	1,00	-0,58	0,41	0,01	0,09	-0,39	0,13	-0,59	-0,48
2	-0,58	1,00	-0,88	0,48	-0,14	0,39	-0,08	0,88	-0,56
3	0,41	-0,88	1,00	-0,65	0,38	-0,35	0,11	-0,81	0,67
4	0,01	0,48	-0,65	1,00	-0,73	-0,06	-0,16	0,23	-0,65
5	0,09	-0,14	0,38	-0,73	1,00	0,11	-0,35	-0,36	0,04
6	-0,4	0,4	-0,3	-0,1	0,1	1,0	-0,3	-0,2	-0,7
7	0,13	-0,08	0,11	-0,16	-0,35	-0,28	1,00	0,20	-0,42
8	-0,59	0,88	-0,81	0,23	-0,36	-0,23	0,20	1,00	0,33
9	-0,48	-0,56	0,67	-0,65	0,04	-0,67	-0,42	0,33	1,00

Matrix 3. Qualitative-Quantitative analysis

Weighted average:
% Matrix 1
+
% Matrix 2

Matirx 1 = 50%
Matrix 2 = 50%

KPI code	1	2	3	4	5	6	7	8	9	Influence
1	2,00	1,21	1,70	1,00	0,55	0,81	1,06	0,71	0,26	**9,30**
2	1,21	2,00	-0,44	0,74	0,93	0,19	-0,04	0,94	1,22	**6,76**
3	1,20	0,56	2,00	0,67	1,69	0,33	1,05	0,59	1,34	**9,44**
4	0,50	0,74	-0,33	2,00	0,13	0,47	0,92	0,61	0,67	**5,72**
5	0,55	-0,07	0,69	0,13	2,00	0,06	0,82	0,82	1,02	**6,02**
6	-0,19	1,69	0,83	0,47	0,56	2,00	0,86	0,88	0,16	**7,26**
7	0,06	0,96	1,55	0,42	0,32	0,86	2,00	1,10	1,29	**8,57**
8	0,71	1,44	-0,41	1,11	0,32	0,88	1,60	2,00	1,16	**8,82**
9	1,26	0,22	1,34	0,67	1,52	-0,34	0,79	1,16	2,00	**8,62**
Dependence	**7,30**	**8,76**	**6,94**	**7,22**	**8,02**	**5,26**	**9,07**	**8,82**	**9,12**	

Notes:

Figures are indicative to show the process to calculate the structural analysis matrixes
Numbers at major rows and columns, represent a code given to each KPI

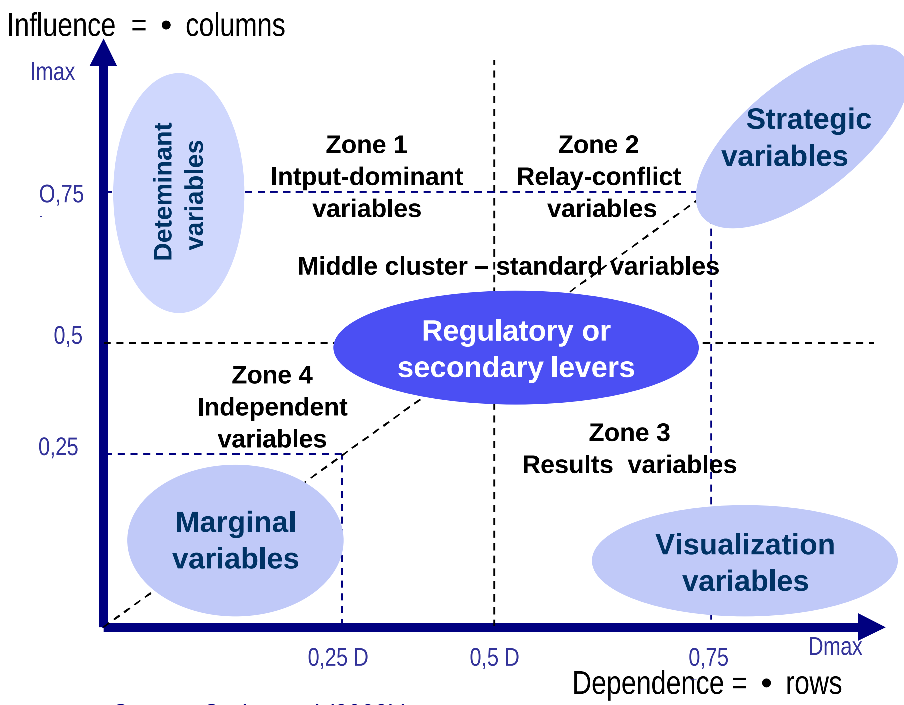
Source: Adapted from Godet et al (2002b)

This whole filling-in process helps analysts to systematically pose *n x n-1* questions for a group of *n* KPIs studied, some of which would have been ignored if such a systematic and thorough approach had not been adopted. This questioning procedure not only enables the analyst to avoid errors, but also helps he/she to organize and classify ideas by creating a common language within the group over the PPP analyzed. It also allows for a redefinition of the variables traditionally considered as KPIs to the PPP analyzed and therefore helps to make analysis of the PPP more accurate.

c. Identification of KPIs set of roles:

This phase helps to identify those KPIs essential to the PPP development, and to understand why they are essential. Firstly, a set of roles are identified through an x-y graph that draws dependence and influence values calculated at the previous step (adding up values of rows and columns respectively for each KPI at matrixes 1 and 2, Figure 3). This is known as the influence-dependence graph. By analyzing the relative position of KPIs within this graph, a rich source of information enables the analyst not only to have a detailed study of the importance of certain variables but also, helps to uncover certain variables which, because of their indirect actions, play an important role not easily evident from traditional cause-effect analyses. Figure 4 shows a standard *influence-dependence* graph. The typical role played by KPIs according to their positioning within this graph is described as follows.

Figure 4. Influence-dependence standard graph.



Source: Godet et al (2002b)

Zone 1:

<u>The power zone</u>, characterized by its high influence to the PPPs objectives and its low dependence from them, which makes KPIs located in this Zone, ideal to explain the determinants of those objectives. Actions, and/or decisions over KPIs on this zone:

- Affect highly the achievement of PPPs objectives.
- Are strongly recommended due to their optimal cost/benefit outputs in the short term.
- Are marginally affected by actions or decisions over KPI at other zones of the influence-dependence graph.

Zone 2:

The conflict zone, characterized by variables that equally affect and can be affected by changes over themselves or over KPIs situated in other zones. This makes their changes very unstable as they may affect other KPIs that may change them again, neutralizing effect of the first change. Actions, and/or decisions over KPIs on this zone:

- Affect KPIs on this and other zones with a strong inertial and unstable effect.
- Are not recommended as long as long as they are part of controlled and "step by step" changes on the PPP
- Should be carefully monitored due to its trend to change.
- Can generate strategic changes on the PPP objectives if KPIs are close to the diagonal axis.

Zone 3:

The output zone, characterized by highly dependent variables which are easily affected by changes in other KPIs, particularly from changes of KPIs situated at zones 1 and 2. Actions, and/or decisions over KPIs on this zone:

- Are not recommended due to their low cost/benefits outputs.
- Have better results when shifted to KPIs situated at zones 1 or 2.
- Generally speaking, demand minor resources (financial, institutional, operational), although only occasionally generate the expected results
- Should be monitored to avoid unexpected or negative effects.

Zone 4:

The independent zone, characterized by highly independent variables with only marginal effects over PPPs objectives (and KPIs situated in other zones), and cannot be affected by changes on those objectives. Actions and/or decisions over KPIs on this zone:

- Have marginal or unobserved effects over PPPs major objectives.
- May generate inertial changes over other KPIs within the same zone, but no over other KPIs.
- Demand major resources as long as they seek to impact PPPs objectives, obtaining low cost/benefits outputs from investments related.
- Do not require monitoring process as their changes cannot compromise PPPs objectives' achievement.

Additional roles can be seen from zones described at Figure 4 as follows;

- KPIs in the left side of Zone 1 are called dominants because the have the higher level of influence together with the lower level of dependence, which turns them into important controllers of change within the PPP.

- The KPIs closer to the diagonal axis within the Zone 2 are called strategic because of their determinant but unstable combination of high levels of influence and dependence. They are strongly recommended to generate structural changes on PPPs but they have to be carefully monitored.

- KPIs at the left-bottom corner of the Zone 4 are considered as marginal as they have none relevant effects over PPPs objectives achievement. This information is useful either to recommend their elimination from any analysis of the PPP under study, or to demonstrate potential low benefit/cost relationships that may come from investments oriented over these KPIs.

- KPIs in the middle of the influence-dependence graph are called regulators or secondary levers because they cannot directly generate major impacts on PPP objectives but indirectly via effects over other indicators (mainly those at Zones 1 and 2).

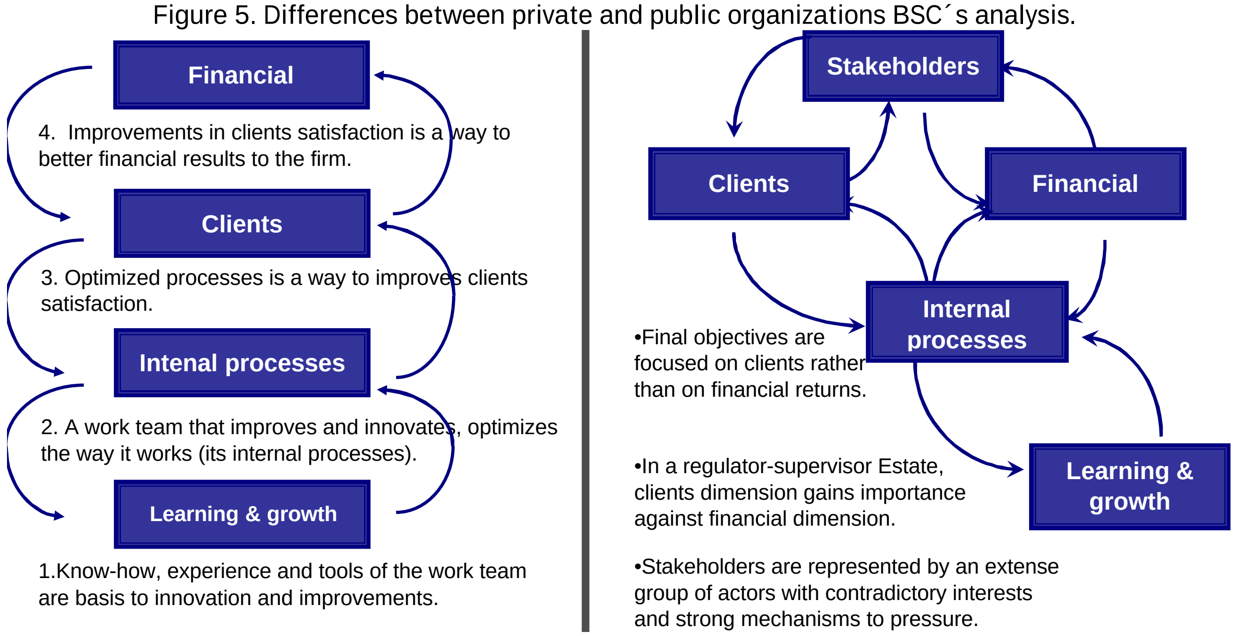
- KPIs at the right-bottom corner of Zone 3 are ideal to the PPP monitoring system, as they are the most sensitive of all the KPIs, been able to show any change within the dynamics of all the KPIs describing PPPs objectives.

3.2 The balanced scorecard tool

The balanced scorecard (BSC) is a management tool designed to help organizations towards the identification and implementation of its mission, vision, major strategies and key actions under four assumptions; i) financial indicators are not good inputs to define actions, when they are isolated analyzed; ii) a balanced vision of performance should includes measures associated with clients, internal processes and technical issues of the organization/subject under analysis, iii) organizations or sectors with better results usually have balanced sets of measures connecting strategies and action plans (Kaplan R and Norton D, 1996).

BSC analyses have been mainly applied at the private firm level, promoting sets of balanced KPIs to measure performance and taking advantage of its strategic-planning focus to help them in developing an integral mission-vision making process. General criteria to built scorecards at private sector, follows a cause-effect process which involves four dimensions of the firm; financial, clients, internal process and growth & learning. KPIs chosen are those that better measure firms objectives related to the four dimensions. From a public organization's point of view, mission and vision changes, as well as the cause-effect chain. In this case, a combination in social objectives achievement and efficiency on production factors is more important as an end in the cause-effect chain, as financial returns are to the private firm. See Figure 5.

Figure 5. Differences between private and public organizations BSC´s analysis.



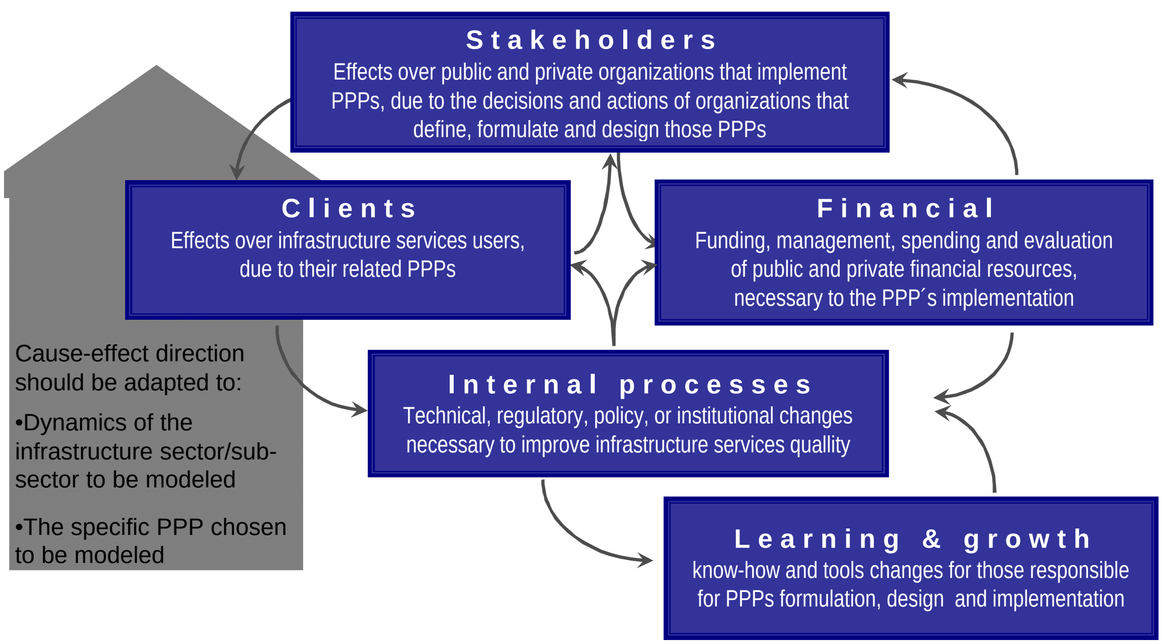
Source: adapted from BSC for government (2005).

The construction of a BSC to the DIES and SAPSB in Colombia, is a combination of elements from a typical public scheme (considering the infrastructure public policies making, implementation and evaluation as the central role of these organizations), as well as elements from a private sector scheme (considering the major played by private investments, agencies and multilateral banking within the promotion of infrastructure projects currently in Colombia). This integrated BSC scheme keeps the cause-effect way for the dimensions of internal processes and learning & growth at the bottom of the cause effect process.

The learning & growth dimension is characterized by all the know-how tools developed from these organizations in order to improve technical and managerial infrastructure projects knowledge. This includes studies, models, policy orientations, analytical methods and other know-how improvement processes at these organizations. The internal processes dimension includes all the technical, regulatory, policy or institutional processes that these offices need to apply to help in the improvement of infrastructure services quality. On the other hand, financial and clients` dimensions of the BSC have a typical private sector scheme due to the role played by users that no only include population in general but mainly private users, as well as donors, banks, private investors, funds and other financial agencies deeply involve in the development of infrastructure projects in Colombia. The clients` dimension integrates all the measures that help to understand the dynamics of infrastructure services from the users` point of view. These measures mainly include quality and cost-efficiency aspects of infrastructure services.

Finally, the at the top of the cause-effect chain, a special stakeholders dimension was defined in order to integrate all the organizations having particular interest in the infrastructure services delivery, finance, promotion or evaluation. They include among others, services operators and associations, special infrastructure funds, commercial and multilateral banking agencies, stock market agents investing in infrastructure, public-private associations, direct investors, researchers and the academic sector as well as consulting groups. See Figure 6.

Figure 6
BSC model to the infrastructure sector in Colombia



Adapted from "The Balanced Scorecard for Government Inc ., 2005"

The role played by the integration of BSC and structural analysis in infrastructure planning, emerges with the first one as a KPI´s visualization tool on trends, new projects implementation and future goals achievement, while the second one works as a control tool on defining those necessary projects and future goals. From this integration, historical trends of KPIs are evaluated both from their own individual evolution (traditional method), and from the cause-effect relationships between all possible combinations of pairs of KPIs (matrix analysis). The effect of new PPPs on current situation for a given sector, is defined through the characterization process that the structural analysis does both to the current situation of the sector and the parameters of the PPP to be implemented. In this sense, the financial dimension includes measures related with all the funding, management, spending and evaluation of public and private financial resources important to develop infrastructure projects.

3.3 The forecasting tool

Finally, future scenarios are analyzed under a systematic approach by combining scenarios planning processes and structural analysis criteria as tools to identify probable developments in the future and systematically constraint the simulation analysis from probable to feasible and doable developments. From a traditional point of view, forecasting models are tools that based on a set of assumptions of the KPIs modelled, simulates their future behaviour and generates sets of annual series as inputs for a planner in the development of his/her policy making or evaluation responsibilities. From a broader point of view a forecasting model is a systematic tool that helps planners to answer at least the first three questions of the strategic prospective (see figure 7)[7].

Figure 7.
The five key questions of the strategic prospective[8].

General question	IGF models context question
¿Who I´m I?	¿Who is the DIES and the SAPSB within the infrastructure sectors where they have planning functions? What do they do in developing those functions?
¿What could happen?	¿What are the probable, feasible or doable futures to the infrastructure in Colombia?
¿What could be done?	¿Which policies, programmes or projects could turn desired futures into a reallity?
¿What could I do?	¿Which strategies could make this policies to work better?
¿How I´m going to do it?	¿What set of actions (action plan) will be necessary to put strategies to work?

Source: own elaboration from Godet, et al [2000a].

According to this, a forecasting model is not only a set of figures that represent probable futures, but also and most important, a set of potential decisions to be taken today and in the nearest future in order to achieve a desired objective represented by a KPIs scorecard. The three questions that this type of forecasting model may help to answer for public organizations with infrastructure planning responsibilities are; i) ¿who I'm within the infrastructure sector where I have planning responsibilities?, ii) ¿what could happen within this sector?, and iii) ¿what could be done to help this happen?.

The first question helps organizations to clarify its specific role and to select KPIs that better measures that role within the sector. In this way a BSC focused on the organization's objectives within the sector is built (not a BSC on the sector's KPIs measures).

The second question involves all process of prospective analysis that the organization wants to develop in order to find probable and doable futures and in work for them.

The third question helps organizations to write down their strategic action plan consistently with its role and desired futures to the sector it works for.

7 Next two questions on figure 7 are responsibility of the analyst or the work team by using model results.

8 Right column includes implications of general questions within the IGF model's context.

4. Methodological integration of tools

The IGF model works under four general steps; i) problem definition and identification of KPIs, ii) KPIs historical trends analysis, iii) current situation and short term effect of new PPPs, and iv) KPIs forecasting simulation analysis. This section summarizes the methodology applied for each step. The following sections include pilot results related of this methodology to the water supply, electricity and telecommunications sectors.

4.1 Problem definition and identification of KPIs

By applying a semi-structured process of strategy formulation, this step seeks to filter past, current and desired objectives, targets and trends related to the PPP to be analyzed, through the four BSC dimensions showed at Figure 6. This helps organizations and strategic business offices to clarify what is actually the problem over which the IGF model is expected to help them[9]. It combines a top-down analysis from major PPP, results and indicators, together with a down-top analysis from a list of all the variables traditionally available and considered as KPIs to the PPP under analysis. The top-down process starts with a brainstorming analysis on sector, sub-sector or service to be focused in. The brainstorming includes statements on mission, success areas, objectives, variables and indicators related to sector, sub-sector or service chosen[10]. Each participant filled a standard sheet with a set of statements based on general definitions as showed in Figure 8, that are categorized down into BSC dimensions. A second questionnaire focuses on the success areas and objectives definition by driving respondents through the following issues[11]:

- On their main working relationships:
  - ¿Who are you working for?
  - ¿Who supply you information? ¿who are benefited from your results?
  - ¿Who takes decisions together with you?
  - List your own perspectives on the subject your work is focused.
  - List your main working relationships.

- On their success areas from different points of view:
  - ¿How do you support DNP and DIES mission and vision?
  - List the PPPs you're currently working on.
  - List other PPPs you consider key to be working in.
  - ¿What would you like to do on those other PPPs?
  - From this, list all your success areas.

- On their objectives for each success area;
  - ¿How do you know, you have reach success on the areas listed above?

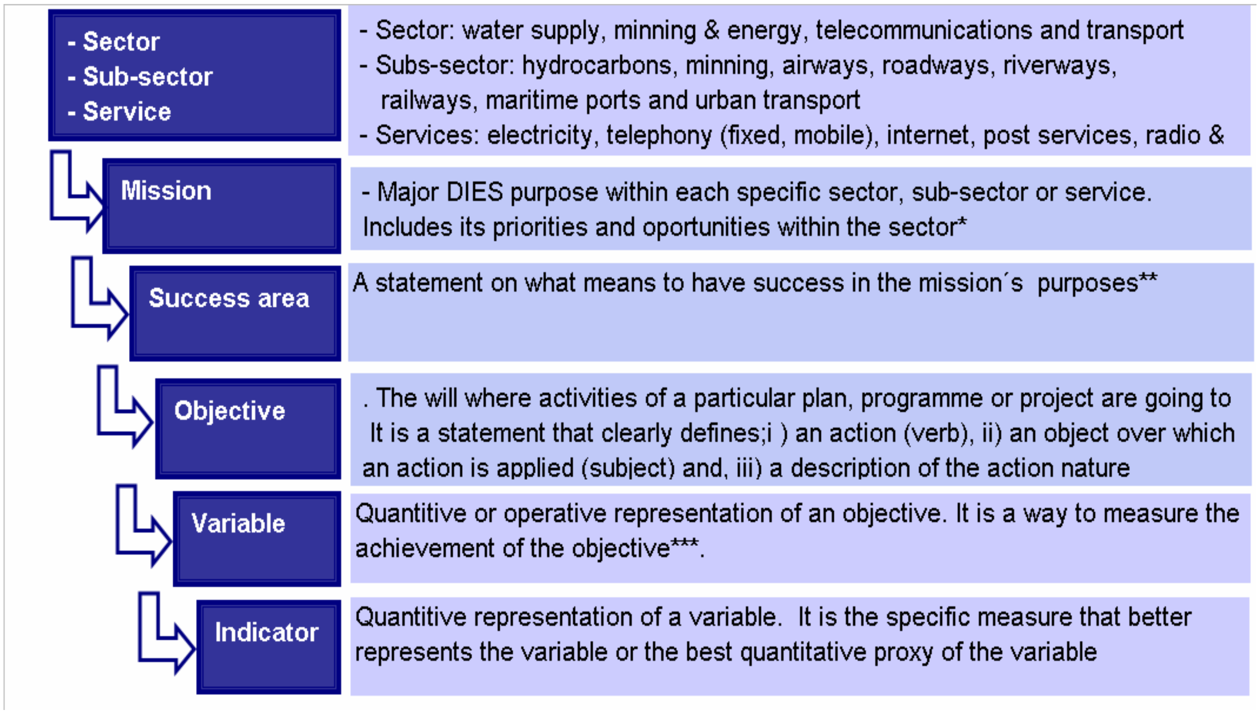
9 Torres-Gracia (2001) demonstrates weaknesses on problem definition across many infrastructure planning organizations in Colombia. These weaknesses have been related with policy making and implementation problems as well as poor performance. Organizations or sectors with better problem definition know-how demonstrated better and more sustainable performance on the infrastructure sectors they were working for. Research also suggest a semi-structured as the more efficient planning focus to improve problem solving processes across infrastructure planning organizations within the Colombian context.

10 The model also allows planners to choose a specific policy, programme of project as the analysis frame.

11 Scope of the model applies to answer these questions for projects, programmes or policies.

- List major objectives related to each area.
- List variables that better represent those objectives.
- List all the indicators that better measure those variables.
- Chose indicators that better satisfy following criteria regarding each objective; objectiveness, pertinence, measurability, availability, easy to update, cost-efficiency.

Figure 8.
Strategy formulation model applied to the problem definition phase.

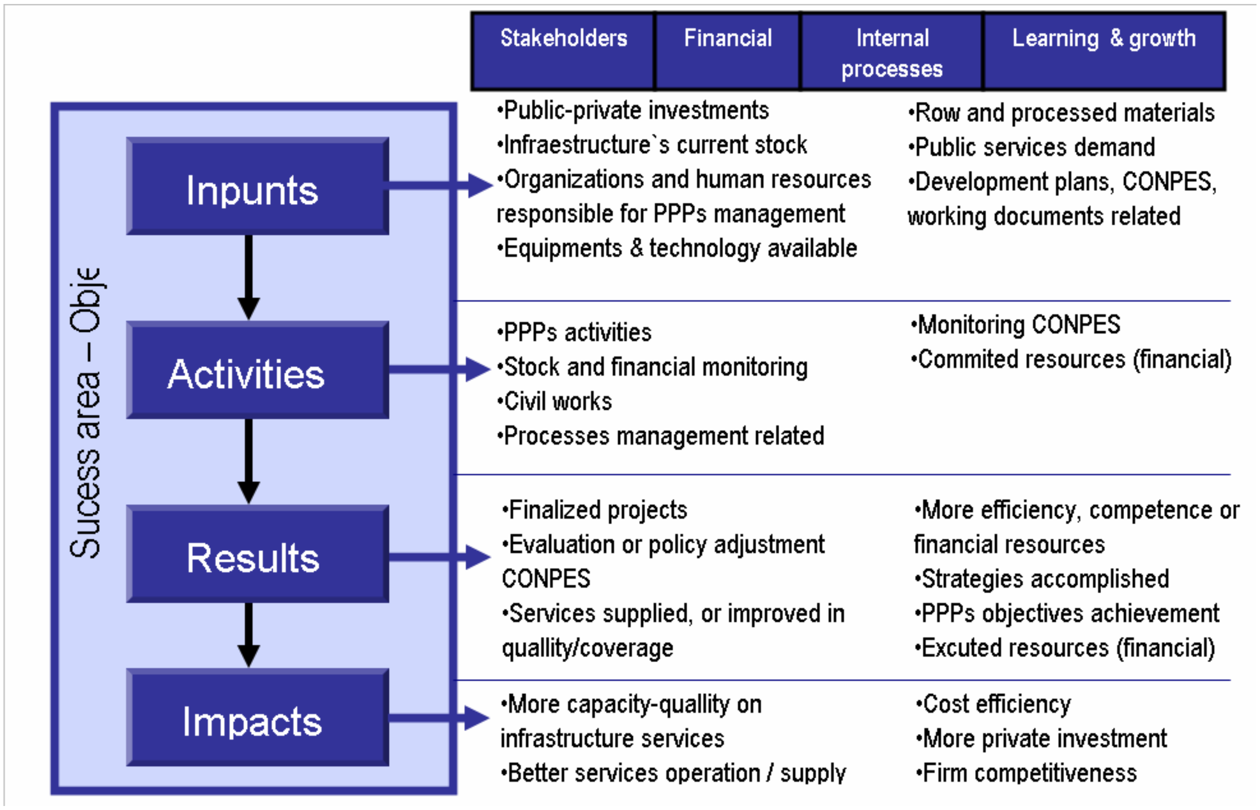


* Hax, a.c et al (1991) "The strategy concept and process; a pragmatic approach" Prentice Hall
** Khadebn et al (1988) "One page management". Morrow & co. Inc
*** Sinergia-DNP (2004) "Guía para elaborar indicadores" ; Veis (2001) "Glosario della recerca valutativa"; Delph et al (1977) "Systems tools for project planning"

A final process on the problem definition and KPIs identification step is a double-check process on the KPIs balanced scorecard resulting from activities described above. Criteria against which the list of KPIs is checked, include a balance between the four dimensions of the BSC from one side (see Figure 6), and the balance between the four phases of a PPP cycle from the other side.

The second criteria means a balance between indicators measurement's subject including inputs, activities, results and impacts of the PPP analyzed. This allows results to be useful on a wide set of evaluations including management evaluations (activities/results), expost evaluations (objectives/results), efficiency evaluations (inputs/results/impacts) and impact evaluations (inputs/impacts). Figure 9 summarizes this double-check process.

Figure 9.
Double balance of KPIs between BSC criteria and PPP implementation cycle.



Source: Own elaboration from World Bank (2004c)

4.2 Module 1; KPIs historical trends analysis

This is the first modelling step and it helps to identify both KPIs past evolution as well as the role played for each KPI, along the analysis period. It combines the traditional approach on past trends evaluation and diagnosis, with a structural analysis process over the same KPIs. Methodological approach analyses historical trends independently for each indicator, without consider causal relationships as a systematic tool to understand KPIs dynamics. A structural analysis result on the contrary, includes an influence-dependence graph which is based on qualitative and quantitative causal relationships between KPIs under study (see figure 4).

Its results, apart from including traditional trends analysis, helps to understand the global role historically played by each KPI within the sector as a key input to explain not only how the KPIs past trends have evolve, but more important, why those trends have been the way they were. This is a key input not only to evaluations but to guide current or future decisions within the PPP analyzed. This module seeks to understand ¿where a sector is coming from? and, ¿why is coming from there? The general process applied includes the three steps generally explained at section 3.1, with the following specificities on each step:

i) KPIs identification:

A fixed time frame should be chosen. This time frame depends both on focus and data availability of the analysis. Consistently with presidential periods, four years periods are recommended[12]. Once the first influence-dependence graph is built, variables situated at the left-bottom corner of its zone 4 (see figure 4) might be eliminated for further analysis. Therefore it is recommended an extensive approach in making the first list of KPIs. However, limitations on the number of KPIs should be considered, regarding on the geometric growth of KPIs relationships that need to be qualitatively analyzed[13].

ii) Description of the relationships between KPIs:

The result of this step is an influence-dependence graph that integrates the qualitative and quantitative KPIs relationships analysis (as showed in Figure 4). Once a Figure 4-type graph is drawn, next step focuses on the interpretation of this influence-dependence graph, according with standard interpretations for each zone of this graph, showed at section 3.1-c. If the influence-dependence graph resulting has problems of interpretation, include not intuitive results, or simply a more accurate analysis is desired, the model allows an iteration process to refine selection of KPIs. See figure 12.

iii) Identification of KPIs set of roles:

This final step seeks to describe the historical role played by each KPI. This role is defined from the relative position of each KPI within the influence-dependence graph. Depending on this position, a set of differentiated roles can be interpreted for each KPI following standard interpretations explained at section 3.1-c. These interpretations have to be referred to the historical time-frame used to the analysis. They are useful to explain not only the whys of past behaviour, but more importantly, to guide decision-makers on current and potentially future implications of their decisions related with the KPIs analyzed. Figure 10 summarizes some of those implications in terms of recommended actions over each KPI, regarding the zone it is positioned within the historical influence-dependence graph

As Figure 10 shows, KPIs positioning within the historical influence-dependence graph reveals not only the role played by each KPI in the past of the PPP analyzed but also the inputs to explain success or failure over past strategies and decisions as well as a guide to drive short term decisions, strategies and actions. This short term guide allows planners to optimize benefit/cost ratios from a set of strategies that need to be putted in place towards the achievement of the PPPs analyzed objectives (a prioritization tool). It also helps to identify KPIs particularly conflictive due to the unstable effects they can generate over many key variables. This is key information to take decisions on strategic actions. Another useful input comes from identifying actions that won't impact at least in the short term the achievement of the PPP objectives (autonomous variables). Decision makers will also realize that autonomous KPIs are not recommended as forecasting variables.

12 If a given KPI has less than four years of data, it is strongly recommended to replace it for the better proxy with four years of data available. If it has more than four years of information but interrupted (a year without information), the model uses stochastic methods to fill time-series gaps (by using LaGrange's linear interpolation method). This filling process is achieved as long as no more than three consecutive years need to be filled. Generally speaking, indicators that do not need this interpolation process should be preferred.

13 If *n* KPIs are chosen, $n \times n - 1$ relationships need to be analyzed. Generally speaking, a maximum of 20 KPIs is recommended to characterize the PPP under study.

Figure 10
Short term recommended actions typology from historical KPIs role (see Figure 4).

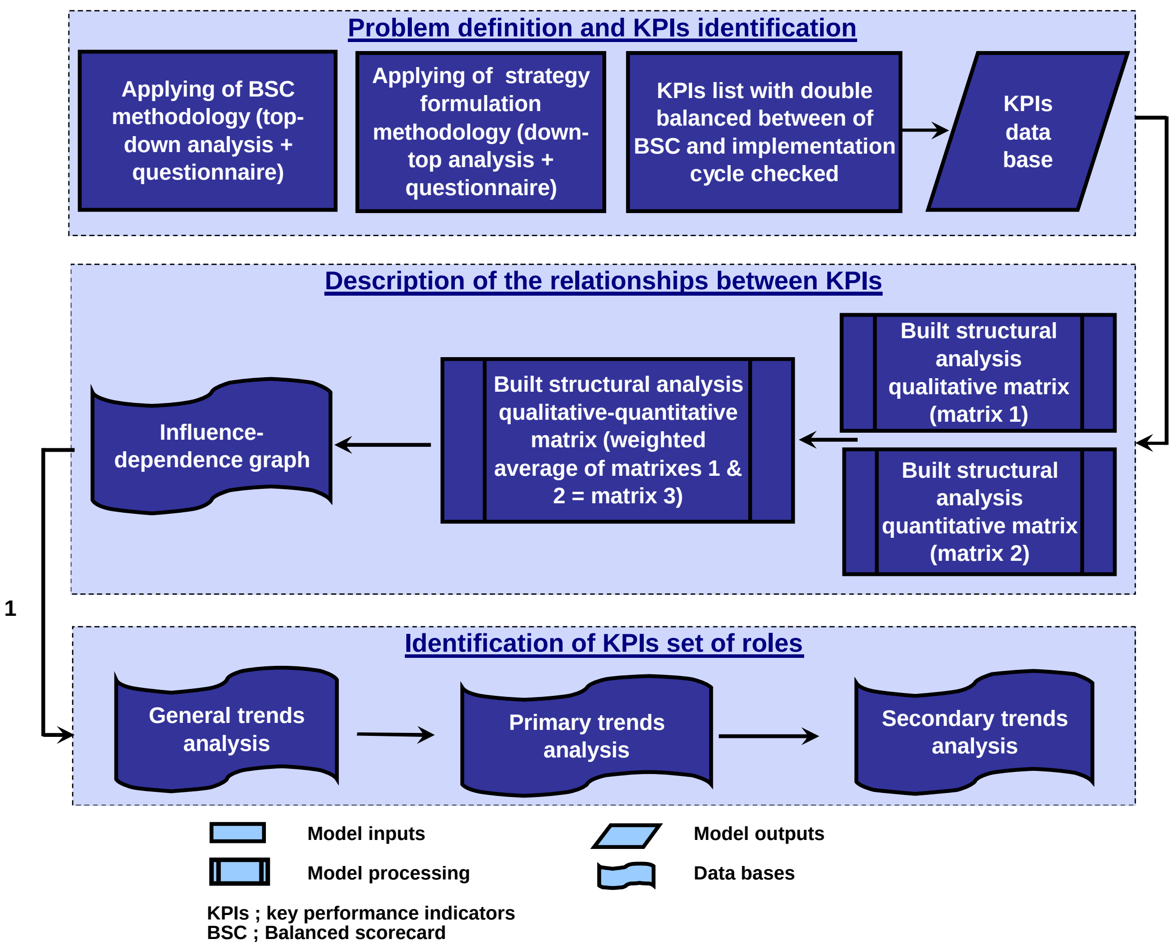
Zone*	Recommended actions
1. Dominant KPIs	All decisions/actions seeking structural or major changes to the PPP Short time effects actions/decisions or those actions demanding a Actions/decisions seeking to change trends on zone 4 KPIs Actions/decisions that do not seek to change trends on KPIs at zone 1 (due to their relatively low dependence)
2. Conflict KPIs	Actions that seek for structural or major changes as long as their effects can be closely monitored and controlled Actions seeking changes in strategic KPIs close to diagonal axis of the zone. They need close monitoring and control
3. Dependent KPIs	Actions should be focused on building monitoring systems using these KPIs to follow PPPs objectives achievement These KPIs are very easy to change by actions over KPIs at zone 1 Actions directly over these KPIs are strongly no recommended due to its marginal benefit/cost ratio Actions over KPIs at Zones 1 or 2 that change trends of KPIs at zone 4. Need lower resources to meet that change (financial, institutional and technical resources). However those changes also have lower benefit/cost ratios
4. Independent KPIs	Actions over these KPIs have not optimal benefit/cost ratios. To improve those ratios, actions demand structural changes across all KPIs here, tend to change because of its own inertial dynamic rather that because of effects induced by changes in other KPIs Actions that change KPIs in other zones cannot affect KPIs trends in Actions that seek to generate effects in the long term trough changes on these KPIs are strongly not recommended
Standard KPIs	Actions seeking indirect effects over PPPs objectives. This due to Actions that seek changes in the long term as long as their forecasting simulations have consistency with other KPIs forecasts
Marginal KPIs	None actions of any kind are recommended over these KPIs if changes over other KPIs are expected from those actions. (they Only actions that will not impact this PPP. They could distract or been distractedly used if they are applied over KPIs traditionally considering as dominant within the PPP. (a politically misused action)

*Quadrant within the influence-dependence graph where the KPI is located.
Source; own elaboration from Godet, et al [2000a].

All these results change structurally the descriptive approach of traditional diagnosis across many infrastructure planning organizations in Colombia. Traditional diagnoses tend to explain what happened rather that why happened that way. These diagnoses are even weaker to link past trends with decisions that should be taken today. This is why, the application of the KPIs historical trends analysis –HTA here explained, represents a competitive advantage to infrastructure planning agencies. Figure 11 summarizes HTA of KPIs process explained through section 4.1 and 4.2. Main results from HTA include:

- General trends analysis; a diagnosis on main growth ratios and evolution trends of KPIs. It is presented as the traditional descriptive approach on which, sets of time-series graphs, show evolution along the analysis period for each KPI independently. This is a graphical representation on what happened in the KPIs past.
- Primary trends analysis; a diagnosis on the most influential causal relationships for the dominant and dependent KPIs. It shows the KPIs more affected by dominant indicators, as well as which were the indicators that more affect dependent KPIs. This is a graphical representation on why trends happened as general trends analysis showed.
- Secondary trends analysis; a diagnosis on the secondary levers that indirectly are better related to the primary causal relationships identified by the previous result. It is a deeper step into the primary causal chain that helps to identify the indicators more affected by those KPIs more affected by dominant indicators. It also helps to identify KPIs that more affect indicators affected by dependent KPIs. These results represent a step forward in the causal chain of the PPP analyzed, giving strategic inputs to explain why trends happened in a particular way.

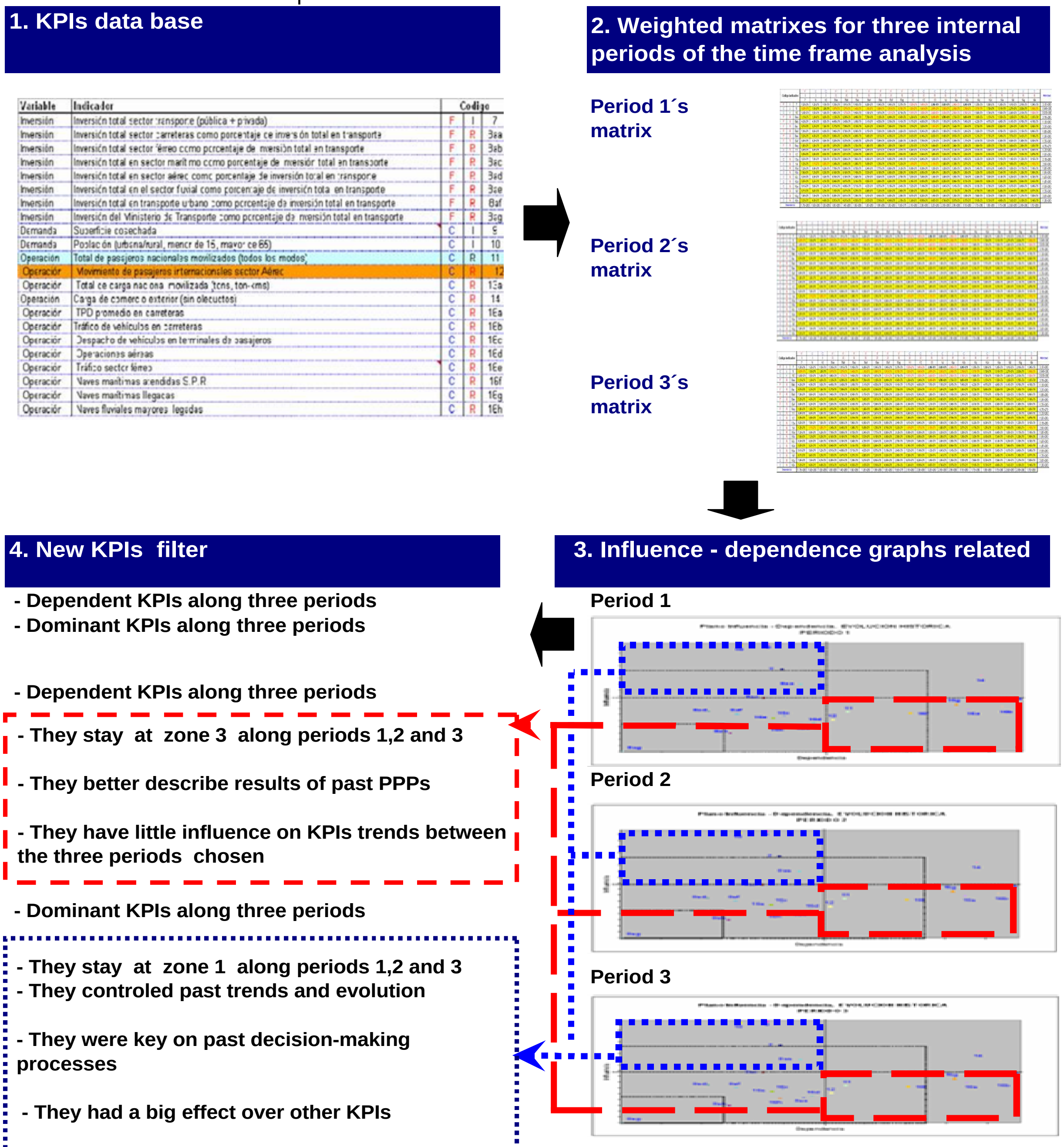
Figure 11
Module 1 process-historical trends analysis



(1) Depending on the quality of results up to this phase and the precision expected in the level of analysis, a second iteration may be achieved a this stage. This iteration activates a double check process that enables the model to refine the relevance of KPIs chosen. Details on the iteration process are showed at Figure 12.

Source: own elaboration.

Figure 12
Iterative process to refine KPIs identification in Module 1[14]



Source: own elaboration

[14] The process starts from the KPIs data bases which results from the phase of problem definition. Instead of only one time frame of analysis, this frame is divided by three historically representative periods and a qualitative-quantitative matrix is calculated for each period (a weighted matrix). Three influence-dependence graphs are drawn respectively. KPIs that remain dependent and dominant in the three graphs (zones 4 and 1) are finally chosen and phase two of the general process (description of the relationships between KPIs) is resumed. To choose the three periods on which preliminary time frame is divided, it is recommended to consider periods within which trends and growth rates tend to be constant (or change but marginally). Periods could have same or different number of years and four years minimum is recommend for each period. This iteration process is recommended when structural changes on evolution and trends are presented within the time frame preliminary chosen.

4.3 Module 2; Current situation and short term effect of new PPPs

This is the second modelling step. It helps to characterize current situation of a given infrastructure PPP, and to study changes on that PPP due to the implementation of new PPPs. This is done by characterizing the PPP to be implemented in, through some of the KPIs chosen to characterize the current situation and deconstructing differences between two comparable influence-dependence graphs. The first graph represents the current sector or PPP and the second graph represents the same sector or PPP under analysis but adding the effect of the new PPP to be implemented, within the structural analysis. This is a combined -*where it comes from & where it is now*-, type of analysis, which develops three major steps as follows.

i) Current situation characterization:

The objective is to represent the way a sector or a given PPP is performing today by using a selected group of KPIs and applying the three standard steps of the structural analysis process as explained in section 3.1 (main characteristics for each step), as follows:

<u>KPIs identification</u>:
It replicates the phase of problem definition and KPI identification of the Figure 11. This means a combination of balanced scorecard, strategy formulation and PPPs implementation cycle methodology. This process is considered necessary as long as the PPP over which the effect of new policies, programmes or projects has not been accurately and clearly defined. The main difference in this case is the time-frame chosen, considering this is a current situation analysis. On this sense, a period that starts from the year when the analysis is made and goes back between 3 to 5 years should be chosen[15]. An alternative way here, is to keep the same KPIs chosen within the historical trends analysis process (module 1), whether the PPP for this case is the same analyzed for that process. In any case, the final result should be a data base of annual series to the indicators that better characterize current and potentially closer future of the PPP under study.

<u>Description of relationships between KPIs:</u>
It replicates the second phase of Figure 11. This means a structural analysis process resulting on an influence-dependence graph that draws down values of a weighted matrix which represents causal relationships and roles between the KPIs chosen. The structural analysis matrixes are calculated to the 3-5 years period chosen in the previous step. In terms of the qualitative matrix, this implies that scaled values should be estimated for that period. Consequently, correlation coefficients should be calculated for the same period regarding the quantitative matrix. Usually KPI values for the last year are not available for several reasons therefore the model applies a filling up process that improves the quality of the data bases as representative of the current situation[16]. The filling up process simulates values where there are lacks in the KPIs data base. By applying three adjustment criterions, mathematically simulated values, are the better proxy of current KPIs trends. Simulation process is based both on historical trends and causal relationships between KPIs[17]. See Figure 13.

15 Based on the following criteria: i) a minimum set of years to get a representative correlation analysis for the quantitative matrix ii) a maximum set of years that could be called as current situation because trends on nearly all the KPIs chosen do not change structurally across those years.

16 Last year data is usually not available because of: i) the last year is the same year when analysis is done, ii) time series are in an annual basis, iii) the year has not end yet when data was collected, iv) data collecting and publication process could be a complex process in many infrastructure sectors, therefore annual series available are updated between 1 and 3 years before the current year.

17 When refereed to the current situation analysis, historical trends are related to no more than 3 to 5 years of past trends.

Figure 13. Annual series filling up criterions.

	Criterion 1. Better historic adjustment	Criterion 2. Better cause-effect adjustment	Criterion 3. Annual growth average adjustment
Description	Forecast adjusted to the curve with both the highest R2 against time, and a feasible forecast to the KPI according to the analyst experience.[1]	Forecast adjusted to the curve with the highest value in the qualitative-quantitative matrix for the KPI analysed against all the other KPIs included within that matrix.	A linear forecast adjusted to the annual growth average registered within the period of analysis
General assumptions	Future trends of the KPI analyzed are function of its past behaviour within a given period.	Future trends of the KPI analysed are function of its cause-effect relationships with the most influential variable considered within the matrix analysis, for a given period. If the qualitative-quantitative matrix does not help to identify a feasible forecast, the highest value mentioned in the description should be searched at the quantitative matrix. [2]	Future trends of the KPI analyzed depends on an average of its past behaviour for a given period, and a fixed coefficient that multiplies that avegare trend. The coefficient is chosen according to the analyst criteria. This forecast it is not always similar to the historic or to the cause-effect criteria.
Calculus	Better historic adjustment curve is automatically chosen from the following options:[3] - Linear adjustment; $y = mX + b$ - Logartmic adjustment; $y = m\,Ln\,X + b$ - Power adjustment; $y = mX^b$ - Euler`s adjustment; $y = m e^{bx}$ -Polynom adjustemt (grade *n*) ; $y = m_1X^n + m_2X^{n-1} + m_3X^{n-2} \ldots + m_nX + b$	a) In the qualitative-quantitative matrix, chose the column of the KPI to be forecasted b) On that column , chose the higher value, and the KPI related with that value c) Check whether a correlation between this second KPI chosen and the KPI to be projected, represents a feasible forecast according to the analysist criteria. d) If it is feasible, chose from curves at Criterion 1, the adjustment curve representing the better proxy to the KPI to be forecasted. e) In it is no feasible, chose the second higher value at the qualitative-quantitative matrix, go to step c) and resume the process up to find a feasible forecast.	- Calculate the annual growth average to the selected period -Multiply that average by the coefficient selected and used the result to calculate the annual forecasted values for followin years [4]

Notes:

[1] A high R2 , does not necessarily represent a high cause-effect relationship. Therefore, the analysis should check among the set of adjustment curves, the one representing the most feasible proxy to the KPI that needs to be forecasted.

[2] The quantitative and the qualitative-quantitave matrixes mentioned here, correspond to matrixes 1 and 3 at Figure 3

[3] With; y = KPI to be forecasted, X = year of forecasting, and m & b = adjustment coefficients. To the polynom adjustment, values of *n* were chosen between 2 and 5. The process to chose the better adjustment curve can be automatically applied by using spreadsheets standard applications.

[4] This cofficient is 1 if future gowth wants to be adjusted to historic trend. It its less than 1 when a slowing down trend could be expected to the future of the KPI, and higher than 1 in case of a speed up trend.

Source: own elaboration.

The influence-dependence graph that finally results from this process can be analyzed through the standard roles interpretation previously explained at figures 4 and 10 having focus on the time frame used to the current situation analysis. In this case, that interpretation provides an integral ¿where are we today?-type vision to the PPP under analysis. Considering that apart from being descriptive on current trends and dynamics of its KPIs, it generates key inputs on today's and future decision making processes, thanks to its systematic way to answer the question ¿why the PPP is there today?.

Up to here, the module has been essentially a systematic analysis tool useful to make integral diagnosis and expost evaluations. From this step on, the model it is added with prospective analysis tools that provide planners and related analysts with value added inputs on their decisions making processes. These inputs are essential to have; i) a short range impact's analysis tool that provides consistent and systematic results on KPIs trends before and after a given policy, programme or project is implemented, and, ii) a medium and long range impact's analysis tool that enables visualisation of both KPIs future trends and future roles on those KPIs. It also provides a unique scorecard to guide future decision making processes under the scenarios planning environment. By applying these criterions, a theoretical assumption is taken that today's dynamic of a given KPI is function of both its own historical trends and its stronger causal relationships with other KPIs included within the analysis. In both cases, time frame is related to the closer past. Once data bases have been filled with these simulated values, it is possible to build the matrix and draw the respective influence-dependence graph that represents causal relationships between KPIs.

Consistently with Module 1 (historical trends analysis), an iteration process can refines KPIs selection step if the first influence-dependence graph cannot generate satisfactory interpretations. This iteration process is shown at Figure 14.

ii) Characterization of new PPPs:

The objective of this step is to describe a policy, programme or project to be implemented, through some indicators coherent with KPIs chosen to characterize the current situation of the sector(s) where that PPP will be developed. To achieve this, a fist task to characterize the new PPP throughout its major parameters, needs to be done, as well as a review about the KPIs of the sector mainly affected by the new PPP`s implementation. Then, common indicators from both tasks are chosen as those that better describe the new PPP. These indicators are the first inputs to the effect analysis tool. Regarding the PPP major parameters, an infrastructure policy, programme or project can be represented trough financial, operation, stock or institutional indicators. The ideal set of indicators should include at least one for each of those aspects. PPPs specifically related to the coverage of public services, as some pilot results showed ahead, usually can be represented trough indicators such as investments to increase coverage (public or private), effective coverage growth due to the project, effects on other aspects to the service due to the coverage growth like quality, technical adjustments and institutional capacity.

Once indicators representing the PPP to be implemented have been chosen, its impact on the current situation can be estimated. To do this, KPIs data bases used to calculate the influence-dependence graph of the previous step (current situation without the PPP) have to be updated by adding annual series from the indicators representing the PPP[18].

18 Annual series on indicators representing the PPP are necessary. (i.e. investment plans, construction schedules, or physical stock plans yearly based). This investments or physical stock plans are translated into annual series that should be added to their correspondent KPI´s current situation (those that characterize the sector were the PPP will be implemented).

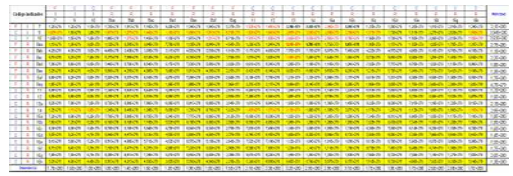
Figure 14

Iteration process to refine KPIs identification in Module 2[19]

1. KPIs data bases

Variable	Indicador	Codigo		
Inversión	Inversión total sector transporte (pública + privada)	F	I	7
Inversión	Inversión total sector carreteras como porcentaje de inversión total en transporte	F	R	3aa
Inversión	Inversión total sector férreo como porcentaje de inversión total en transporte	F	R	3ab
Inversión	Inversión total en sector marítimo como porcentaje de inversión total en transporte	F	R	3ac
Inversión	Inversión total en sector aéreo como porcentaje de inversión total en transporte	F	R	3ad
Inversión	Inversión total en el sector fluvial como porcentaje de inversión total en transporte	F	R	3ae
Inversión	Inversión total en transporte urbano como porcentaje de inversión total en transporte	F	R	8af
Inversión	Inversión del Ministerio de Transporte como porcentaje de inversión total en transporte	F	R	3ag
Demanda	Superficie cosechada	C	I	9
Demanda	Población (urbana/rural, menor de 15, mayor de 65)	C	I	10
Operación	Total de pasajeros nacionales movilizados (todos los modos)	C	R	11
Operación	Movimiento de pasajeros internacionales sector Aéreo	C	R	12
Operación	Total de carga nacional movilizada (tons, ton-kms)	C	R	13a
Operación	Carga de comercio exterior (sin oleuductos)	C	R	14
Operación	TPD promedio en carreteras	C	R	16a
Operación	Tráfico de vehículos en carreteras	C	R	16b
Operación	Despacho de vehículos en terminales de pasajeros	C	R	16c
Operación	Operaciones aéreas	C	R	16d
Operación	Tráfico sector férreo	C	R	16e
Operación	Naves marítimas atendidas S.P.R	C	R	16f
Operación	Naves marítimas llegadas	C	R	16g
Operación	Naves fluviales mayores llegadas	C	R	16h

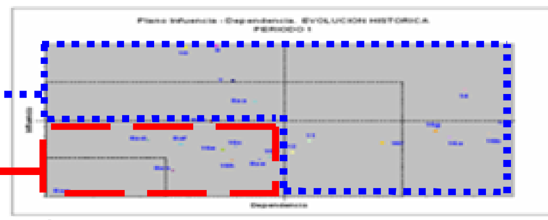
2. Weighted matrix for a current representative period



Representative period:

- Statistically representative to the correlation analysis
- Only marginal changes in KPIs trends within the period

3. Influence - dependence graph related



4. New KPIs filter

-Excludes marginal & standard KPIs

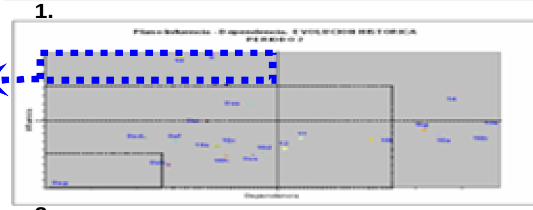
- Marginal KPIs are independent from the PPP analyzed.
- They cannot affect or been affected by the PPP.
- Standar KPIs play an unstable role which may leads to misconceptions

- Includes :

1.- Dominant KPIs outside standard zone

- They have a major influence over current situation.
- Decisions focused on them are strongly recomended due to the high benefit/cost ratio resulting

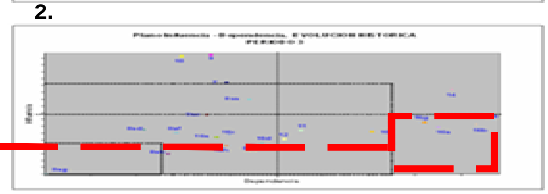
1.



2.- Dependent KPIs outside standard zone

- They are ideal to visualize PPP results.
- Decisions focused on them are strongly recommended due to the low benefit/cost ratio resulting

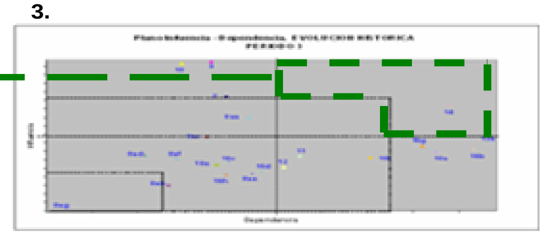
2.



3.- Conflict KPIs outside standard zone

- Strong power and influence to affect the PPP.
- Decisions focused on them are strongly recommended as long as they are carefuly monitored to avoid inertial or none expected effects over other KPIs.
- Useful for conservative decisions that seek for marginal adjustments.

3.



Source: own elaboration

19 The process starts from the KPIs databases built from the KPIs identified in the first iteration. Then a deeper review is made to the time-frame selected as current situation. In this case a representative period corresponds with the maximum number of years between the current year and the last year in the past where any KPI have changed 15% or less from the current year. This helps to have a time-frame statistically representative and with only marginal changes on its KPIs, which is considered as a good proxy of their current situation. Once the time-frame is reviewed the qualitative-quantitative matrix is recalculated and the influence-dependence graph is amended. Then KPIs can be identified from this graph. Those KPIs that cannot adequately represent current situation include the ones at marginal and standard zones. Those considered as good proxy to the current situation in the following order are: dominant KPIs outside the standard zone (influence-dependence graph No.1 at Figure 14, dependent KPIs outside the standard zone (influence-dependence graph No.2), and conflict KPIs outside the standard zone (influence-dependence graph No.3).

This adding process, affect only those KPIs expressed exactly in the same terms that PPP´s indicators are expressed[20]. The rest of KPIs are causally linked with directly affected KPIs through the better adjustment curves that were determined to fill empty year on KPIs today's annual series (see Figure 13). The adjustment of these not-directly affected KPIs, is an automatic process within the model data bases[21].

iii) Identification of KPIs set of roles:

As generally explained above, the objective to this step is to estimate the impact that PPP characterized in the previous step, may have over the sector where is expected to be implemented. To do this, updated data bases from previous step (those adding up effects of new PPP), need to be used in order to repeat the standard process of analysing relationships between KPIs. Therefore, three new matrixes are calculated representing qualitative, quantitative and qualitative-quantitative relationships. Matrix 1(qualitative) is subjectively updated by changing those relationships that the analyst estimates, are mainly affected by the new PPP. Matrix 2 (quantitative) is automatically updated from the previous step by using annual time series that have been changed on data bases (thanks to the adding effect of new PPPs indicator over current situation's KPIs). Matrix 3 (qualitative-quantitative) is also automatically calculated as a weighted average between matrix 1 and 2[22]. The new identification of KPIs roles comes from the resulting influence-dependence graph. This graph represents current's situation of the sector as if the new PPP where already implemented (short range impact situation). By studying differences between the graphs resulting here and the one resulting at the step i) within this section, the model generates detailed inputs for the analyst to make a comparative analysis on the effects of new PPPs implementation. These effects can be analyzed in two groups; effects on each zone of the influence-dependence graph, and effects on each KPI individually.

In the first case, changes in the composition of dominant, dependent, independent and conflict's zones are inputs to confirm or adjust actions within the new PPP implementation process, depending on which changes are considered positive or negative to the future of the sector. In the second case a detailed comparative analysis over each indicator, helps analysts to review short range decisions/actions that were designed to affect a given indicator particularly. Additional to these groups, analysis can be making on the level of change over KPIs. This generates value-added inputs to planners regarding both KPIs sensitiveness to the PPP implemented, as well as pre-active and pro-active decisions to facilitate changes expected or neutralize unexpected changes.

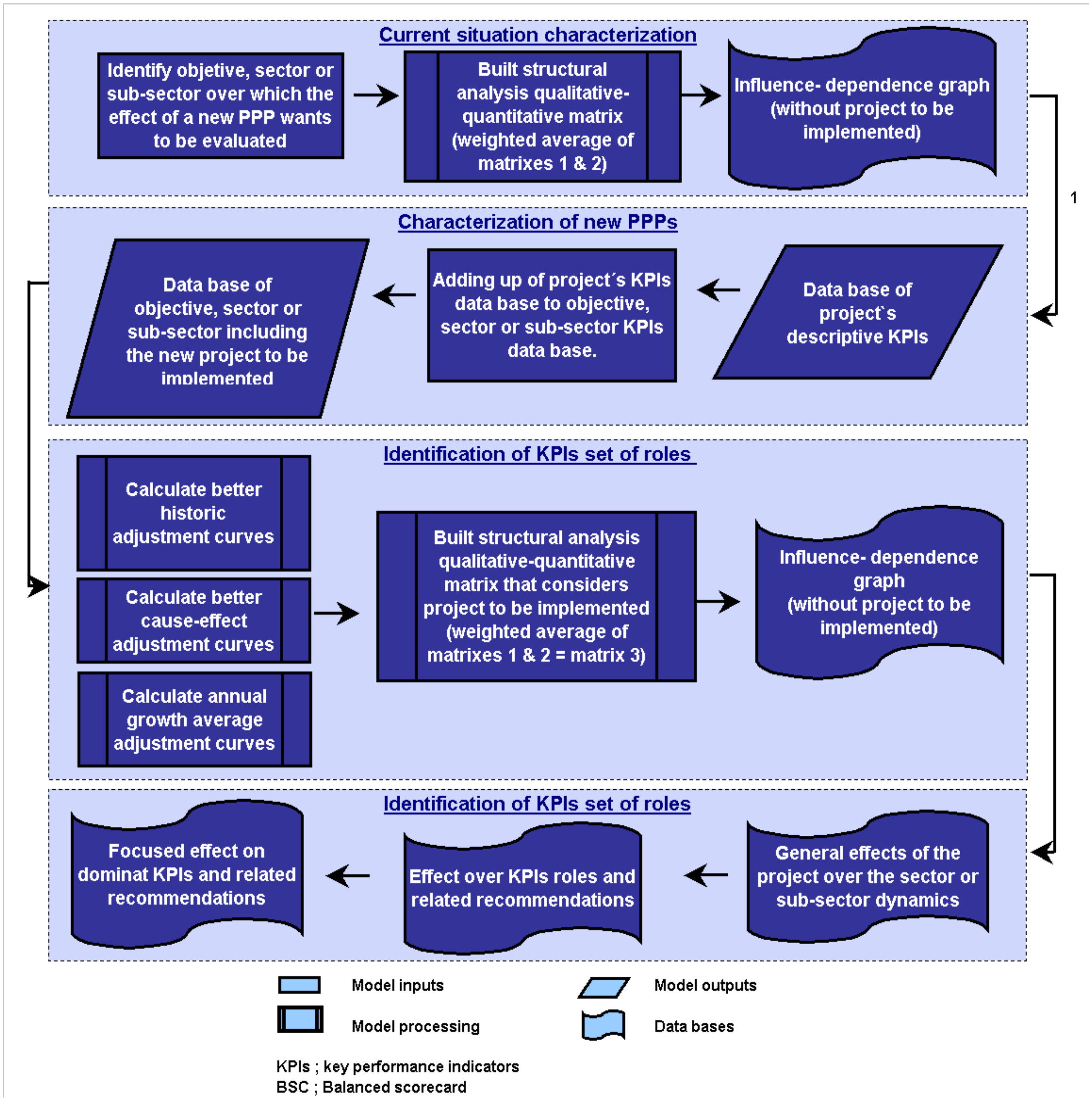
This means a guide to structurally take decisions about controlled changes in the short range, which may represent a structural addition to the way the implementation of new policies, programmes or projects is achieved across infrastructure sectors in Colombia. As long as top level managers keep interest to improve quality and results from their decision making skills, there will be options to improve performance of those infrastructure sectors trough the advantage of systematically integrate their political and technical parameters, into a short term modelling tool such as the IGF model. Figure 15 summarizes the whole module 2 process, including its major inputs, procedures, outputs and data bases. The internal iteration process that can be made at this module was shown at Figure 14.

20 i.e. public investments if PPP´s indicators include new public resources to be added, national coverage o a particular service if the PPP´s indicators include a specific coverage goal which is expected to impact national coverage.

21 Data base's empty years are initially completed through process described in figure 13). They are automatically updated every time an independent KPI value is changed. Independent KPIs are those that did not need a correlation curve of adjustment. This could be because they have all the necessary data (including current's year data), or because forecasts are available from authorized institutions (as statistics official authorities that officially publish production, demographic, economic or markets projections periodically).

22 The analyst can change weights (i.e. importance percentages between matrixes 1 and 2) if a change of relevance of qualitative or quantitative criterion is considered once the new PPP is implemented.

Figure 15
Module 2 process- current situation and short term effect of new PPPs on KPIs



(1) Depending on the quality of results up to this phase and the precision wished in the level of analysis, a second iteration may be started here to activate a double check process that enables the model to refine the relevance of KPIs chosen. The iteration process was shown at figure 15.

Source: own elaboration.

4.4. Module 3: KPIs forecasting simulation analysis.

This is the third module and it seeks to analyse medium and long range impacts through the visualisation of future trends and future roles on sets of KPIs. It combines two methods; structural analysis and scenarios planning. By studying probabilistic crossed impacts, the structural analysis enables analysts to systematically identify KPIs that will better represent future trends of a given PPP. It takes advantage of potential KPIs future relationships as inputs to optimize results. On the other hand, by a situational analysis perspective, the scenarios planning tool, helps to build a comprehensive universe of probable futures to the sector or PPP analyzed, as well as progressively studies future scenarios and relates KPIs roles with the highest feasibility to occur.

Just like modules 1 and 2, Module 3 has been designed to integrate, qualitative and quantitative data under a flexible and systematic approach. More than the generation of future trends and figures, Module 3 outputs were designed to assist a broader vision of a strategic prospective exercise as it was introduced in section 3.3. In doing so, this module seeks to satisfactory respond to the first three questions stated at Figure 7. This is, to generate information to quantify the role of the DIES and SAPSB within the infrastructure sectors they work for, to identify probable, feasible and doable futures on those sectors, and to define policies, programmes or projects that DIES and SAPSB can actually implement towards sectors` doable futures.

Recent studies on prospective analysis promoted at the DNP, have focused on agreed and narrowed future scenarios, as a practical alternative to the complexities of technical forecasting[23]. Although asking principal actors to agree on probable futures on their sectors is a valid approach on prospective analysis, this methodology however, may leads to critical weaknesses when subjectivity plays a determinant role over the final consensus reached. While subjectivity cannot and should not completely be eliminated from prospective exercises, in order to give validity to prospective results, it has to be not only prudently weighted but also complemented with objective parameters of performance measures[24].

By combining structural analysis with scenarios planning, the forecasting methodology here introduced, combines a controlled entry of subjective consensus with a systematic filter of probable futures. The process starts with a comprehensive review on all possible futures and goes up in a detailed analysis of highly probable scenarios. Basic steps on module 3 process, includes:

I. Identification of KPIs key to forecast,

II. Strategic diagnosis on their dominant forces

III. Scenarios design

IV. Structural analysis to the scenarios designed.

The process integrates qualitative and quantitative analysis tools, under a holistic view both from the internal KPIs dynamics and their external context and determinants. The main steps of the process are summarized in Figure 16.

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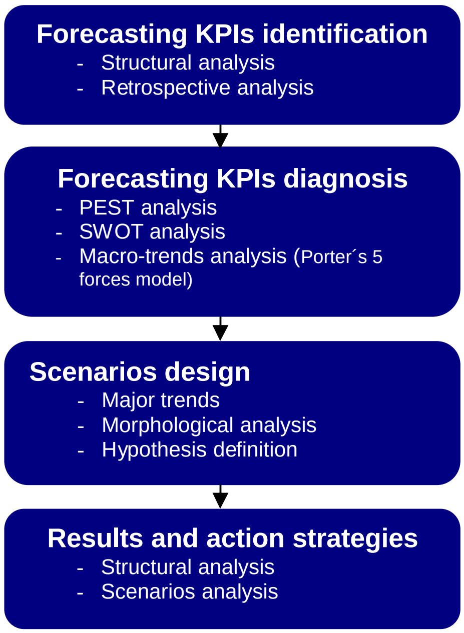
23 Among others see: DNP 1997a, 2004a, 2004b, 2005a, 2005b, 2005d, 2005m, 2006a to 2006o

24 Subjective approaches on prospective exercises, tends to purposely ignore systematic reviews on all the information relevant to the analysis. The validity of results coming from these exercises is proportionally reduced (in a geometric proportion) as lacks of information increase.

Figure 16.
Major tools used in the prospective process.



Notes:
PEST: Political, economic, social and technical aspects of the analysis
SWOT: Strengths, weaknesses, opportunities, threats

Source: own elaboration from Godet, et al [2000a].

i) Forecasting KPIs identification;

There are many parameters useful to define a variable as key indicator for forecasting analysis. Literature review and unstructured interviews related with more than fifty forecasting exercises and their responsible institutions within the infrastructure public sector in Colombia, shows how KPIs that have been used as inputs to a forecasting model, follow at least one of these aspects:

- Strong causal relationships on the subject analyzed according to previous literature reviews.
- They are empirically considered as strong determinants on the subject dynamics, according to best practices reviews.
- They have been chosen according to experience of other analysts.

The main misconception of KPIs chosen applying these criterions is that those KPIs are essentially good to describe past trends, but not necessarily determinants to analyse future trends. Therefore a conceptual misinterpretation on indicators roles is a frequent lack on forecasting KPIs identification processes related. On the contrary, this step seeks to demonstrate how KPIs should and can be chosen by analyzing their probable role as future dominant variables, rather than based on their past role. The tools that help to achieve this objective essentially are structural analysis and scenarios planning. The process starts with a comprehensive list of variables representing the sector, public service or PPP over which future scenarios wants to be studied. This list may come from KPIs previously selected on modules 1 or 2 whether their match in terms of their PPP scope. Otherwise, the list may come from a detailed review on the PPP objectives.

Structural analysis allows a first approximation towards identifying of KPIs for forecasting analysis by using three general parameters; the type of indicator, its location at the influence-dependence graph and, the quality of its annual series. The type of indicator is a parameter related with the PPP implementation cycle as it was previously introduced in Figure 9. In this case, indicators previously chosen may play two different roles; those that better work as inputs and those that better work as outputs to the model. Indicators previously chosen were classified in terms of both their BSC dimension and their classification. Therefore, those indicators classified as inputs and activities will be chosen as inputs to the forecasting model. These indicators will be considered as independent or entry variables to the model. They will be determinants of other indicators future trends.

Those classified as results or impacts indicators, will be chosen as the outputs of the forecasting model. They will be carefully monitored as highly sensitive indicators and ideal variables to measure changes on future trends.

In terms of the location of KPIs at the influence-dependence graph, indicators considered more relevant to forecasting analysis are in order; current situation's dominant indicators (zone 1, from Module 2´s analysis), historically conflict indicators (zone 2, from Module 1´s analysis), and both current and past result indicators (zone 3, Module 1 and 2 analysis).

The first two groups represent the combined effect between past and current trends, while the third group represents the way to visualize results to the PPP under study. Finally, in terms of the quality of KPIs annual series, uncompleted series should not be chosen as long as they will need to be filled using stochastic simulations that could delay the general process. However, whether necessary, the model enables this simulation by using LaGrange's linear interpolation method. The whole process of selecting KPIs helps analyst to combine both past and current trends which helps to control the dominant role that current trends use to wrongly have on forecasting analysis[25]. This process is summarized at Figure 17.

ii) Forecasting KPIs diagnosis:

Once KPIs to be used in the forecast have been identified, the second step is a diagnosis on strategic and qualitative major aspects that may affect those KPIs. It is an internal-external context analysis that helps in building a critical view towards probable future of KPIs. The analysis is based in the sector driven forces, in the institutional context of the organization responsible for the forecast and, in those cross-sector macro trends affecting KPIs involved in the forecasting exercise. (Figure 16) According to this, traditional strategic analysis offers three useful tools: PEST analysis to study the sector's context, SWOT analysis to better understand its institutional context and Porter's five forces model to identify macro trends that may challenge sector's dynamics. Module 3 incorporates these tools to generate basic qualitative inputs necessary for the quantification of future scenarios.

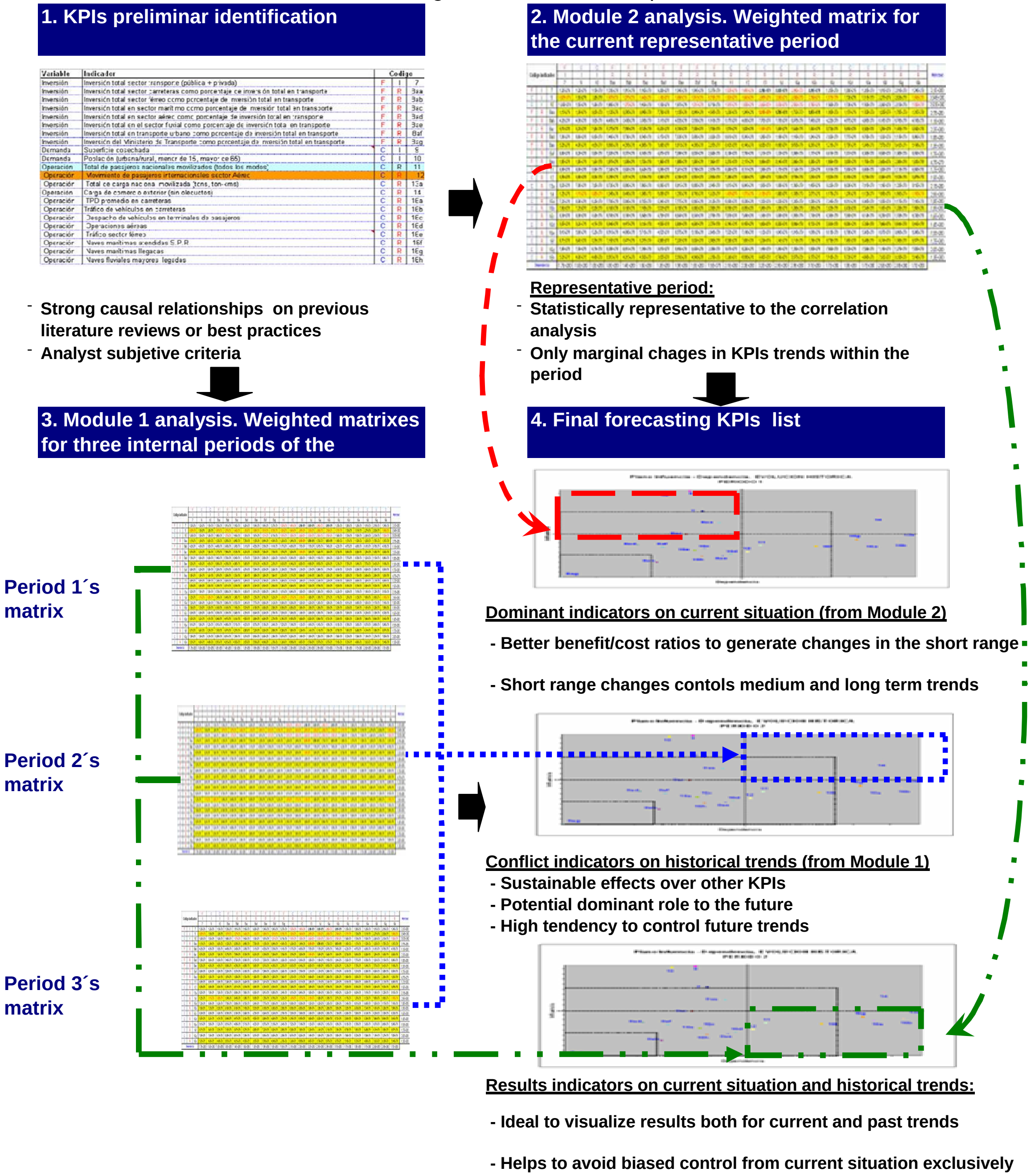
To apply these tools, first of all, it is necessary to identify political, economical, social and technical aspects within the sector, that mainly affect the KPIs chosen (PEST analysis). Secondly a review on the major strengths, weaknesses, opportunities and threats related to those KPIs, needs to be done, in order to understand their internal driving forces (SWOT analysis). Thirdly, it is necessary to identify potential impacts over KPIs due to their mainly related external forces. Porter's model helps to identify main aspects that may be recognized as their external determinants. Regarding infrastructure sectors, these determinants can be summarised into five driven forces: competitiveness, technological development, institutional change, economic market merges and globalization.

iii) Scenarios design:

A scenario is a hypothetical representation of a probable outcome. Module 3´s scenarios are designed through two general steps: identification of major trends on each KPI, and definition of hypothesis that better describe potential combinations among those trends. The first step helps in building a map with all the possible future developments to the KPIs, while the second step, reduces uncertainty by taking all possible developments and only those probable future developments. In identifying major trends, the model differentiates three general options on each KPI; optimist, pessimist and medium options. By defining representative growth rates, the analyst has to build a detailed micro-scenario for each option within each KPI. In doing so, it is defined the morphological chart for all the KPIs analyzed, which is the array of the macro-scenarios resulting when all the possible combination of micro-scenarios is developed.

25 Torres-Gracia (2001) demonstrates that current biased analysis is a common focus on infrastructure decision makers in Colombia. In doing so, not only current advantages but also disadvantages can easily be replicated on forecasts. Important control parameters form the past, from which forecasts could take advantage, could be also ignored.

Figure 17
Forecasting KPIs identification process[26]



Source: own elaboration.

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[26] The process is based both in past and current trends of KPIs initially chosen at modules 1 and 2, from which a selected group of the variables more adequate for forecasting purposes, can be identified. It starts from an initial list of KPIs chosen by the analyst from modules` 1 and 2 KPIs and other criterion as showed at step 1 in the Figure 17. Then, the processes of historic and current situation analysis need to be quickly implemented as previously shown at Figures 11 and 15 respectively to obtain their related influence-dependence graphs (step 2 and step 3. Figure 17). From those graphs KPIs with best properties for forecasting will be chosen. In the case of historic influence-dependence graph (which should be divided in three representative periods according to Figure 12) those indicators positioned at the results zone (Zone 3) and the conflict zone (Zone 2), will be chosen. In the case of current situation's influence-dependence graphs, indicators on the dominant zone (Zone 1) should be chosen. Figure 17 explains why these groups of indicators should be chosen for forecasting purposes (step 4). Finally, those indicators that will be specifically needed to be forecasted and that are not within any of the two previous groups of selected KPIs should be chosen according to criteria of the analyst.

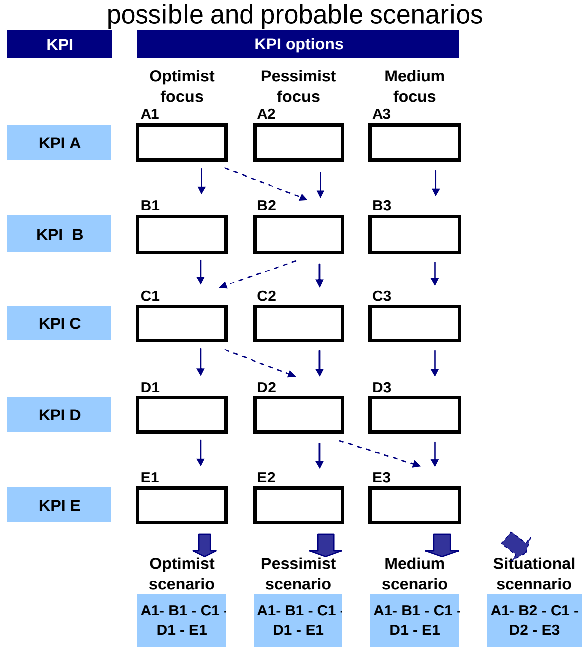
The total number of macro-scenarios is equal to *3n* where *n* is the number of KPIs selected. (i.e. 60 macro-scenarios results if 20 KPIs where identified by applying Figure 17´s process) The last step is to reduce this comprehensive universe of possible scenarios to a few number of scenarios with high probability to happen (probable scenarios), by applying a feasibility hypothesis design process. Each hypothesis is the combination of an option to the variable *i*, with an option to the variable *j*, up to chose an option for all the KPIs[27].

To define the combination of options, hypotheses are based on the same criteria used to define variable's options, which means there is an optimistic hypothesis, a pessimist hypothesis and a medium one. The optimistic hypothesis combines all the micro-scenarios built upon optimistic trends, as the pessimistic one includes all pessimistic micro-scenarios. The medium hypothesis is a mixture of all micro-scenarios that somehow represent a middle point between an optimistic and a pessimistic situation on each KPI forecast.

The final result of this step is a highly specified group of three designed scenarios called optimist, pessimist and medium scenarios. Each macro-scenario is a combination of micro-scenarios correspondingly linked by the same general criteria that defines the macro-scenario. Figure 18 shows this process graphically for a selected group of five KPIs (A to E). In this case (5 KPIs with three options each), the morphological universe of all the possible scenarios is represented by 3^5 = 243 possible scenarios. Thanks to the hypothesis process described, this universe is systematically reduced to three probable scenarios only. Therefore, each scenario is a hypothesis that combines a specific option (optimist, pessimist or medium) for a set of KPIs specifically selected as dominant inputs or determinant in the future trends of the PPP analyzed. Arrows at Figure 18 show graphically the combination of KPIs trends that may give origin to a particular scenario.

For example, by adding optimist options of all the KPIs selected, an optimist scenario is built (see A1-B1-C1-D1-E1 combination). In the same way, three basic scenarios can be designed (optimist, pessimist and medium). A fourth type that combines different focus on each KPI could be useful to define a more flexible scenario according to analyst criteria. This is called a situational scenario[28].

Figure 18
Module 3´s Morphological analysis: universe of possible and probable scenarios



Source: adapted from Godet, et al [2000a].

iv) Scenarios structural analysis

This final step seeks to translate all the information generated by KPIs diagnosis and scenarios design into a new structural analysis process. By combining scenarios analysis and structural analysis, the model provides its main value added compared with traditional

27 Options to each variable include; optimist, pessimist and medium.

28 From the situational planning school of though also referred as Issue-based planning, where the external environment is the major force that controls an scenario planning process and scenarios design is the result of adaptive, unstructured and changing future KPIs options rather than a logic and structured combination of options (Miller, 1995). Quoted at Torres-Gracia, 2001 (pp.52).

forecasting methods, which is the systematic cause-effect study on future KPIs trends. Traditionally, is common to choose growth rates for each KPI considered as key entries to the model and to forecast them according with the analyst's criteria. The IGF model on the contrary, is based on an objective criteria process to choose entry variables and aloud the analyst to count on a set of quantitative and qualitative cause-effect relationships to define forecasting trends. By doing this, a whole group of related KPIs, can be forecasted, following trends as they actually behave, and not only following subjective criterion as traditionally methods ten to work. By combining scenarios analysis and structural analysis the model generates two outputs:

- *Scenarios impact on each KPI´s trends and roles*: this is an analysis on future evolution for each KPI, depending on the criteria driving each scenario forecast. It is measured by the KPI change on its relative position in the influence-dependence graph before and after the implementation of the scenario. In doing so, not only the direct impact on each KPI is measured[29], but also pre-active and pro-active information is generated on the KPIs future role for each scenario. By knowing this, a decision maker can define strategy and action plans in advance either to reinforce previous decisions or to change inertial or potentially negative trends. The model generates these outputs to the whole period of forecasting or to intermediate periods within it, in case that detailed evolution analysis is needed for stepped strategies design.
- *Scenarios impact on strategic decision areas trends and roles*: it is an analysis on future evolution dynamics for groups of KPIs representing key areas in terms of high impact decisions, highly sensitive subjects, marginal or low impact decisions and those decisions that need to be more carefully taken and monitored. It is measured by a review on structural changes of each zone to the influence-dependence graph. These changes are studied between the influence-dependence graph that represents the current situation of the PPP analyzed, and each scenario's influence-dependence graph. These outputs helps analysts to answer some key questions related with the implications that each scenario may have on major aspects of future decision making process such as;

  – *What is the general impact of an optimist trend on dominant KPIs?*
  – *¿What is their effect on dependent KPIs?*
  – *If dominant KPIs have optimist trends, ¿will all KPI have an optimist evolution?*
  – *¿What could happen to other strategic variables?*
  – *¿What actions/decisions should be taken in advance to promote/avoid a trend that needs to be changed on a specific KPI?*

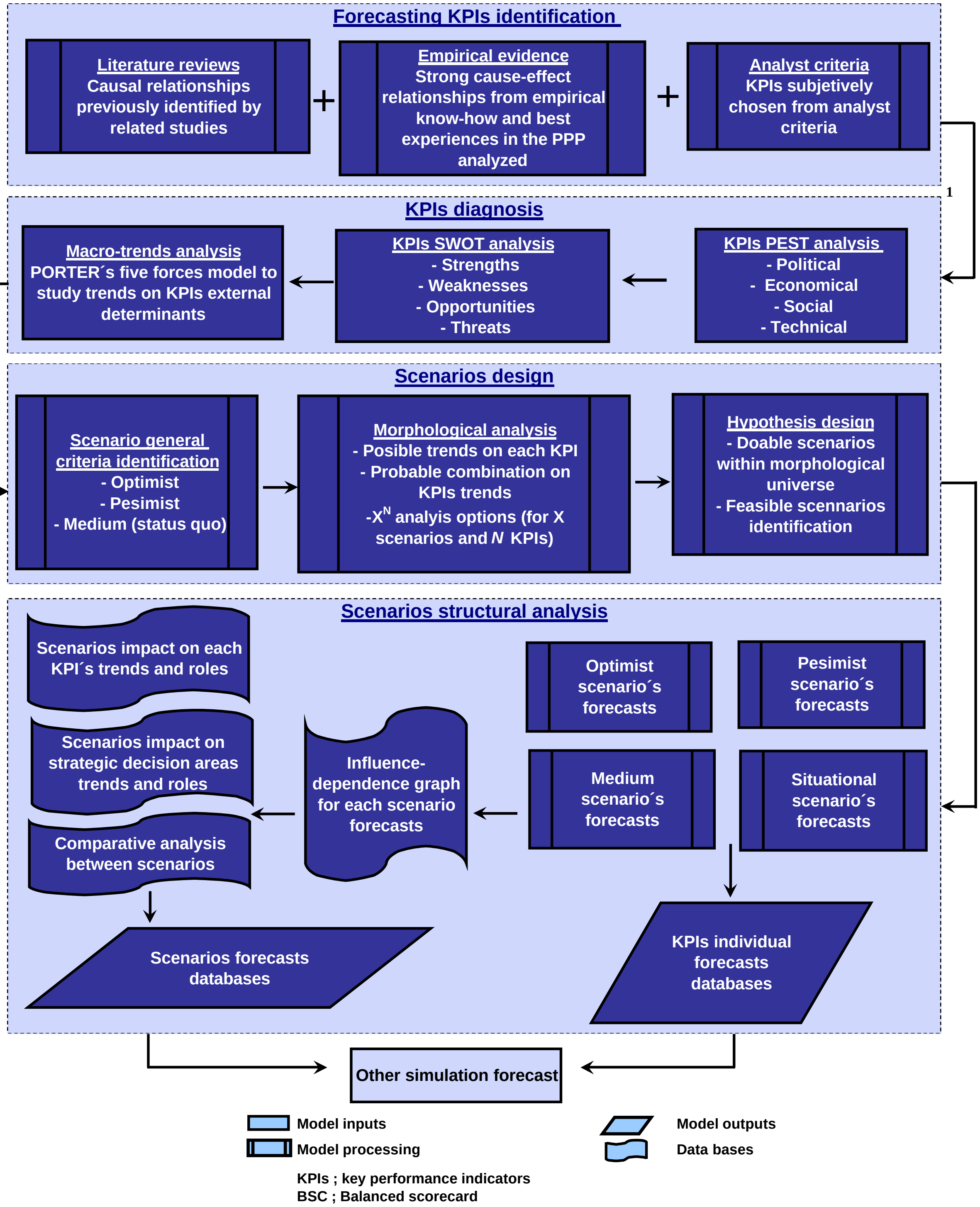
- *Comparative analysis between scenarios*: it is a gap analysis about differences in roles and trends between optimist, pessimist and medium scenarios. It is measured by changes on the KPIs relative position among related scenario's influence-dependence graphs. This analysis helps to the prioritization of future strategies by giving key data related with:

  - General characteristics of each scenario.
  - Specific effects from each scenario's criteria over KPIs.
  - Figures and growth rates resulting on KPIs due to the implementation of each scenario.
  - Decisions and actions necessary to implement each scenario.
  - Cost-benefit differences between each scenario's implementation.

Figure 19 summarizes the whole Module 3 process. Its iteration process to optimize KPIs´ identification is explained at Figure 17.

[29] Impact it is measured not only in terms of changes in KPIs trends, where analysis on growth rates, and absolute figures is done, but also in terms of changes in the role played by each KPI today and in the future under each scenario implementation

Figure 19.
Module 3 process- KPIs forecasting analysis.



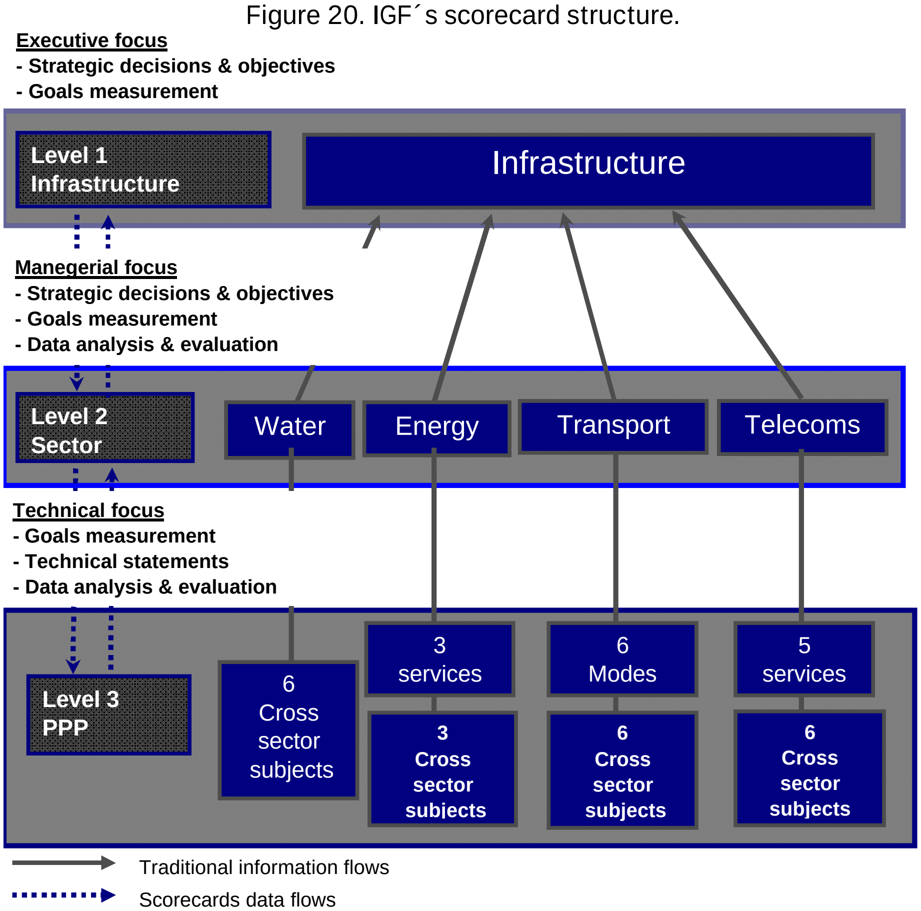
(1) A faster process to identify forecasting KPIs may be initially based upon indicators employed in Modules 1 and 2. Then, depending on the results of the scenarios structural analysis, a review on KPIs initially chosen can be done following procedure explained at Figure 17.

Source: own elaboration.

5. IGF´s Scorecard structure

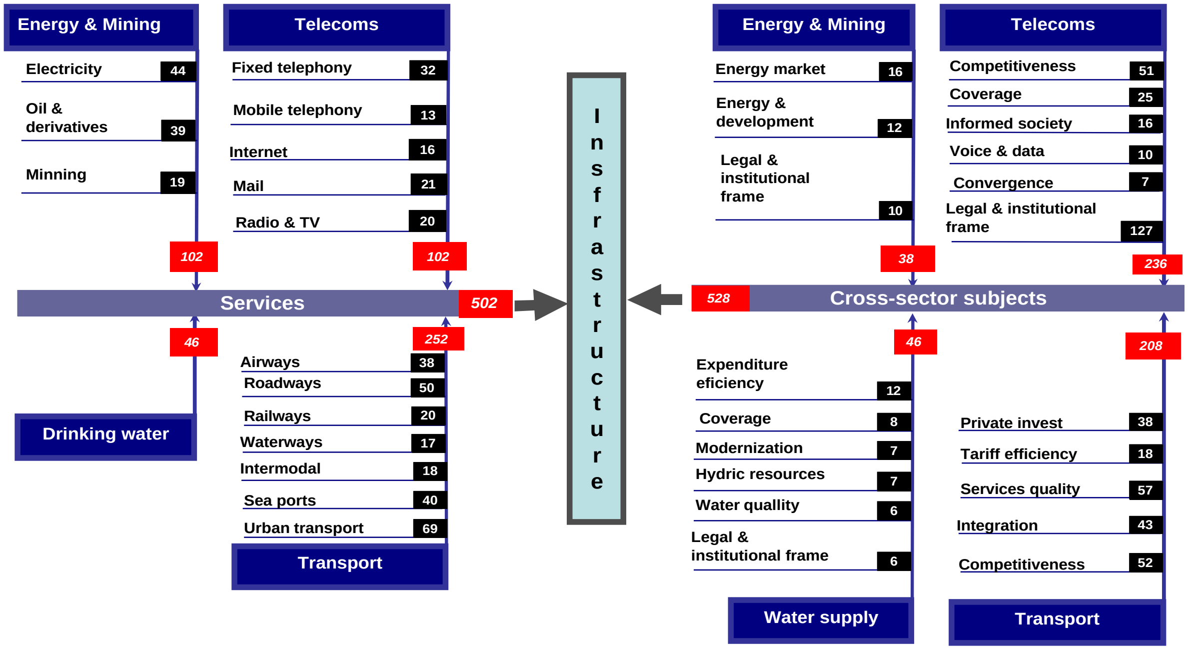
Pilot analyses that were implemented on each sector within the design process of the IGF model required a preliminary design to the general structure of the scorecard including it scope on success areas, objectives and variables as well as a review on standard indicators used within each sector. This design process ended in a cascade structure with three major levels as Figure 20 shows. The PPP basic level includes specific measures for 14 different infrastructure services and transport modes, as well as 18 major subjects (or key themes) within each sector. The sector intermediate level integrates all the services and thematic measures into a multidimensional sector BSC. The infrastructure top level is a filter on strategic measures of the intermediate level. Measures at each level are consistent with DIES and SAPSB organizational structure, and satisfy the technical, operative or administrative focus demanding by them. This is a managerial top infrastructure BSC designed to assist executive, managerial and technical information demands. The Basic level (PPP level) includes measures on sixteen different services, and twenty different cross-sector subjects. At the intermediate level, they are integrated into five general sectors. The infrastructure top level is a selected group of KPIs from intermediate and basic levels. Figure 20 shows the general structure of this BSC and Figure 21 details on the services and cross-sector subjects included. Values within boxes represent the number of KPIs identified in each case. Services measures are 502 in total, while the cross-sector measures include 528 KPIs.

Figure 20. IGF´s scorecard structure.



Source: own elaboration

Figure 21. Infrastructure scorecard services and cross-sector issues



Notes: From the services point of view, the BSC includes 502 KPIs, and 528 from the cross-sectors point of view. Some KPIs are present in both cases.

Source: own elaboration

5.1 Energy balanced scorecard

The energy sector's scorecard integrates six success areas at services and cross-sector levels; electricity, oil & derivatives, and mining. The major cross-sector success areas identified were energy market, energy & development, coverage and legal & institutional frame. They are organized in 21 objectives, 51 variables and 140 KPIs detailed at Figures 22a and 22b.

5.2 Telecommunications scorecard

The Telecommunications´ scorecard is divided in 11 success areas including five services and six cross-sector's areas. Services measures include KPIs to the following telecommunication services; fixed telephony, mobile telephony, internet, mail and radio & television. Cross-sector measures include KPIs on the following issues common to all telecommunication services: competitiveness, coverage, informed society, voice & data, convergence and legal & institutional frame. They are divided in 40 objectives, 106 variables and 231 KPIs, detailed at Figures 23a, 23b and 23c.

5.3 Water supply scorecard

Water supply's scorecard integrates six success areas all on cross-sector issues. They include; sector's spending efficiency, aqueducts & sewerage coverage, quality of drinking water, water resources management, operators´ modernisation and CRA & SSPD[30]. They are divided in 23 variables and 46 KPIs.

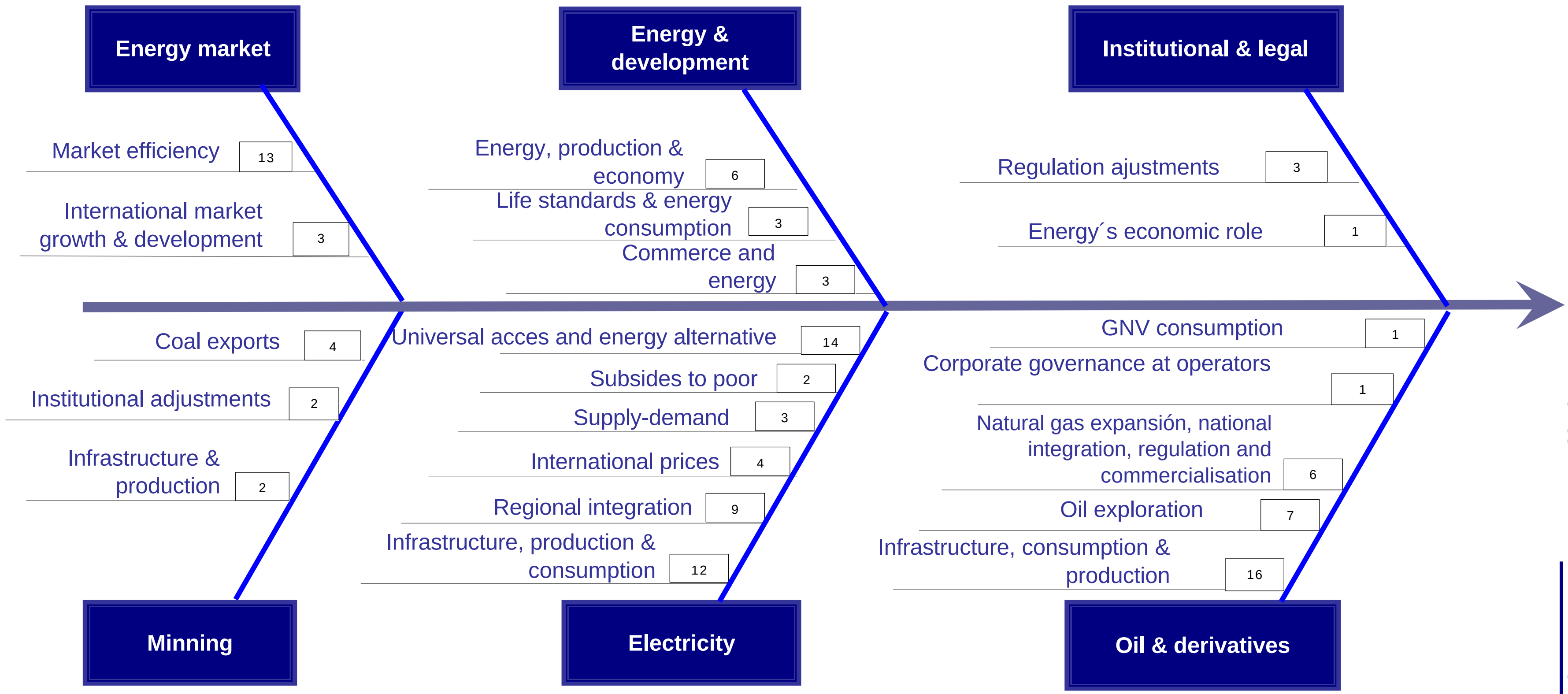
5.4 Transport scorecard

The transport sector's scorecard integrates twelve success areas including each transport mode and some cross-mode issues. Modal measures include; air transport, roadways, riverways, railways, sea ports, urban transport, and intermodal transport. Cross-sector issues include; competitiveness, integration, services quality & efficiency, tariffs and private participation. This BSC include 58 objectives, 186 variables and 488 KPIs detailed at Figures 24a, 24b, 24c, and 24d.

[30] CRA (Regulatory Commission for Water and Sanitation); SSPD (Superintendence of Public Utilities)

Figure 22a.
Energy balanced scorecard[31]

GENERAL STRUCTURE OF THE BSC



Source: own elaboration

31 Energy KPIs are detailed in the Annexe 2

Figure 22b
Success areas in the energy sector

OBJECTIVES AND VARIABLES IN EACH SUCCESS AREA

Success area 1: energy market, national integration

Objectives	Variables
To increase national energy market efficiency	National energy balance
	Energy delivery firms and users
More growth and development of the sector towards the international energy market	National vs intenational energy balances

Succes area 2: energy & development

Objectives	Variables
Energy, production and economy	Energy sources
	Energy consumption
	Investment and production
Life standards and energy consumption	Social investment related
Energy and commerce	Social spending in energy

Succes area 3: institutional & legal development

Objectives	Variables
Regulation adjustments	Electricity
	Natural gas
	Minning
Energy`s economic role	Energy value-added social investments
	Energy services subsides
	National government investment transfers

Success area 4: efficiency, integration and coverage of electricity services

Objectives	Variables
Infrastructure , production and consumption	Infrastructure & production
	Electricity market
	Electricity operators
	Investments
Regional integration	Andean integration
	Internal - external integration
International prices determinants	Electricity national stock market prices
	Electricity services prices
Supply-demand equilibrium	Private participation in electricity
Subsides to poor users	ZNI subsides (none interconnected zones)
	SIN subsides (Interconnected national system)
Universal access and alternative energy sources	Electricity universal access
	Electricity service efficiency
	National service integration
	Electricity alternative sources development

Success area 5: Sustainabillity and expansion of oil products and derivatives

Objectives	Variables
Infrastructure, production and consumption	Infrastructure
	Production
	Consumption
	Operation
	Investments
Oil exploration sustainabillity	Exploration activities
	Exploration investments
	Refinery
Natural gas expansion,	Integration investments
	Operation and coverage
Corporate governance at	Oil stock prices
GNV consumption	GNV Regulation
	GNV Demand
	GNV Subsides

Succes area 6: minning sector expansion

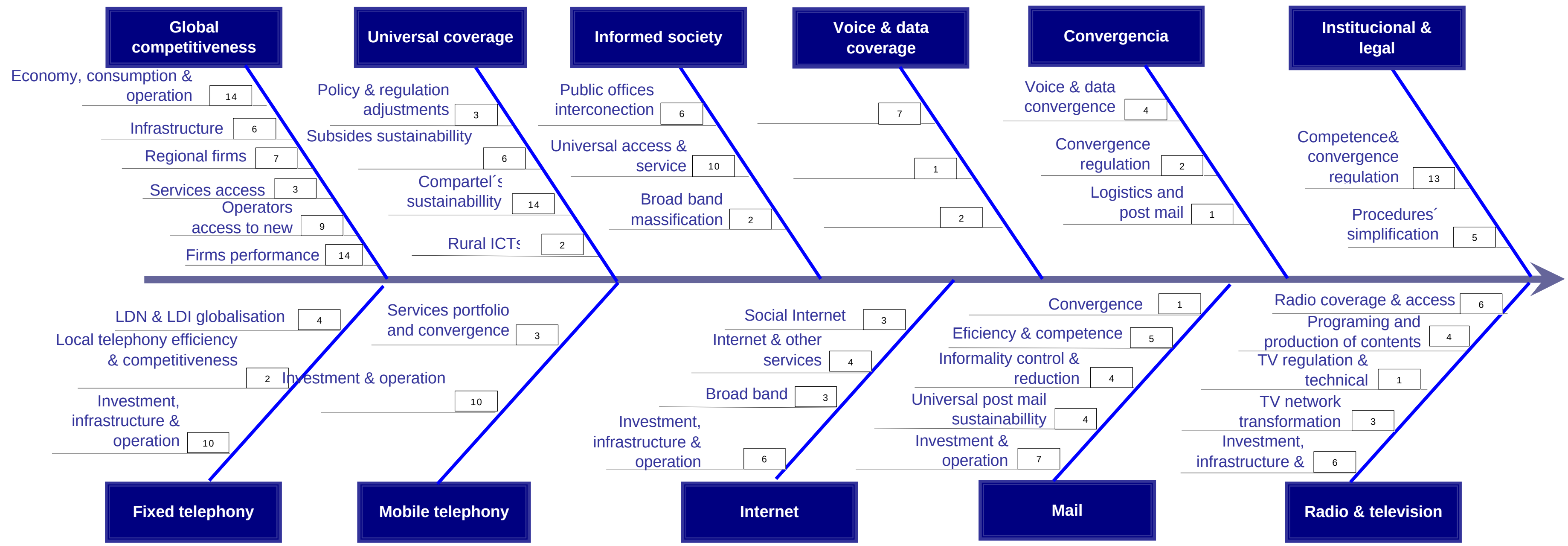
Objectives	Variables
Infrastructure & production	Minning products
	Investments & regional value-added
	Minning exports
Institucional adjustments	Legal operation requirements
	Minning territorial planing
	Minning information systems development
Coal exports	Coal production & consumption

Source: own elaboration

Figure 23a

Telecommunications balanced scorecard[32]

GENERAL STRUCTURE OF THE BSC



Source: own elaboration

32 Telecommunications KPIs are detailed in the Annexe 2

Figure 23b
Success areas in the telecommunications sector 1

OBJECTIVES AND VARIABLES IN EACH SUCCESS AREA

Success area 1: global competitiveness in telecommunications

Objectives	Variables
Economy, consumption & operation	Economic & financial issues
	Tariffs
	Investments
	Sector incomes
	Services operation
Infrastrucure to compete globally	Fixed telephony
	Mobile telephony
	ICTs
Regional firms	Performance local telephonic operators
Facilitation of services access	Private participation
Operators acces to new markets	Participation in other markets
	Commerce agreements effects
Firms performance	Services supply
	Services quallity
	Telecoms firms and markets

Success area 2: universal coverage

Objectives	Variables
Policy & regulation adjustments	Universal service national plan
	Subsides and contributions scheme
	Connectivitty agend
Subsides sustainabillity	Universal services focus
	Universal services financial balance
Compartel´s sustainabillity	Social telephony at rural areas
	Public offices connectivity
	Radio services at rural areas
	Post mail universal service
Rural TICs	Bi-annual plans for local telephony

Success area 3: a better informed society

Objectives	Variables
Public offices interconnection	Government intranet
	Regional offices compettitiveness
	Connectivity agend
Universal access & service	Social telephony at rural areas
	Social internet
	Radio services at rural areas
	Post mail universal service
	telephony
Broad band massification	Broad band performance

Success area 4: voice and data coverage

Objectives	Variables
TICs access and utilisation	Investments to expand
	Coverage
Government´s role	Planning role
Services convergence	Mobile operators
	Internet operators

Source: own elaboration

Figure 23c
Success areas in the telecommunications sector 2

Success area 5: convergence in technology, infrastructure, contents and

Objectives	Variables
Voice & data convergence	Services´ integration
	Networks´integration
Convegence regulation	Network regulation
	Contents
Logistics & post mail	Development of proposal to integration

Success area 6: institutional and legal adjustments

Objectives	Variables
Competence & convergence regulation	Network regulation
	Constraints of access to externat markets
	Commerce agreements effects
Procedures´ simplification	Planning
	Services` control and supervision
	Regulation
	Operation titles

Success area 7: fixed telephony improvements in management and access

Objectives	Variables
Investment, infrastructure & operation	Investments
	Physical stock
	Operation
	Tariffs
Local telephony efficiency & competitiveness	Telecom strategic joint-venture
	User services´quallity
	Financial performance of local operators
LDN & LDI globalisation	Services´operation
	Sector incomes
	Sector spending

Succes area 8: mobile telephony penetration

Objectives	Variables
Investment and operation	Investments
	Operation
	Tariffs
	Sector incomes
Services portfolio and convergence	Operators portfolio expansion
	Internet acces from mobile operators
	Income distribution by services

Succes area 9: internet massification

Objectives	Variables
Investment, infrastructure & operation	Investments
	Operation
	Tariffs
Broad band netwwork development	Service policy
	Investments
	Operation to expansion
Internet & other services convergence	Internet service`s incomes by operator
	Internet service from none internet networks
	ICT`s know-how
	Digital acces index
Social internet	Investments
	Internet acces to disable people

Succes area 10: post mail massification towards globalization

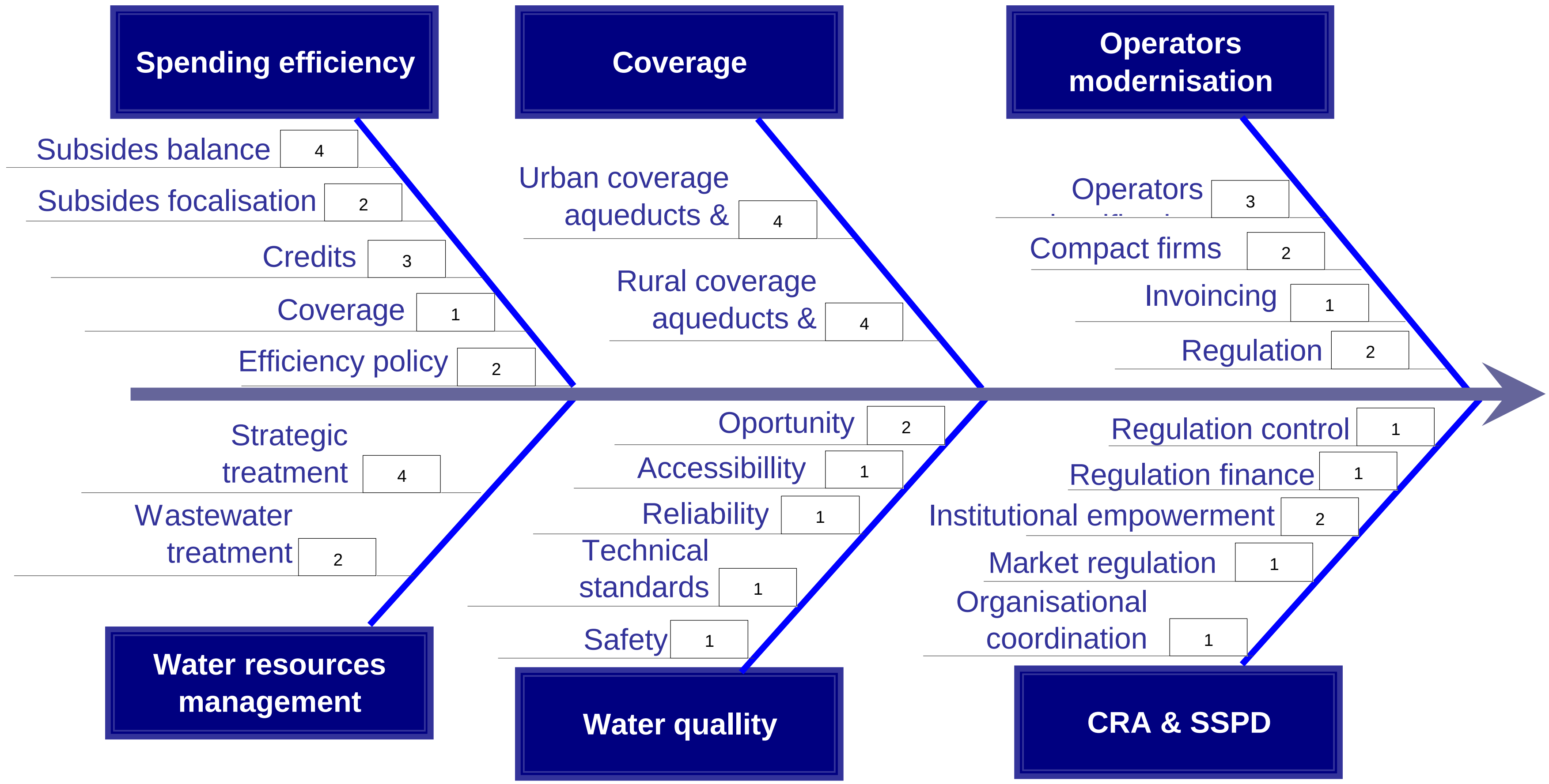
Objectives	Variables
Investment & operation	Investments
	Operation
	Tariffs
Universal post mail sustainabillity	Coverage
	Financial equilibrium
	Planning
Informallity control & reduction	Control & supervision
	Services specialization
	Informality´s size
Efficiency and competence	Investments efficiency
	Operation efficiency
	Regulation to eficciency
Convergence	Logistics integration

Succes area 11: radio & TV services modern and reliable

Objectives	Variables
Investment, infrastructure & operation	Investments
	Infrastructure
	Operation
TV network transformation	Raising TV technical standards
	Digital TV
	TV networks integration
TV adjusments (technology, regulation & policy)	Efficient TV model
Improvement of TV contents´programming and production	TV production
	Contents policy & regulation
	TV convergence
Radio coverage and access	Radio density
	Radio coverage
	Community radio

Source: own elaboration

Figure 24
Water supply balanced scorecard[33]

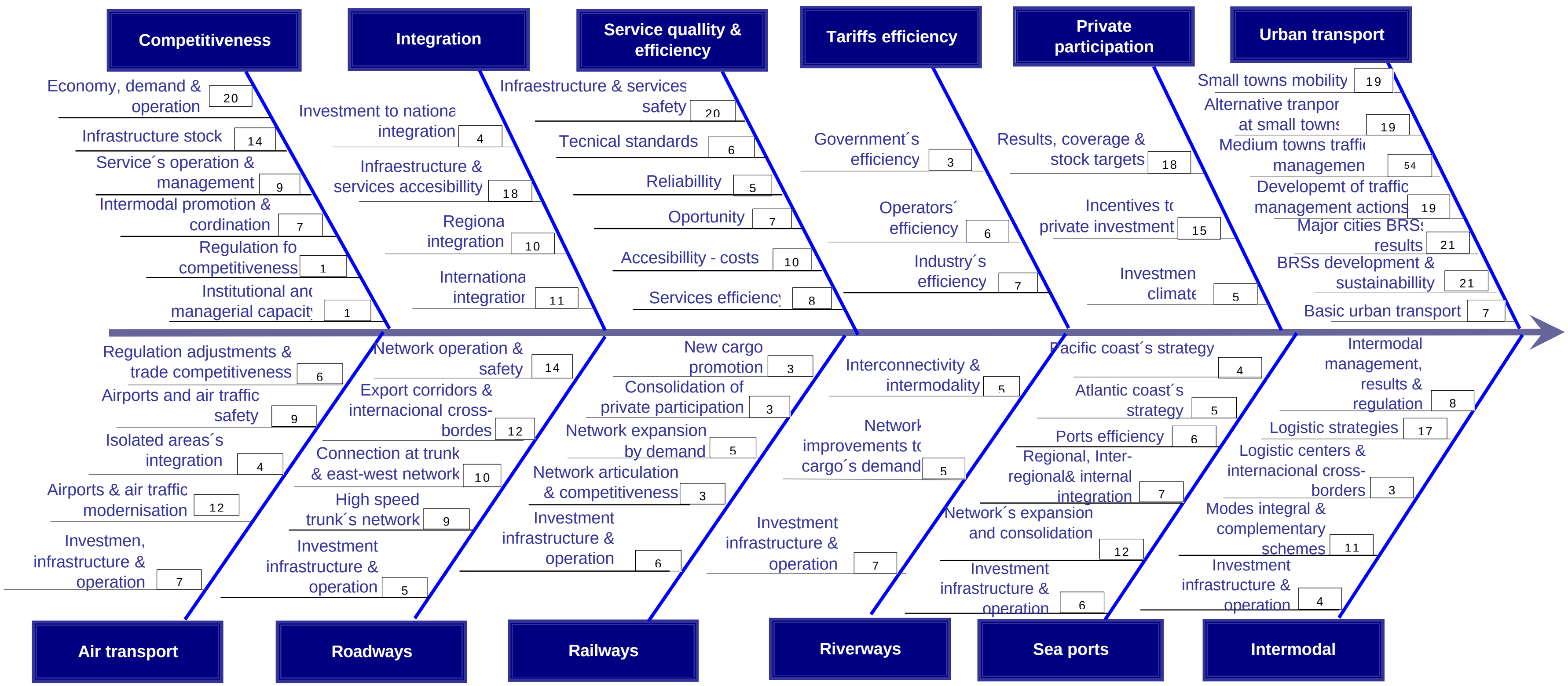


Source: own elaboration

33 Drinking water KPIs are detailed in the Annexe 2

Figure 25a
Transport balanced scorecard[34]

GENERAL STRUCTURE OF THE BSC



Source: own elaboration

34 Transport KPIs and all related modelling analysis were previously published as the first results on this project. See DNP (2007).

Figure 25b
Success areas in the Transport sector 1

OBJECTIVES AND VARIABLES IN EACH SUCCESS AREA

Success area 1: Competitiveness to the transport system

Objectives	Variables
Economy, demand & operation	Economy
	Invetments
	Demand
	Operation
Infrastructure stock	Air transport
	Roadways
	Railways
	Riverways
	Seaports
	Intermodal
Services´ operation & management	Roadways
	Riverways
	Seaports
	International commerce
Intermodal promotion &	Interchange nodes
	Intermodal regulation
Regulation for competitiveness	Regulation & competitiveness
Institutional and managerial capacity	Corporate governace developments

Sucess area 2: Transport to the national, regional and international integration

Objectives	Variables
Investment to national integration	Trunk´s network
	Secondary network
	Firms modernisation
Infrastructure & services accesibillity	Acces´s infrastructure
	Rural accesibillity
	Regional infrastructure´s decentralization
Regional integration	Modes´strategies
	IIRSA
	Logistics
	Interchange nodes
	New projects
International integration	International commerce
	Trade policy
	Commerce strategies

Succes area 3: Public transpor services and quallity´s inprovement

Objectives	Variables
Infrastructure & services safety	Transport safety
	Air transport safety
	Roadways safety
	Railways safety
	Riverways safety
	Seaports safety
	Urban transport safety
Technical standards	Infrastructure & services
Reliabillity	Infrastructure & services reliabillity
Oportunity	Services frequency by demand
Accesibillity - costs	Equity at services costs
Services efficiency	Input-product ratios for stock, operation & investments

Success area 4: Transport tariffs´ efficiency

Objectives	Variables
Government´s efficiency	Government´s spending
	Government´s incomes
	Government´s balance
Operator´s effciency	Operators` spending
	Operators` incomes
	Operator´ balance
Industry´s efficiency	Industry´s spending
	Industry´s incomes
	Industry´s balance

Source: own elaboration

Figure 25c
Success areas in the Transport sector 2

Success area 5: Incentives to the private

Objectives	Variables
Results, coverage & stock targets	Investments
	Contract risks
	Stock
	Operation
Incentives to private investments	Technical assistance
	Policy & regulation
	Demand incentives
	Supply incentives
	Negotiation options
	New projects
Inverstments´ climate	Legal & regulation
	Climate
	Economy & safety
	Investors interest

Succes area 6: Air transport modernisation &

Objectives	Variables
Investments, infrastructure & operation	Investments
	Infrastructure
	Operation
Airports & air traffic modernisation	Modernisation investments
	Air transport standards
	Airports decentralization
Isolated areas´ integration	Regional air transport´s financing
	Airports decentralization & deregulation
Airports and air traffic safety	Air traffic safety
	Airports safety
	Operation safety
	Safety investments
Regulation adjustments & trade	Trade competitiveness
	Policy, commerce and tariffs regulation

Succes area 7 : Roadways integration & articulation under optimal service standards

Objectives	Variables
Investments, infrastructure & operation	Investments
	Infrastructure
	Operation
High speed trunk´s network (Occidente, Magdalena, Central del Norte y Marginal de la Selva)	Trunk network`s infrastructure
	Trunk network`s investments
	Trunk network`s operation
	East-west network´s infrastructure
Connection at trunk & east-west networks (5 trunks + east-west connections = 39 projects)	Secondary network`s infrastructure
	Secondary network`s investments
	Secondary network`s operation
	Secondary network`s decentralisation
Export corridors & international cross-borders (10 Corridors + 5 cross-borders)	Infrastructure
	Operation
	Investments
	IIRSA´s projects
Network operation & safety	Infrastructure´s stock
	Roadways operation standards
	Roadways safety

Success area 8: Railways articulation with freight transport

Objectives	Variables
Investments, infrastructure & operation	Investments
	Infrastructure
	Operation
Network articulation & competitiveness	Network´s phycical standards
	Network´s operation
	Competitiveness
Network expansion by demand	Network´s gorwth monitoring
	Network´s development alternatives
	Network´s operation
Consolidation of private participation	Private investments
	Private participation consolidation
New cargo promotion	Promotion through regulation
	New cargo generated

Source: own elaboration

Figure 25d
Success areas in the Transport sector 3

Succes area 9: Riverways network´s growth, improvement, inteconnection and intermodality

Objectives	Variables
Investments, infrastructure & operation	Investments
	Infrastructure
	Operation
Network improvements to cargo´s demand	Permanent navigation
	Cargo´s investments
Interconnectivity & intermodality	Cargo´s riverways network
	New projects related
	Riverways projects from IIRSA

Succes area 10: Seaports improvement of capacity, efficiency & productivity

Objectives	Variables
Investments, infrastructure & operation	Investments
	Infrastructure
	Operation
Network`s expansion and consolidation	Growth of Seaports´capacity
	Seaports´ operation
	Capacity and consolidation investments
Regional, inter-regional & international	Strategic harbouring regions
	Maritime regional connection
	International commerce by
Atlantic coast´s strategy	Seaports´ access
	Regional seaports promotion
	Environmental impact
Pacific coast´s strategy	Seaports´ access & capacity
	Regional seaports promotion
Ports efficiency (infrastructure, equipment, logistics & tariffs)	Infrastructure´s efficiency
	Equipment´s efficiency
	Logistics
	Operation tariffs
	Commercial efficiency

Succes area 11: Efficiency, equitty, sustainabillity & flexibillity to the urban transport system

Objectives	Variables
Investments, infrastructure & operation	Investments
	Infrastructure
	Operation
Alternative transport in small towns	Alternative transport´s infrastructure
	Alternative transit
	Urban transport operation
	Safety and reliabillity
	Environmental impact
	Organisational impacts
	Urban routes restructuring
	Urban transport tariffs
Small towns mobility	Related investments small towns
	Mobility plans´ management
Development of traffic management actions at medium towns	Related investments medium towns
	Traffic management
Medium towns traffic management results	Urban transport operation
	Safety and reliability
	Environmental impact
	Organisational impacts
	Urban routes restructuring
	Urban transport tariffs
BRSs development & sustainabillity at major cities	BRSs´ investments
	BRSs´ implementation
Major cities BRSs results	Urban transport operation
	Safety and reliability
	Environmental impact
	Organisational impacts
	Urban routes restructuring
	Urban transport tariffs

Succes area 12: Intermodal development (infrastructure, logistics & international cross-borders)

Objectives	Variables
Investments, infrastructure & operation	Investments
	Infrastructure
	Operation
Modes integral & complementary schemes	Intermodal operation size
	Regulation & new projects
	IIRSA projetcs
	Multimodal efficiency
Logistics centres & international cross-borders	Investments on logistics
	Multimodal operators
	Cross-borders investments
Logistics strategies	Development of internal
	IIRSA projetcs
	Interchange nodes development
	Promotion and control
	Corporate governance
Intermodal management, results & regulation	Intermodal management
	Private participation
	Efficiency of intermodal operation

Source: own elaboration.

6. Pilot results in electricity coverage and its market in Colombia

This section summarizes major findings on the application of the IGF model to the analysis of strategic policies and potential trends of the electricity coverage and its market size in Colombia[35.] Electricity sector policies were identified by applying the strategic planning process suggested at the methodology section (Figure 8). Policies chosen were also checked against recent forecasting exercises related to the Colombia´s National Development Plan 2007-2010[36] and the Colombia 2019 programme. These pilot results can improve those plans´ objectives. In some cases results helped to confirm previous forecasts as well as to ratify decisions chosen by plans, strategies and programmes previously proposed. Results are presented following the same steps of the general methodology explained at section 4.

6.1 Problem definition and key performance indicators -KPIs

To characterize the electricity sector in Colombia, six major success areas were identified: i) infrastructure, production & consumption; ii) regional integration; iii) international prices determinants; iv) supply-demand equilibrium; v) subsides to poor users, and vi) universal access and energy alternative sources (see Figure 22a). These areas were defined from unstructured interviews with managers and professionals at the Energy and Mining group at DNP, from a comprehensive review on past and current policies, programmes and projects at the energy sector, as well as from a data collection process on KPIs related to each area.

From this process, a total of 140 KPIs were chosen and organized by objectives and variables within each success area. Finally a semi-structured questionnaire was developed on the scope and focus of success areas identified in order to select the *development of coverage and market of the electricity sector*, as the programme that better integrates current and future needs within the sector, as well as the programme that can be better characterised through available and reliable data.

A following process of data analysis was achieved in order to reach an equilibrium of KPIs among the BSC dimensions and the implementation cycle phases, as explained in Figures 6 and 9.

To compliment this previous procedure, a structural analysis process was applied in order to identify KPIs useful to the historical trend analysis as was explained at Figure 12.

From both processes, 18 KPIs were finally chosen to characterise the electricity coverage and its market and to study the historic trends related.

These KPIs were organized in four objectives including tariffs, infrastructure/production, investments and population/GDP as Figure 26 shows.

[35] The study also included modeling analysis to the following policy issues in Colombia:
i. Water supply; *Improvements on aqueduct and sewerage coverage at urban and rural levels*.
ii. Telecommunications; *Coverage improvements of voice and data services (telephony and internet)*.
iii. Transport; *investments, demand and operation general public policies to the sector*.

Results on transport applications are available at *Modelos de prospective e infraestructura. Análisis structural balanced scorecard para una nueva planeación de la infraestructura en Colombia.* Torres – Gracia, D. 2007 and *Revista Planeación & Desarrollo.* Vol. 37. No. 1. January – June 2006. Departamento Nacional de Planeación. Bogotá. Colombia.

[36] The Development National Plan 2007-2010 was under construction during this pilot exercise.

Figure 26
KPIs on electricity coverage and its market in Colombia

Variable	INDICATOR	Indicator Code (3)			
		BSC dimmension	Indicator type	Number	Unit
Population & GDP	Total population	C	I	1	inhabitants
	Real GDP growth	F	R	2	%
Investments	Electricity public investmet	F	I	3	$COL Mill 2005 (2)
	Electricity private investmet	F	I	4	$COL Mill 2005 (2)
	ZNI public investments (executed resources) (1)	F	I	5	$COL Mill 2005 (2)
Infrastructure and production	Effective generation capacity installed (hydraulic)	P	I	6	MegaWatts
	Effective generation capacity installed (thermal)	P	I	7	MegaWatts
	SIN coverage (1)	P	R	8	%
	ZNI coverage	P	R	9	%
	Electricity demand annual growth	P	IP	10	%
	Residential electricity demand	P	IP	11	Gigawatts/hour/inhab
	Electricity exports	P	IP	12	GWh
	Electricity international interchange connections	P	R	13	connection
Users tariffs	SIN subscribers	C	I	14	subscribers
	ZNI subscribers	C	I	15	users
	Average electricity residential tariffs	F	IP	16	$ COL current / kwh
	Average electricity stock market prices	F	IP	17	$ COL 2005 / kwh
	Average electricity contracts prices	F	IP	18	$ COL 2005 / kwh

Notes:
(1) SIN= National interconnected system (urban and major sub-urban areas);
ZNI = not interconnected zones (rural areas outside the national interconnected electricity system-sin)
(2) $COL Mill = Millions of Colombian Pesos at December 2005. (1 US$ Dollar = $ 2.278 Colombian pesos)
(3) Alphanumeric identification for each KPI based on its BSC dimmension and indicator type, regarding the objectiv e frame.
BSC dimmensions; C = clients, F = financial, P = internal processes
Indicator type; I = input, A = activities, R = results, IP = impacts

Source: own elaboration

6.2 Module 1. Historical trends analysis

Starting from KPIs identified (Figure 26), the related influence-dependence graph was built. Matrixes 1 and 2, from which this graph is drawn, were equally weighted, meaning that both qualitative and quantitative criteria have the same importance level within the analysis. These criterions are related with the cause-effect scale and the Pearson's coefficient respectively as previously explained in section 3.1. Matrix shows at Figure 27 is the one resulting from this process. It is a quantitative representation on the relationships among KPIs identified where both qualitative and quantitative relationships, are equally important. As bigger the number within this matrix, as bigger the causal relationship between the pair of KPIs related within each box. While the absolute number in the box is irrelevant, its relative position between the maximum and minimum values within the matrix, represents the importance level on the causal relationship among all the KPIs included in the matrix.

Figure 27
Qualitative-Quantitative matrix on historical trends (1970-2005) of the electricity coverage / market

Sector: **Energy**
Sucess area: **Electricity**
Programe: **Development of electricity coverage and market**
QUALITATIVE & QUANTITATIVE MATRIX   Type: Input - Result - Impact (8th power)

Indicator code	C	F	F	F	F	P	P	P	P	P	P	P	P	C	C	F	F	F	Influence
	I	R	I	I	I	I	I	R	R	IP	IP	IP	R	I	I	IP	IP	IP	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
C I 1	2,5E+157	3,7E+157	5,1E+157	5,4E+157	5,0E+157	4,4E+157	4,9E+157	4,3E+157	4,5E+157	4,8E+157	4,9E+157	5,8E+157	5,2E+157	4,1E+157	3,8E+157	5,7E+157	5,4E+157	5,1E+157	8,5E+158
F R 2	1,9E+157	2,8E+157	3,9E+157	4,2E+157	3,8E+157	3,4E+157	3,7E+157	3,3E+157	3,4E+157	3,6E+157	3,7E+157	4,4E+157	3,9E+157	3,2E+157	2,9E+157	4,4E+157	4,1E+157	3,9E+157	6,5E+158
F I 3	2,8E+157	4,1E+157	5,8E+157	6,1E+157	5,6E+157	5,0E+157	5,5E+157	4,8E+157	5,1E+157	5,4E+157	5,5E+157	6,5E+157	5,8E+157	4,7E+157	4,3E+157	6,5E+157	6,1E+157	5,8E+157	9,6E+158
F I 4	2,2E+157	3,2E+157	4,4E+157	4,7E+157	4,3E+157	3,8E+157	4,2E+157	3,7E+157	3,9E+157	4,1E+157	4,2E+157	5,0E+157	4,5E+157	3,6E+157	3,3E+157	5,0E+157	4,7E+157	4,4E+157	7,3E+158
F I 5	1,4E+157	2,0E+157	2,9E+157	3,0E+157	2,8E+157	2,5E+157	2,7E+157	2,4E+157	2,5E+157	2,7E+157	2,7E+157	3,2E+157	2,9E+157	2,3E+157	2,1E+157	3,2E+157	3,0E+157	2,9E+157	4,7E+158
P I 6	3,2E+157	4,7E+157	6,5E+157	6,9E+157	6,3E+157	5,6E+157	6,2E+157	5,4E+157	5,7E+157	6,0E+157	6,1E+157	7,3E+157	6,5E+157	5,2E+157	4,8E+157	7,3E+157	6,8E+157	6,5E+157	1,1E+159
P I 7	2,4E+157	3,5E+157	4,9E+157	5,2E+157	4,7E+157	4,2E+157	4,6E+157	4,1E+157	4,3E+157	4,5E+157	4,6E+157	5,5E+157	4,9E+157	3,9E+157	3,6E+157	5,4E+157	5,1E+157	4,8E+157	8,0E+158
P R 8	3,3E+157	4,8E+157	6,8E+157	7,2E+157	6,6E+157	5,8E+157	6,5E+157	5,6E+157	5,9E+157	6,3E+157	6,4E+157	7,6E+157	6,8E+157	5,5E+157	5,0E+157	7,6E+157	7,1E+157	6,7E+157	1,1E+159
R 9	1,9E+157	2,8E+157	3,9E+157	4,2E+157	3,8E+157	3,4E+157	3,8E+157	3,3E+157	3,5E+157	3,7E+157	3,7E+157	4,4E+157	4,0E+157	3,2E+157	2,9E+157	4,4E+157	4,1E+157	3,9E+157	6,5E+158
P IP 10	2,5E+157	3,6E+157	5,1E+157	5,4E+157	5,0E+157	4,4E+157	4,9E+157	4,2E+157	4,5E+157	4,7E+157	4,8E+157	5,7E+157	5,1E+157	4,1E+157	3,8E+157	5,7E+157	5,3E+157	5,1E+157	8,4E+158
P IP 11	2,7E+157	3,9E+157	5,4E+157	5,7E+157	5,3E+157	4,6E+157	5,2E+157	4,5E+157	4,7E+157	5,0E+157	5,1E+157	6,1E+157	5,4E+157	4,4E+157	4,0E+157	6,0E+157	5,7E+157	5,4E+157	8,9E+158
P IP 12	2,5E+157	3,7E+157	5,2E+157	5,5E+157	5,0E+157	4,4E+157	4,9E+157	4,3E+157	4,5E+157	4,8E+157	4,9E+157	5,8E+157	5,2E+157	4,2E+157	3,8E+157	5,8E+157	5,4E+157	5,1E+157	8,5E+158
P R 13	2,3E+157	3,3E+157	4,6E+157	4,9E+157	4,5E+157	4,0E+157	4,4E+157	3,9E+157	4,1E+157	4,3E+157	4,4E+157	5,2E+157	4,7E+157	3,7E+157	3,4E+157	5,2E+157	4,9E+157	4,6E+157	7,7E+158
C I 14	2,1E+157	3,0E+157	4,2E+157	4,4E+157	4,1E+157	3,6E+157	4,0E+157	3,5E+157	3,7E+157	3,9E+157	4,0E+157	4,7E+157	4,2E+157	3,4E+157	3,1E+157	4,7E+157	4,4E+157	4,2E+157	6,9E+158
C I 15	1,6E+157	2,3E+157	3,2E+157	3,4E+157	3,2E+157	2,8E+157	3,1E+157	2,7E+157	2,8E+157	3,0E+157	3,1E+157	3,6E+157	3,3E+157	2,6E+157	2,4E+157	3,6E+157	3,4E+157	3,2E+157	5,3E+158
F IP 16	1,9E+157	2,8E+157	3,9E+157	4,1E+157	3,8E+157	3,3E+157	3,7E+157	3,2E+157	3,4E+157	3,6E+157	3,7E+157	4,4E+157	3,9E+157	3,1E+157	2,9E+157	4,3E+157	4,1E+157	3,9E+157	6,4E+158
F IP 17	1,8E+157	2,6E+157	3,6E+157	3,9E+157	3,6E+157	3,1E+157	3,5E+157	3,0E+157	3,2E+157	3,4E+157	3,4E+157	4,1E+157	3,7E+157	2,9E+157	2,7E+157	4,1E+157	3,8E+157	3,6E+157	6,0E+158
F IP 18	1,9E+157	2,7E+157	3,8E+157	4,0E+157	3,7E+157	3,3E+157	3,6E+157	3,2E+157	3,3E+157	3,5E+157	3,6E+157	4,2E+157	3,8E+157	3,0E+157	2,8E+157	4,2E+157	4,0E+157	3,8E+157	6,2E+158
Dependence	4,1E+158	6,0E+158	8,3E+158	8,8E+158	8,1E+158	7,2E+158	8,0E+158	6,9E+158	7,3E+158	7,7E+158	7,9E+158	9,3E+158	8,4E+158	6,7E+158	6,2E+158	9,3E+158	8,8E+158	8,3E+158	

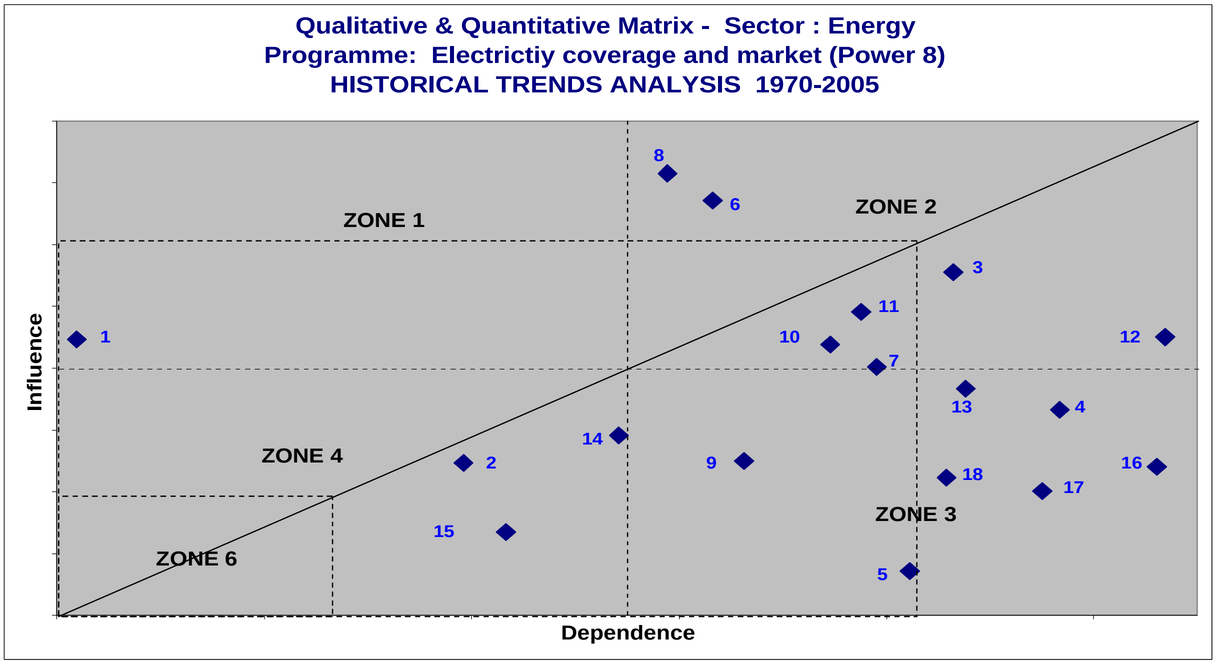
Note: absolute values are irrelevant. Relevance is given through relative values against maximum and minimum figures on influence and dependence. Total values on dependence and influence for each KPI are drawn in an x-y graph to have the influence-dependence graph

From drawing total values of influence and dependence for each KPI, the graph at Figure 28 is built as a graphical representation on the relationships among and the role of the KPIs that better describe the development of coverage and market to the electricity sector.

According with Figure 28, the total population (Indicator 1) played a dominant role during the 1970-2005 time frame of historical analysis. This is due to its relatively high influence level combined with a quite low dependence level. This means, that population dominates changes in the rest of KPIs included within the analysis, without being affected back by them. Although this finding is consistent with traditional understanding of population as a key input on tailoring electricity demand and therefore its coverage and market size, the value added of this finding relays on the fact that other KPIs traditionally considered as dominant on coverage policies and plans, have not played such a historic role. Looking at zone 2, some of these KPIs show a high value of influence (as expected) but also a medium-to-high value of dependence. This is a very interesting finding as it shows how KPIs such as hydraulic generation capacity and SIN coverage (indicators 6 & 8 respectively) did have a strong influence on past trends of electricity national coverage and market, and also have been much more sensitive to other KPIs changes than traditionally though.

This is a key input when it comes to analyze inertial and none expected effects resulting from policies/actions directly affecting KPIs within zone 2. Other findings from figure 28 can be summarized as follows:

Figure 28
Influence-dependence graph on historical trends of the electricity coverage and market.



Zone 1. Input- dominant KPIs

1	Total population (urban & rural)

Zone 2. Relay- conflict KPIs

3	Electricity public investmet
6	Effective generation capacity installed (hydraulic)
7	Effective generation capacity installed (thermal)
8	SIN coverage (1)
10	Electricity demand annual growth
11	Residential electricity demand
12	Electricity exports

Zona 4: Independent KPIs

2	Real GDP growth
14	SIN subscribers
15	ZNI subscribers

Zone 3: Results KPIs

4	Electricity private investmet
5	ZNI public investments (executed resources) (1)
9	ZNI coverage
13	Electricity international interchange connections
16	Average electricity residential tariffs
17	Average electricity stock market prices
18	Average electricity contracts prices

Zone 5: Middle cluster or standard KPIs

1	Total population (urban & rural)	10	Electricity demand annual growth
2	Real GDP growth	11	Residential electricity demand
7	Effective generation capacity installed (thermal)	14	SIN subscribers
9	ZNI coverage	15	ZNI subscribers

Zone 6: Marginal KPIs

19	Sewerage rural subscribers

Source: own elaboration. Numbers in the graph are codes representing each KPIs as classified in figure 26.

- KPIs that have been more dependent or affected by other KPIs, include private investment and electricity prices (KPIs 4, 16, 17 and 18).

- KPIs such as GDP, investments, SIN generation capacity and residential tariffs, played a relay or conflict role (see Figure 10) rather than a dominant role, as traditionally assumed.

- A critical case is GDP growth which is generally considered as a variable strongly correlated with electricity coverage. Figure 28 shows an independent rather than a dominant role for this KPI. Considering recommendations given in Figure 10 for independent KPIs, many past recommendations to the sector that came from econometric driven analysis, where GDP growth was considered as a dominant variable on electricity coverage could be related with very low benefit/cost results.

- Electricity investments have played different historical roles. While public investments have played a conflict role, private investments have played a dependent rather than a dominant role as it is traditionally understood within the sector. Private investments like electricity prices have been affected by KPIs at Zone 2, rather than control them.

- KPIs related with infrastructure stock and electricity production have mainly played a control role on electricity prices rather than sector investments.

Previous results are some examples of potential uses of the influence-dependence graph. In all cases analysts benefited from these analyses should also have in mind the following limitations on these results:

- These results are highly dependent on the time frame of analysis. Therefore rather than longer periods of analysis, shorter periods ranging around 3-5 years are strongly recommended, therefore trend changes can be easily identified.

- Final results combine both hard and soft data analysis (time series and analyst's criteria respectively). Depending on the importance that the analyst wants to give to each factor, he/she can represent it within the model by changing the relative weight on the quantitative-qualitative matrix.

- The description of roles should be subscribed to the KPIs selected within the analysis. Therefore an iterative approach is suggested by starting with a comprehensive list with as many KPIs as could be considered according with the objectives of the analyses. Then, smaller groups of KPIs could be used on a following iteration by extracting those KPIs considered less relevant in the previous iteration (i.e. those at the independent or marginal zones of the influence-dependence graph). This process will give better results on the analysis focus, as well as a systematic process of KPIs prioritization.

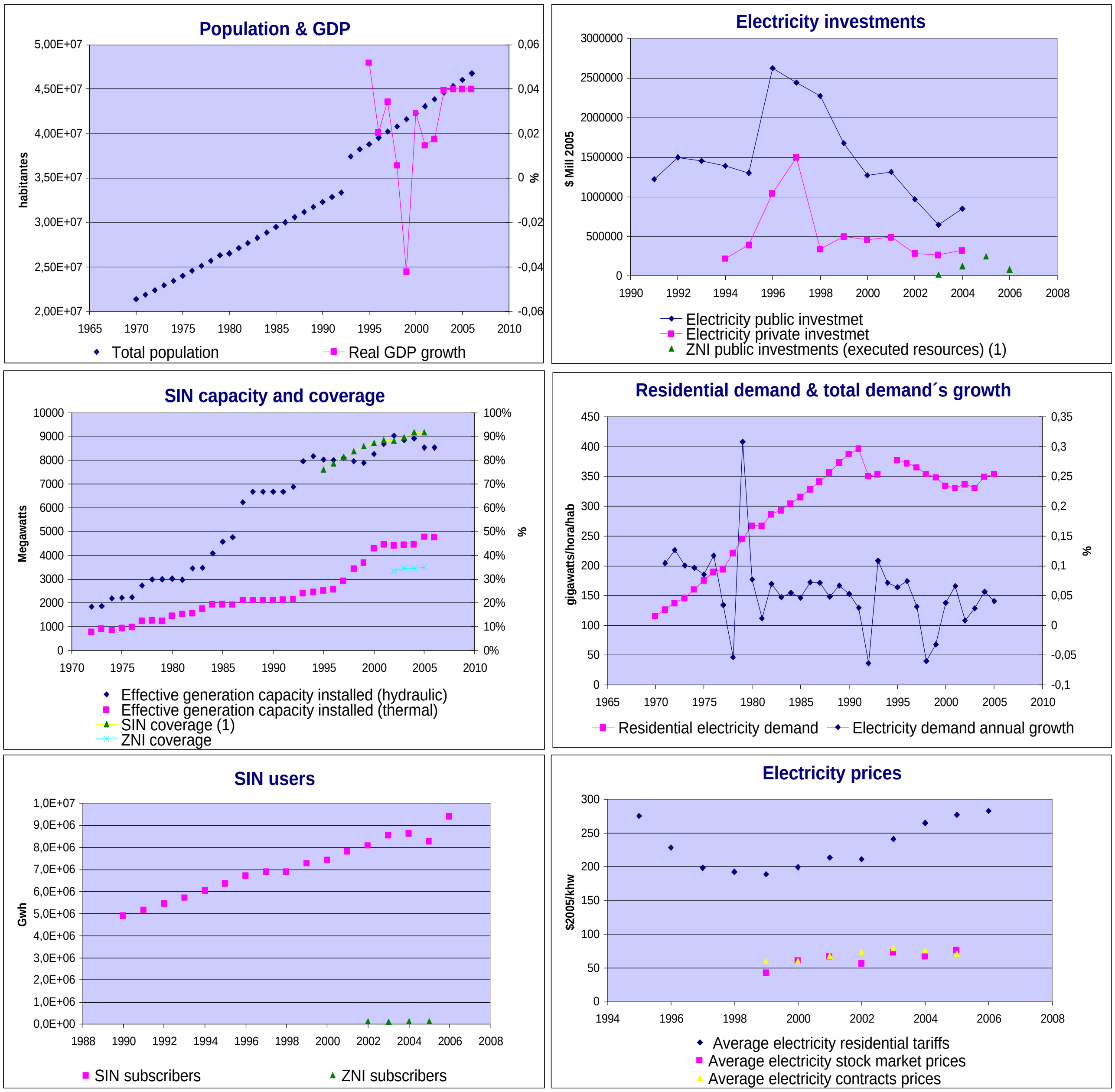
The second group of results comes from the **general trends analysis**. This is a traditional *where it comes from* type of analysis, quite useful to understand what have happened to each KPI historically, independently from its external determinants. Figure 29 shows general trends on the electricity coverage and market's KPIs chosen. A broad review on general trends showed in this figure can be summarized as follows:

- A relatively stable trend of total electricity investments. On the other side, ZNI investments[37] show an unstable trend to growth since 2003. They have represented around 15% of public investments in electricity.

- Regarding capacity and coverage trends, a stable and growing trend has been shown since 1970. The none-hydraulic generation capacity (which is mainly thermal), has to be

[37] Investments at rural and non interconnected areas.

Figure 29.
General trends 1970-2005 on electricity coverage & market.



Sources: CREG (12006), DANE (1996), DNP (1997a), MME (2006a, 2006b, 2006c), UPME (2006).

highlighted, with a constant annual 6% growth between 1972 and 2006. Electricity coverage has grown at 2% annual average in the same period, both to the SIN and ZNI systems.

- Regarding electricity demand, residential demand shown for almost 20 years a stable annual growth around 5%, up to mid the 90s when reduction trends on consumption were related with economic recession, and residential demand fall to -1% between 1995 and 2005. Unstable trends from past growth to mid 90s reductions, are also shown by electricity total demand.

- Finally, electricity prices show reduction trends on residential tariffs up to the end of the XX century, followed by a recuperation period up to the end of 2006, were tariffs were equal to 1996 figures. This recuperation period came together with increases on the electricity stock market prices as well as contract prices negotiated under BOOT schemes.

The third group of results is called **primary & secondary causal trend analysis**, and it helps describing why dominant KPIs played that role. To do this, structural analysis results are used to identify the KPIs having the stronger causal relationships with, i) the dominant KPIs identified at the original KPIs trend analysis (primary causal trend), ii) the KPIs with the stronger causal relationships with the previous ones (secondary causal trend). By studying the structural analysis matrixes, those causal relationships can be identified both from the quantitative and the qualitative point of view. The firs step here is to identify the KPIs more strongly controlled by the dominant KPIs (dominated KPIs).

From Figure 29, *total population* as the unique dominant KPI, has played a control role on other KPIs dynamics. But, ¿what KPIs have been mostly affected by this control role? From values at Figure 27, those KPIs can be identified as the ones corresponding with the higher values of the first row in the matrix, which represents the level of influence of total population (KPI No. 1) to all the other KPIs included in the analysis. From this, *private investments and residential tariffs* (KPIs number 4 and 16 respectively) can be identified as those more affected by the total population dynamics, both qualitatively and quantitatively. From other side, electricity stock prices are also affected but because of their qualitative relationships with total population rather than its quantitative connections[38]. Finally, from a quantitative point of view, *international interchange connections of electricity, SIN coverage and ZNI users*, (KPIs number 13, 8 and 15 respectively), are the KPIs mostly affected by total population trends.

To continue with the primary causal trend analysis, it is necessary to identify the higher values within the qualitative-quantitative matrix for those KPIs identified with a dependent role[39]. These dependent KPIs include; electricity private investments (No.4 at Figure 28), ZNI public investments (No. 5), ZNI coverage (No.9), electricity international interchange connections (No. 13), average electricity residential tariffs (No. 16), average electricity stock market prices (No. 17) and average electricity contract prices (No. 18). By identifying the three KPIs that more affect these dependent KPIs, a pattern emerges; SIN coverage (KPI No. 8) is the stronger causal variable that affects all dependent KPIs, together with the effective generation capacity installed (No.6) and the electricity public investment. (No. 8)[40] This means that past actions and decisions directly affecting those three variables (SIN coverage specially), were highly determinants for the electricity coverage and market historical trends.

[38] Figure 27´s matrix is a weighted average from qualitative and quantitative independent matrixes as explained at Figure 3. If the total population as the stronger qualitative effect over electricity stock prices, this means that column No. 17 (which represents stock prices), has the higher value within the first row (which represents total population)

[39] KPIs with a dependent role were located at Zone 3 in Figure 28. In this case, the higher values within the matrix represent those KPIs that more affected the dependent KPIs. They are coincident with the rows having the higher values within each dependent KPI´s column in the qualitative-quantitative matrix (see Figure 27).

[40] With the last ones, having a lower level of influence.

By advancing another step in the causation chain (**secondary causal trend analysis**), two variables were identified as those that more affect SIN coverage trends. They are the effective generation capacity installed (No.6) and the electricity international interchange connections (No. 13). The first one is a variable traditionally considered as dominant within the sector, confirming the strong role played by a sector essentially controlled by its hydraulic generation.

The second one on the contrary, was not expected to be a dominant variable considering that international electricity connections are in place since early 2000. Therefore results about its historical effects over the SIN coverage are not quite clear[41].

Figure 30 summarizes results on primary and secondary causal trends analysis. Boxes at left columns on each case show KPIs codes as defined in Figure 26. Following columns from left to right, show the codes of the three KPIs that more affect each dependent KPI respectively from quantitative, qualitative and qualitative-quantitative focuses[42].

These results are powerful inputs to build an electricity sector's diagnosis which not only explain what had happened to the electricity coverage and market past trends, but also and more important, to systematically understand why those trends have been the way they were in the past.

By identifying those cause-effect connections, better informed and improved decisions can be taken on current electricity coverage and market policies, whether they have to be taken or not.

Figure 30.
Primary and secondary causal trends analysis on electricity coverage & market[43].

Primary causal trend analysis

(1) Dependent KPIs	KPIs that more affect (1)		
	Qualitatively	Quantitatively	Qualitatively and quantitatively
4	13	8	8
	12	6	6
	8	3	3
5	13	8	8
	12	6	6
	8	3	3
9	13	8	8
	12	6	6
	8	3	3
13	12	8	8
	8	6	6
	1	3	3
16	13	8	8
	12	6	6
	8	3	3
17	13	8	8
	12	6	6
	8	3	3
18	13	8	8
	12	6	6
	8	3	3

Secondary causal trend analysis

(1) Dependent KPIs	KPIs that more affect (1)		
	Qualitatively	Quantitatively	Qualitatively and quantitatively
8	13	6	6
	12	3	3
	15	10	11
6	13	8	8
	12	3	3
	8	10	11
3	13	8	8
	12	6	6
	8	10	11

Source: own elaboration

[41] To clarify the role of this KPI, there might be necessary to apply the iteration process suggested at Figure 12.
[42] Taken from quantitative, qualitative and qualitative-quantitative matrixes respectively. The last one is showed at Figure 27.

[43] Circles show stronger causality patterns

6.3 Module 2. Current situation and short term effect of new policies

According to Figure 15, the first step to implement this module is to identify the KPIs that better characterise the **current situation** of the programme studied. Giving consistency to the Module 1´s analysis, the programme chosen is related with the electricity coverage and market goals that have been defined to the medium and long term by the DNP *(see DNP, 2006a).*

Success area:	*an electricity market with enhanced efficiency, national integration and* international *expansion.*
KPIs:	*18 KPIs classified into four variables looking at user tariffs, infrastructure & production, investments and population and GDP related issues (Figure 26).*
Time frame:	*2002-2006* [44]

As part of this step, lacks of data in the annual time-series within the time frame, were fulfilled by applying a three-side criteria of historical, cause-effect and average growth KPIs dynamics, as explained in Figure 13. According with that, time series on the 18 KPIs were completed as shown at Figure 31. Time series resulting were used to calculate the qualitative-quantitative matrix that represents current situation on electricity coverage and market. This matrix is based on two more matrixes as was explained in Figure 3. The three matrixes are showed at Figure 32. While the quantitative matrix was calculated from stochastically filled up time series, the qualitative one was based on the same assumptions of the Module 1´s analysis[45]. The influence-dependence graph resulting from these matrixes is showed at Figure 33

Figure 31.
Filling up criterions applied to electricity coverage and market´s KPIs.

KPIs with empty years on their time-series		.(1) · Better historic adjustment curver	.(2) · Better cause-effect adjustment curve / · Independent KPI	.(3) · Annual growth average (time frame) / · Multiplying coefficient	.(4) · Period with Lagrange´s linear interpolation
3	Electricity public investmet	Euler´s curve	· Euler´s curve (R^2=0,1705)	·1,69% (1992-2005)	
		(R^2=0,2101)	· 6 - Effective generation capacity installed (hydraulic)	·1,00	
4	Electricity private investmet	Linear curve	· Euler´s curve (R^2=0,191)	·22,82% (1995-2004)	
		(R^2=0,1023)	· 6 - Effective generation capacity installed (hydraulic)	·1,00	
8	SIN coverage	Logarithmic curve	· Logarithmic curve (R^2=0,5296)	·1,91% (1996-2005)	
		(R^2=0,9372)	· 6 - Effective generation capacity installed (hydraulic)	·1,00	
9	ZNI coverage	Logarithmic curve	· Logarithmic curve (R^2=0,7127)	·1,59% (2002-2005)	
		(R^2=0,7531)	· 8 - SIN coverage	·1,00	
10	Electricity demand annual growth	Polynom-grade 2	· Polynom-grade 2 (R^2=0,414)	·-47,81% (1971-2005)	
		(R^2=0,1729)	· 8 - SIN coverage	·1,00	
11	Residential electricity demand	Logarithmic curve	· Polynom-grade 2 (R^2=0,7594)	·3,37% (1971-2005)	1994 y 1998
		(R^2=0,7234)	· 8 - SIN coverage	·1,00	
12	Electricity exports	Euler´s curve	· Linear (R^2=0,995)	·26,74% (2003-2005)	
		(R^2=0,8231)	· 8 - SIN coverage	·1,00	
15	ZNI subscribers	Linear curve	· Linear (R^2=0,7558)	·1,598% (2002-2005)	
		(R^2=0,7235)	· 8 - SIN coverage	·1,00	
17	Average electricity stock market prices	Logarithmic curve	· Logarithmic curve (R^2=0,6728)	·-11,88% (1999-2005)	
		(R^2=0,653)	· 8 - SIN coverage	·1,00	
18	Average electricity contracts prices	Linear curve	· Power curve (R^2=0,5126)	·-4,97% (2000-2005)	
		(R^2=0,6126)	· 8 - SIN coverage	·1,00	

Source: own elaboration

[44] A period chosen accordingly with the dynamics on KPIs selected, so there are not structural changes on their current trends within this period.
[45] This is because time frame for Module 1 and Module 2 is very similar, therefore similar qualitative cause-effect relationships among KPIs should be expected.

Figure 32.

Structural analysis matrixes for the Module 2 application on electricity coverage and market.

Sector: ENERGY
Sucess area: ELECTRICITY
Programe: DEVELOPMENT OF ELECTRICITY COVERAGE AND MARKET

QUALITATIVE MATRIX (1st power) - CURRENT SITUATION 2000-2006

KPI code			C I 1	F R 2	F I 3	F I 4	F I 5	P I 6	P I 7	P R 8	P R 9	P IP 10	P IP 11	P IP 12	P R 13	C I 14	C I 15	F IP 16	F IP 17	F IP 18	Influence
C	I	1	3	2	2	1	1	2	1	2	1	2	3	1	0	2	1	2	0	0	26
F	R	2	2	3	2	1	0	1	0	1	0	3	2	2	1	1	0	1	1	1	22
F	I	3	0	1	3	2	1	3	2	3	2	2	2	2	2	2	1	2	2	2	34
F	I	4	1	2	1	3	1	1	2	1	2	1	1	1	2	2	1	1	2	2	27
F	I	5	0	0	1	0	3	1	1	0	3	0	0	0	0	0	3	1	0	0	13
P	I	6	0	2	3	1	2	3	3	2	1	3	3	3	2	3	1	2	3	2	39
P	I	7	0	1	2	1	3	1	3	2	2	1	1	1	1	1	2	2	2	2	28
P	R	8	1	2	3	2	1	3	2	3	1	3	3	2	2	3	1	2	2	2	38
	R	9	0	0	2	1	3	1	2	0	3	1	1	1	1	1	3	1	0	0	21
P	IP	10	1	3	2	3	1	2	2	1	0	3	2	2	2	2	0	3	2	2	33
P	IP	11	1	2	2	2	1	2	2	1	0	3	3	2	2	1	0	3	2	2	31
P	IP	12	0	0	1	3	1	2	2	1	2	1	0	3	2	1	1	2	2	2	26
P	R	13	0	0	1	2	2	1	2	0	1	0	0	3	3	1	1	2	2	2	23
C	I	14	0	0	1	2	0	1	1	3	0	2	2	1	0	3	0	2	2	2	22
C	I	15	0	0	1	1	3	0	1	0	3	1	1	0	1	0	3	1	0	0	16
F	IP	16	1	1	1	2	1	0	0	1	2	2	2	1	1	1	0	3	2	2	23
F	IP	17	0	1	1	2	1	1	1	0	0	2	2	2	1	0	0	2	3	0	19
F	IP	18	0	1	1	2	1	0	0	1	0	1	1	2	1	0	0	2	3	3	19
Dependence			10	21	30	31	26	25	27	22	23	31	29	29	24	24	18	34	30	26	

Note: Values describe the nature on influence from the KPI in the row to the KPI in the column. 0 = it doesn´t exist; 1= weak influence; 2: medium influence; 3 = strong influence.

QUANTITATIVE MATRIX (1st power or Pearson^2) - CURRENT SITUATION 2000-2006

KPI code			C I 1	F R 2	F I 3	F I 4	F I 5	P I 6	P I 7	P R 8	P R 9	P IP 10	P IP 11	P IP 12	P R 13	C I 14	C I 15	F IP 16	F IP 17	F IP 18	Influence
C	I	1	1,00	0,52	0,08	0,17	0,17	0,01	0,76	0,93	0,66	0,03	0,72	0,94	0,89	0,80	0,81	0,95	0,54	0,42	10,41
F	R	2	0,52	1,00	0,19	0,15	0,47	0,03	0,22	0,57	0,37	0,02	0,32	0,71	0,76	0,39	0,23	0,64	0,50	0,19	7,27
F	I	3	0,08	0,19	1,00	0,82	0,47	0,48	0,02	0,05	0,47	0,17	0,02	0,76	0,99	0,17	0,64	0,06	0,02	0,69	7,10
F	I	4	0,17	0,15	0,82	1,00	0,34	0,52	0,00	0,09	0,74	0,39	0,00	0,89	0,98	0,21	0,95	0,10	0,00	0,68	8,04
F	I	5	0,17	0,47	0,47	0,34	1,00	0,24	0,39	0,33	0,01	0,06	0,07	0,11	0,48	0,23	0,36	0,37	0,05	0,92	6,08
P	I	6	0,01	0,03	0,48	0,52	0,24	1,00	0,02	0,00	0,27	0,11	0,05	0,47	0,71	0,06	0,56	0,00	0,05	0,51	5,10
P	I	7	0,76	0,22	0,02	0,00	0,39	0,02	1,00	0,69	0,28	0,08	0,65	0,59	0,88	0,43	0,70	0,73	0,58	0,10	8,12
P	R	8	0,93	0,57	0,05	0,09	0,33	0,00	0,69	1,00	0,52	0,13	0,69	0,88	0,84	0,70	0,82	0,98	0,55	0,32	10,09
	R	9	0,66	0,37	0,47	0,74	0,01	0,27	0,28	0,52	1,00	0,11	0,27	0,75	0,60	0,57	0,46	0,52	0,16	0,72	8,48
P	IP	10	0,03	0,02	0,17	0,39	0,06	0,11	0,08	0,13	0,11	1,00	0,08	0,55	0,30	0,03	0,58	0,10	0,19	0,03	3,96
P	IP	11	0,72	0,32	0,02	0,00	0,07	0,05	0,65	0,69	0,27	0,08	1,00	0,99	0,76	0,62	0,85	0,67	0,27	0,07	8,09
P	IP	12	0,94	0,71	0,76	0,89	0,11	0,47	0,59	0,88	0,75	0,55	0,99	1,00	0,80	0,44	0,90	0,90	0,04	0,32	12,03
P	R	13	0,89	0,76	0,99	0,98	0,48	0,71	0,88	0,84	0,60	0,30	0,76	0,80	1,00	0,09	0,91	0,97	0,16	0,75	12,85
C	I	14	0,80	0,39	0,17	0,21	0,23	0,06	0,43	0,70	0,57	0,03	0,62	0,44	0,09	1,00	0,30	0,70	0,38	0,59	7,70
C	I	15	0,81	0,23	0,64	0,95	0,36	0,56	0,70	0,82	0,46	0,58	0,85	0,90	0,91	0,30	1,00	0,74	0,21	0,31	11,33
F	IP	16	0,95	0,64	0,06	0,10	0,37	0,00	0,73	0,98	0,52	0,10	0,67	0,90	0,97	0,70	0,74	1,00	0,65	0,32	10,40
F	IP	17	0,54	0,50	0,02	0,00	0,05	0,05	0,58	0,55	0,16	0,19	0,27	0,04	0,16	0,38	0,21	0,65	1,00	0,17	5,53
F	IP	18	0,42	0,19	0,69	0,68	0,92	0,51	0,10	0,32	0,72	0,03	0,07	0,32	0,75	0,59	0,31	0,32	0,17	1,00	8,10
Dependence			10,41	7,27	7,10	8,04	6,08	5,10	8,12	10,09	8,48	3,96	8,09	12,03	12,85	7,70	11,33	10,40	5,53	8,10	

Note: Pearson^2 values are betwen -1 and 1. The closer to +1 or -1 the stronger the correlation between each pair of KPIs´ statistical variance. The closer to 0, the weaker that correlation.

WEIGHT FACTOR:
QUALITATIVE (%) 50%
QUANTITATIVE (%) 50%

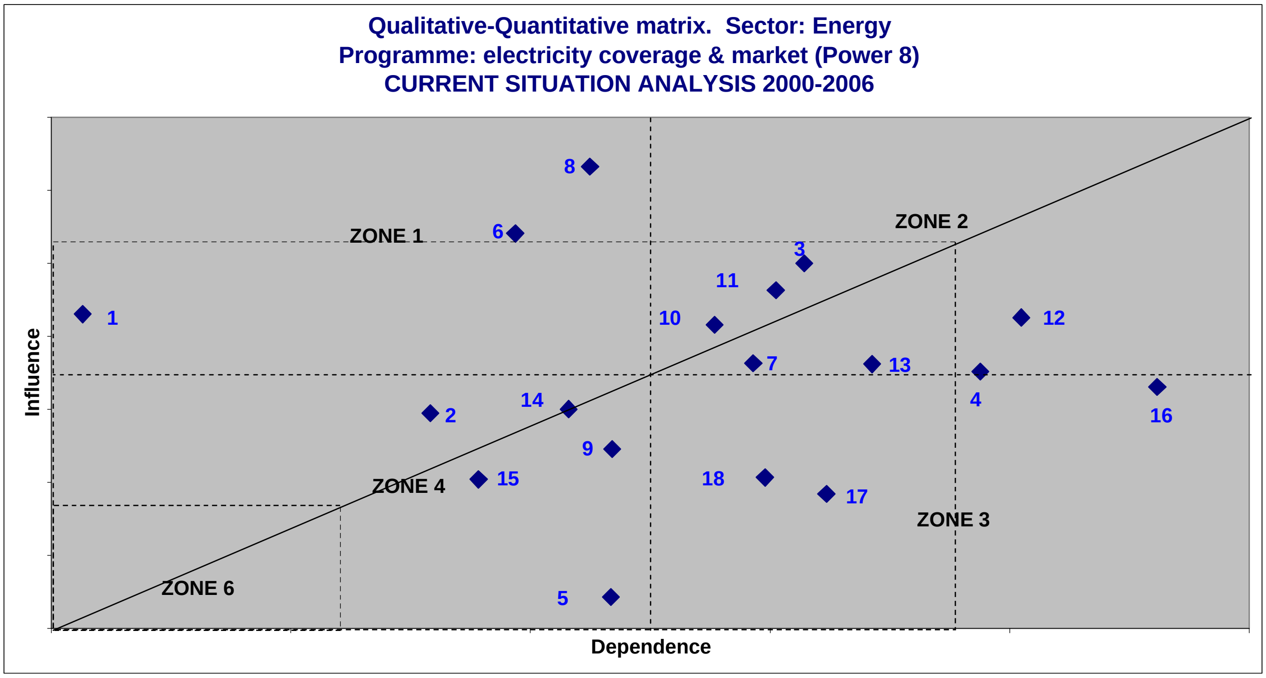
QUANTITATIVE -QUALITATIVE MATRIX (8th power) - CURRENT SITUATION 2000-2006

KPI code			C I 1	F R 2	F I 3	F I 4	F I 5	P I 6	P I 7	P R 8	P R 9	P IP 10	P IP 11	P IP 12	P R 13	C I 14	C I 15	F IP 16	F IP 17	F IP 18	Influence
C	I	1	1,1E+156	1,5E+156	2,0E+156	2,2E+156	1,7E+156	1,6E+156	1,9E+156	1,7E+156	1,7E+156	1,9E+156	2,0E+156	2,3E+156	2,1E+156	1,7E+156	1,6E+156	2,5E+156	2,0E+156	2,0E+156	3,35E+157
F	R	2	8,4E+155	1,2E+156	1,6E+156	1,8E+156	1,4E+156	1,3E+156	1,5E+156	1,4E+156	1,4E+156	1,5E+156	1,6E+156	1,8E+156	1,7E+156	1,4E+156	1,3E+156	2,0E+156	1,6E+156	1,6E+156	2,68E+157
F	I	3	1,2E+156	1,7E+156	2,2E+156	2,5E+156	1,9E+156	1,8E+156	2,1E+156	1,9E+156	1,9E+156	2,1E+156	2,2E+156	2,5E+156	2,3E+156	1,9E+156	1,7E+156	2,7E+156	2,2E+156	2,2E+156	3,70E+157
F	I	4	9,3E+155	1,3E+156	1,8E+156	2,0E+156	1,5E+156	1,4E+156	1,7E+156	1,5E+156	1,5E+156	1,7E+156	1,7E+156	2,0E+156	1,8E+156	1,5E+156	1,4E+156	2,2E+156	1,8E+156	1,7E+156	2,96E+157
F	I	5	4,4E+155	6,4E+155	8,5E+155	9,4E+155	7,4E+155	6,9E+155	8,2E+155	7,3E+155	7,4E+155	8,0E+155	8,3E+155	9,7E+155	8,8E+155	7,2E+155	6,7E+155	1,0E+156	8,6E+155	8,2E+155	1,42E+157
P	I	6	1,2E+156	1,8E+156	2,3E+156	2,6E+156	2,0E+156	1,9E+156	2,3E+156	2,0E+156	2,0E+156	2,2E+156	2,3E+156	2,7E+156	2,4E+156	2,0E+156	1,8E+156	2,9E+156	2,4E+156	2,3E+156	3,91E+157
P	I	7	9,5E+155	1,4E+156	1,8E+156	2,0E+156	1,6E+156	1,5E+156	1,7E+156	1,5E+156	1,6E+156	1,7E+156	1,8E+156	2,1E+156	1,9E+156	1,5E+156	1,4E+156	2,2E+156	1,8E+156	1,8E+156	3,02E+157
P	R	8	1,4E+156	2,0E+156	2,6E+156	2,9E+156	2,3E+156	2,1E+156	2,5E+156	2,2E+156	2,3E+156	2,5E+156	2,6E+156	3,0E+156	2,7E+156	2,2E+156	2,0E+156	3,2E+156	2,6E+156	2,5E+156	4,36E+157
	R	9	7,6E+155	1,1E+156	1,5E+156	1,6E+156	1,3E+156	1,2E+156	1,4E+156	1,2E+156	1,3E+156	1,4E+156	1,4E+156	1,7E+156	1,5E+156	1,2E+156	1,1E+156	1,8E+156	1,5E+156	1,4E+156	2,43E+157
P	IP	10	1,0E+156	1,5E+156	2,0E+156	2,2E+156	1,7E+156	1,6E+156	1,9E+156	1,7E+156	1,7E+156	1,8E+156	1,9E+156	2,2E+156	2,0E+156	1,7E+156	1,5E+156	2,4E+156	2,0E+156	1,9E+156	3,28E+157
P	IP	11	1,1E+156	1,6E+156	2,1E+156	2,3E+156	1,8E+156	1,7E+156	2,0E+156	1,8E+156	1,8E+156	2,0E+156	2,1E+156	2,4E+156	2,2E+156	1,8E+156	1,7E+156	2,6E+156	2,1E+156	2,0E+156	3,52E+157
P	IP	12	1,0E+156	1,5E+156	2,0E+156	2,2E+156	1,7E+156	1,6E+156	1,9E+156	1,7E+156	1,7E+156	1,9E+156	2,0E+156	2,3E+156	2,1E+156	1,7E+156	1,6E+156	2,5E+156	2,0E+156	1,9E+156	3,33E+157
P	R	13	9,4E+155	1,4E+156	1,8E+156	2,0E+156	1,6E+156	1,5E+156	1,7E+156	1,5E+156	1,6E+156	1,7E+156	1,8E+156	2,1E+156	1,9E+156	1,5E+156	1,4E+156	2,2E+156	1,8E+156	1,8E+156	3,01E+157
C	I	14	8,5E+155	1,2E+156	1,6E+156	1,8E+156	1,4E+156	1,3E+156	1,6E+156	1,4E+156	1,4E+156	1,5E+156	1,6E+156	1,8E+156	1,7E+156	1,4E+156	1,3E+156	2,0E+156	1,6E+156	1,6E+156	2,70E+157
C	I	15	7,0E+155	1,0E+156	1,3E+156	1,5E+156	1,2E+156	1,1E+156	1,3E+156	1,1E+156	1,2E+156	1,2E+156	1,3E+156	1,5E+156	1,4E+156	1,1E+156	1,0E+156	1,6E+156	1,3E+156	1,3E+156	2,22E+157
F	IP	16	9,0E+155	1,3E+156	1,7E+156	1,9E+156	1,5E+156	1,4E+156	1,6E+156	1,5E+156	1,5E+156	1,6E+156	1,7E+156	1,9E+156	1,8E+156	1,4E+156	1,3E+156	2,1E+156	1,7E+156	1,7E+156	2,85E+157
F	IP	17	6,7E+155	9,6E+155	1,3E+156	1,4E+156	1,1E+156	1,0E+156	1,2E+156	1,1E+156	1,1E+156	1,2E+156	1,2E+156	1,4E+156	1,3E+156	1,1E+156	1,0E+156	1,6E+156	1,3E+156	1,2E+156	2,12E+157
F	IP	18	7,0E+155	1,0E+156	1,3E+156	1,5E+156	1,2E+156	1,1E+156	1,3E+156	1,1E+156	1,2E+156	1,3E+156	1,3E+156	1,5E+156	1,4E+156	1,1E+156	1,0E+156	1,6E+156	1,4E+156	1,3E+156	2,24E+157
Dependence			1,7E+157	2,4E+157	3,2E+157	3,5E+157	2,8E+157	2,6E+157	3,1E+157	2,7E+157	2,8E+157	3,0E+157	3,1E+157	3,6E+157	3,3E+157	2,7E+157	2,5E+157	3,9E+157	3,2E+157	3,1E+157	

Note : absolute values are irrelevant. Relevance is griven through relative values against maximun and minimum figures on influence and dependence. Total values on dependence and influence for each KPI are drawn in an x-y graph to have the influence-dependence graph

Source: own elaboration. Numbers at major columns and rows are KPIs codes as classified in Figure 26

Figure 33
Influence-dependence graph on current situation 2002-2006 of the electricity coverage and market



Zone 1. Input- dominant KPIs

1	Total population (urban & rural)
6	Effective generation capacity installed (hydraulic)
8	SIN coverage

Zone 2. Relay- conflict KPIs

3	Electricity public investmet
4	Electricity private investmet
7	Effective generation capacity installed (thermal)
10	Electricity demand annual growth
11	Residential electricity demand
12	Electricity exports
13	Electricity international interchange

Zona 4: Independent KPIs

2	Real GDP growth
5	ZNI public investments (executed resources)
9	ZNI coverage
14	SIN subscribers
15	ZNI subscribers

Zone 3: Results KPIs

16	Average electricity residential tariffs
17	Average electricity stock market prices
18	Average electricity contracts prices

Zone 5: Middle cluster or standard KPIs

1	Total population (urban & rural)
2	Real GDP growth
3	Electricity public investmet
5	ZNI public investments (executed resources)
7	Effective generation capacity installed (thermal)
9	ZNI coverage
10	Electricity demand annual growth
11	Residential electricity demand
13	Electricity international interchange
14	SIN subscribers
15	ZNI subscribers
17	Average electricity stock market prices
18	Average electricity contracts prices

Zone 6: Marginal KPIs

19	Sewerage rural subscribers

Source: own elaboration. Numbers in the graph are codes representing each KPIs as classified in Figure 26

From Figure 33, the major patterns emerging on KPIs roles can be summarized as follows:

- More than 50% of chosen KPIs can affect current situation on electricity coverage and market, however any action or decision over half of them, might generate uncontrollable effect over the rest of KPIs chosen. This is because thirteen KPIs were located at the standard zone (Zone 5).

- Only 5 KPIs are actually located at the zone were KPIs ideal to describe current situation are. These indicators include; electricity private investments, effective generation capacity installed (hydraulic), SIN coverage, electricity exports and average electricity residential tariffs. The role of these five KPIs is widely different; from on side hydraulic capacity and SIN coverage's role is dominant, having the stronger influence on current electricity coverage and market's situation. Strategies and actions directly affecting them may generate significant changes on others general trends of the electricity coverage and market. Those actions may have excellent cost/benefit ratios, without generate inertial or uncontrollable side-effects on other KPIs[46].

- On the other side, private investments and electricity exports have a medium level of influence within the programme studied, but because of their conflicting role, actions over them are unstable and could generate uncontrollable side effects to other KPIs. This is why, only carefully monitored actions are strongly recommended as well as actions within a step-by-step strategies or action looking for marginal changes only. Actions or strategies looking for structural changes are strongly not recommended over these KPIs.[47]

- Finally, the variable residential tariffs (average value for the middle income population), is shown as ideal to visualize or describe the current dynamics of the electricity coverage and market. Because of its high level of dependence and sensitiveness, residential tariffs are excellent sensors of the programme. This is why they are recommended for a monitoring system but not as candidates for direct actions or strategies. Those actions might have very inadequate cost/benefits ratios.

- It is interesting to realise how KPIs like real GDP growth, public investments, ZNI coverage and number of subscribers (both to the SIN and the ZNI), show an independent role. Some of them (GDP and public investments particularly) have been traditionally considered as strong determinants within the electricity sector.

- Major changes on KPIs from their historical trends to their current situation were showed by highlighting related KPIs in Figure 33`s boxes. They can be summarised as follows[48]:

  - Hydraulic installed capacity and SIN coverage reduce their dependence level but keep their influence level. Therefore they come from being unstable and conflicting KPIs to be power and dominant KPIs. As power KPIs direct actions or strategies over then are know strongly recommended.

  - Electricity private investments and international connections increase their influence level, becoming conflict KPIs (they were dependent KPIs historically). Because of this, their strategic relevance is increased and actions over them generate bigger changes within the programme, although they have to be carefully monitored to avoid side-effects over other KPIs.

  - Public investments and ZNI coverage reduce their dependence level, therefore they become independent KPIs (they were

[46] These KPIs are within Zone 1 but out of the Standard boundary. (See Figure 33).
[47] These KPIS are within Zone 2 but out of the Standard boundary (See Figure 33)

[48] Graphically speaking, these changes can be identified by comparisons between Figures 28 and 33.

dependent historically). Because of this, they loose their importance within the programme. In the past they were good sensors of the programme changes. Currently, they not only loose that property but their changes do not generate any relevant impact on the programme trends.

Once electricity coverage and market's current situation have been properly simulated by the model, it is possible to calculate changes over that situation because of the implementation of a new PPP[49]. This is possible as long as the new PPP can be properly characterised through some of the KPIs used to represent the current situation of the programme over which that PPP will be implemented. To keep consistency, the new PPP was the implementation of a specific goal expected for the electricity coverage and market programme within the DNP´s medium term goals within the sector (Goals 1 and 2 stated at *DNP, 2006a*). Accordingly, Figure 34 describes the main parameters of the following project[50]:

- Project objective: *To increase coverage of electricity national service and the size of its international market.*
- Investment expected: *$ 6.011,70* (US$Mill.2005) [51]
- Investment period: *2006-2019 (14 years)*

It is assumed that project investments start in 2006. To calculate the effect of the project in the short term, the influence-dependence graph for the current situation (see Figure 33) needs to be recalculated. To do this, the quantitative matrix was recalculated while the qualitative matrix was kept as in the current situation analysis[52].

New values used to the quantitative matrix change from the current situation quantitative matrix in two ways;

- First, in terms of the KPIs that are used to represent the project to be implemented. For example, investments related KPIs have to consider new investments coming from the project implementation (those shown at Figure 34). Consistently, coverage related KPIs should be replaced by coverage goals from the project since the new scenario assumes that the project is under implementation.

- Second, and because KPIs used to represent the new project have been change, therefore their relationships have also change. These relationships affect the filling up process previously used to complete empty years within the time series. Therefore this process needs to be recalculated. Figure 35 shows this recalculation's results.

Once new inputs to the quantitative matrix, have been reviewed considering the implementation of the coverage and market increasing project, an iteration it is applied in order to generate a new quantitative matrix, then to leverage this one with the current situation matrix, and finally to generate a new qualitative-quantitative matrix. These matrixes are shown in Figure 36. From them, a new influence-dependence graph is generated (see Figure 37). By comparing Figures 37 and 33 the short term impact of implementing the project, can be measured.

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[49] Policy, programme or project.

[50] Scope and execution assumptions were taken to simulation purposes from discussions with the Mining & Energy Unit at DIES. Future changes on those assumptions might affect models results discussed at this section. .

[51] Original figures in $Mill 2005.COL. Representative exchange rate used; *2.284,22* US$/COL$. Source; Central Bank of Colombia, 08/2007.

[52] By doing this, it is assumed that the implementation of the project, affects correlations among KPIs but it does not affect cause-effect relationships among them. This is a simplification assumption for simulation purposes. If the analyst considers that the new project may change those cause-effect relationships, he/she can easily include his/her perceptions by introducing the related changes in the qualitative matrix.

Figure 34
Investment and physical stock goals to increase electricity coverage and international market in Colombia[53]

Indicador	Year 2005 situation	Year 2010 situation	Year 2019 Goal	Public investment US$Mill.2005	Private investment US$Mill 2005	Total investment US$Mill 2005
SIN coverage	90,39%	92,81%	97,04%	$ 192,67	$ 1.503,44	**$ 1.696,11**
ZNI coverage	35,41%	45,80%	74,68%	$ 148,57	$ 9,19	**$ 157,77**
SIN generation total capacity (MW)	13.398	14.201	17.306	$ 1.637,31	$ 2.308,62	**$ 3.945,94**
Electricity international connections	5	7	7		$ 211,88	**$ 211,88**
			Total	**$ 1.978,56**	**$ 4.033,14**	**$ 6.011,70**

Year	SIN coverage (%)	Investment for SIN coverage: Public investment $Mill.2005	Private investment $Mill 2005	Total investment $Mill 2005	ZNI coverage (%)	Investment for ZNI coverage: Public investment $Mill.2005	Private investment $Mill 2005	Total investment $Mill 2005
2005	90,39%	$ 12,83	$ 111,00	$ 123,83	0,354071838	$ 5,00	$ -	$ 5,00
2006	90,89%	$ 12,82	$ 107,95	$ 120,77	0,368037067	$ 23,45	$ -	$ 23,45
2007	91,43%	$ 12,81	$ 109,32	$ 122,13	0,382759979	$ 23,46	$ -	$ 23,46
2008	91,89%	$ 12,79	$ 105,01	$ 117,80	0,398312337	$ 23,48	$ -	$ 23,48
2009	92,37%	$ 12,99	$ 104,90	$ 117,89	0,437929548	$ 23,28	$ -	$ 23,28
2010	92,81%	$ 12,98	$ 101,76	$ 114,73	0,45798063	$ 4,86	$ 0,92	$ 5,78
2011	93,49%	$ 12,96	$ 112,29	$ 125,25	0,479830775	$ 4,87	$ 0,92	$ 5,79
2012	94,06%	$ 12,94	$ 106,16	$ 119,10	0,503663133	$ 4,89	$ 0,92	$ 5,81
2013	94,59%	$ 12,92	$ 103,11	$ 116,03	0,529690186	$ 4,91	$ 0,92	$ 5,83
2014	95,06%	$ 12,88	$ 98,10	$ 110,98	0,55556175	$ 4,95	$ 0,92	$ 5,87
2015	95,49%	$ 12,86	$ 95,21	$ 108,06	0,586720476	$ 4,98	$ 0,92	$ 5,90
2016	95,83%	$ 12,83	$ 89,48	$ 102,31	0,620957915	$ 5,01	$ 0,92	$ 5,92
2017	96,29%	$ 12,80	$ 92,37	$ 105,17	0,658689854	$ 5,04	$ 0,92	$ 5,96
2018	96,62%	$ 12,76	$ 85,27	$ 98,03	0,700419942	$ 5,07	$ 0,92	$ 5,99
2019	97,04%	$ 12,51	$ 81,51	$ 94,02	0,746765269	$ 5,33	$ 0,92	$ 6,25
	Total	**$ 192,67**	**$ 1.503,44**	**$ 1.696,11**		**$ 148,57**	**$ 9,19**	**$ 157,77**

Year	Generation capacity (MW)	Hydraulic generation capacity (MW)	Thermal generation capacity (MW)	Investment for generation capacity: Public investment US$Mill.2005	Private investment US$Mill 2005	Total investment US$Mill 2005	Investment for international expansion: International connections	Private inverstment US$Mill 2005
2005	13398,0	8.576,5	4.821,5	$ 55,47	$ 68,66	$ 124,13	5	
2006	13554,9	8.693,4	4.861,5	$ 55,71	$ 72,52	$ 128,23	5	
2007	13713,6	8.846,7	4.866,9	$ 55,95	$ 76,60	$ 132,55	6	$ 105,94
2008	13874,2	8.862,1	5.012,1	$ 56,19	$ 80,90	$ 137,09	6	
2009	14036,7	8.876,6	5.160,1	$ 56,43	$ 85,45	$ 141,88	7	$ 105,94
2010	14201,0	8.890,2	5.310,8	$ 56,68	$ 90,25	$ 146,93	7	
2011	14516,5	8.995,4	5.521,1	$ 67,09	$ 104,69	$ 171,78	7	
2012	14839,0	9.100,8	5.738,2	$ 79,41	$ 121,44	$ 200,86	7	
2013	15168,7	9.206,5	5.962,1	$ 94,00	$ 140,88	$ 234,88	7	
2014	15505,6	9.312,5	6.193,2	$ 111,27	$ 163,42	$ 274,69	7	
2015	15850,1	9.418,5	6.431,5	$ 131,70	$ 189,58	$ 321,28	7	
2016	16202,2	9.524,7	6.677,5	$ 155,90	$ 219,91	$ 375,81	7	
2017	16562,1	9.631,0	6.931,1	$ 184,53	$ 255,11	$ 439,64	7	
2018	16930,0	9.737,3	7.192,8	$ 218,43	$ 295,93	$ 514,36	7	
2019	17306,1	9.843,5	7.462,6	$ 258,55	$ 343,29	$ 601,84	7	
			Total	**$ 1.637,31**	**$ 2.308,62**	**$ 3.945,94**		**$ 211,88**

Representative exchange rate used; 2284,22 *US$/COL$. *Source; Central Bank of Colombia, 07/2007

[53] Source: DNP-SMEN (DN, 2006a). Changes on assumptions behind those calculations might affect these goals.

Figure 35.
Filling up criterions applied to electricity coverage and market´s KPIs – after new PPP´s implementation.

KPIs with empty years on their time-series	.(1) · Better historic adjustment curve	.(2) · Better cause-effect adjustment curve / · Independent KPI	.(3) · Annual growth average (time frame) / · Multiplying coefficient
1 Total population**			
2 Real GDP growth**			
3 Electricity public investmet*	· N.A.	· N.A.	·N.A.
4 Electricity private investmet*	· N.A.	· N.A.	·N.A.
5 ZNI public investments (executed resources)*	· N.A.	· N.A.	·N.A.
6 Effective generation capacity installed (hydraulic)*	· N.A.	· N.A.	· N.A.
7 Effective generation capacity installed (thermal)*	· N.A.	· N.A.	· N.A.
8 SIN coverage*	· N.A.	· N.A.	· N.A.
9 ZNI coverage*	· N.A.	· N.A.	· N.A.
10 Electricity demand annual growth	Polynom-grade 2	· Polynom-grade 2 (R^2=0,414)	·-47,81% (1971-2005)
	(R^2=0,1729)	· 8 - SIN coverage	·1,00
11 Residential electricity demand (per -capita)	Logaithmic curve	· Polynom-grade 2 (R^2=0,7594)	·3,37% (1971-2005)
	(R^2=0,7234)	· 8 - SIN coverage	·1,00
12 Electricity exports	Euler`s curve	· Linear (R^2=0,995)	·26,74% (2003-2005)
	(R^2=0,8231)	· 8 - SIN coverage	·1,00
15 ZNI subscribers	Linear curve	· Linear (R^2=0,7558)	·1,598% (2002-2005)
	(R^2=0,7235)	· 8 - SIN coverage	·1,00
17 Average electricity stock market prices	Logarithmic curve	· Logarithmic curve (R^2=0,6728)	·-11,88% (1999-2005)
	(R^2=0,653)	· 8 - SIN coverage	·1,00
18 Average electricity contracts prices	Linear curve	· Power curve (R^2=0,5126)	·-4,97% (2000-2005)
	(R^2=0,6126)	· 8 - SIN coverage	·1,00

* On lined indicators, criterions do not apply on new values. Values are directly taken from Figure 34 instead.

** Population figures from DNP-DDS-DDUPA base on DANE. Real GNP from DNP-DEE

Comparing Figures 33 and 37, and having in mind that investments coming from the new project could be considered not significant to the whole sector, the general impact of its implementation could be expected as marginal. However, regarding the private investments, which have increased 2,1 times between 2005 and 2006 because of the project implementation, it is surprising that the role only has marginal changes. Only the role of public investments had a significant change from independent to dependent. This means that the increasing of the investments for ZNI is significant enough to transform the public investment into a good "viewer" to the sector dynamics.

Public investments increase 4,6% and 66,4% for 2005 and 2006 respectively if they are compared against the scenario without the new project. Other marginal changes generated by the new project within the sector can be summarised ad follows:

- Within Zone 1 (power KPIs) the effect of the new project is a marginal growth in the dependence level of the effective generation capacity (hydraulic), as well as a marginal decreasing on the dependence level to the SIN coverage. However this change is not enough to change the role of both indicators, which keeps as the dominant role as it was before the project implementation.
- Within Zone 2 (conflict KPIs), the effect of the new project is a marginal growth in both dependence and influence levels to the electricity residential demand (per capita). Although unexpected, considering that these KPI´s projections did not change from previous conditions, this change does no affect considerably the conflict role that keeps characterising the effect of this variable within the electricity coverage and market objectives.
- It is important to realise how those KPIs traditionally related with the market size of the electricity sector, do not show any representative change on their role within the sector once the new project is implemented. This includes KPIs such as private investment, electricity exports, electricity stock market and contract prices, and electricity international connections. This might be an expected result since there won't be investments on international connections before the end of 2007. However it is unexpected considering that private investments grew 2,1 times as a result of the new project implementation. These results seem to show that there are weak causal relationships between private investments within the electricity sector and its market size. It is strongly recommended to build a closer understanding on them through a new simulation exercise.

Figure 36.

SAP´s matrixes for the Module 2 on effect of the Figure 34´s project in the electricity coverage and market

Sector: ENERGY
Sucess area: ELECTRICITY
Programe: DEVELOPMENT OF ELECTRICITY COVERAGE AND MARKET
Project: COVERAGE AND MARTKET INCREASING

QUALITATIVE MATRIX (1st power) - EFFECT OF COVERAGE AND MARKET INCREASING PROJECT ON CURRENT SITUATION

KPI code			C	F	F	F	F	P	P	P	P	P	P	P	P	C	C	F	F	F	Influence
			I	R	I	I	I	I	I	R	R	IP	IP	IP	R	I	I	IP	IP	IP	
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
C	I	1	3	2	2	1	1	2	1	2	1	2	3	1	0	2	1	2	0	0	26
F	R	2	2	3	2	1	0	1	0	1	0	3	2	2	1	1	0	1	1	1	22
F	I	3	0	1	3	2	1	3	2	3	2	2	2	2	2	2	1	2	2	2	34
F	I	4	1	2	1	3	1	1	2	1	2	1	1	1	2	2	1	1	2	2	27
F	I	5	0	0	1	0	3	1	1	0	3	0	0	0	0	0	3	1	0	0	13
P	I	6	0	2	3	1	2	3	3	2	1	3	3	3	2	3	1	2	3	2	39
P	I	7	0	1	2	1	3	1	3	2	2	1	1	1	1	1	2	2	2	2	28
P	R	8	1	2	3	2	1	3	2	3	1	3	3	2	2	3	1	2	2	2	38
	R	9	0	0	2	1	3	1	2	0	3	1	1	1	1	1	3	1	0	0	21
P	IP	10	1	3	2	3	1	2	2	1	0	3	2	2	2	2	0	3	2	2	33
P	IP	11	1	2	2	2	1	2	2	1	0	3	3	2	2	1	0	3	2	2	31
P	IP	12	0	0	1	3	1	2	2	1	2	1	0	3	2	1	1	2	2	2	26
P	R	13	0	0	1	2	2	1	2	0	1	0	0	3	3	1	1	2	2	2	23
C	I	14	0	0	1	2	0	1	1	3	0	2	2	1	0	3	0	2	2	2	22
C	I	15	0	0	1	1	3	0	1	0	3	1	1	0	1	0	3	1	0	0	16
F	IP	16	1	1	1	2	1	0	0	1	2	2	2	1	1	1	0	3	2	2	23
F	IP	17	0	1	1	2	1	1	1	0	0	2	2	2	1	0	0	2	3	0	19
F	IP	18	0	1	1	2	1	0	0	1	0	1	1	2	1	0	0	2	3	3	19
Dependence			10	21	30	31	26	25	27	22	23	31	29	29	24	24	18	34	30	26	

Note: Values describe the nature on influence from the KPI in the row to the KPI in the column. 0 = it doesn´t exist; 1= weak influence; 2: medium influence; 3 = strong influence.

QUANTITATIVE MATRIX (1st power or Pearson²) - EFFECT OF COVERAGE AND MARKET INCREASING PROJECT ON CURRENT SITUATION

KPI code			C	F	F	F	F	P	P	P	P	P	P	P	P	C	C	F	F	F	Influence
			I	R	I	I	I	I	I	R	R	IP	IP	IP	R	I	I	IP	IP	IP	
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
C	I	1	1,00	0,52	0,00	0,30	0,40	0,09	0,77	0,77	0,69	0,03	0,72	0,94	0,89	0,80	0,81	0,95	0,54	0,42	10,63
F	R	2	0,52	1,00	0,04	0,10	0,61	0,01	0,23	0,54	0,38	0,02	0,32	0,71	0,76	0,39	0,23	0,64	0,50	0,19	7,18
F	I	3	0,00	0,04	1,00	0,66	0,64	0,42	0,21	0,04	0,18	0,17	0,16	0,75	0,96	0,02	0,70	0,00	0,01	0,45	6,43
F	I	4	0,30	0,10	0,66	1,00	0,56	0,24	0,73	0,08	0,01	0,16	0,55	0,64	0,87	0,11	0,70	0,33	0,36	0,04	7,47
F	I	5	0,40	0,61	0,64	0,56	1,00	0,60	0,52	0,09	0,11	0,12	0,24	0,30	0,72	0,06	0,57	0,61	0,11	1,00	8,26
P	I	6	0,09	0,01	0,42	0,24	0,60	1,00	0,00	0,15	0,39	0,09	0,00	0,24	0,60	0,19	0,45	0,03	0,01	0,65	5,14
P	I	7	0,77	0,23	0,21	0,73	0,52	0,00	1,00	0,39	0,29	0,08	0,72	0,67	0,87	0,48	0,71	0,73	0,56	0,10	9,05
P	R	8	0,77	0,54	0,04	0,08	0,09	0,15	0,39	1,00	0,54	0,14	0,46	0,32	0,16	0,66	0,51	0,85	0,41	0,45	7,54
	R	9	0,69	0,38	0,18	0,01	0,11	0,39	0,29	0,54	1,00	0,11	0,29	0,75	0,57	0,60	0,59	0,54	0,17	0,71	7,91
P	IP	10	0,03	0,02	0,17	0,16	0,12	0,09	0,08	0,14	0,11	1,00	0,08	0,55	0,30	0,03	0,58	0,10	0,19	0,03	3,78
P	IP	11	0,72	0,32	0,16	0,55	0,24	0,00	0,72	0,46	0,29	0,08	1,00	0,99	0,76	0,62	0,85	0,67	0,27	0,07	8,78
P	IP	12	0,94	0,71	0,75	0,64	0,30	0,24	0,67	0,32	0,75	0,55	0,99	1,00	0,80	0,44	0,90	0,90	0,04	0,32	11,24
P	R	13	0,89	0,76	0,96	0,87	0,72	0,60	0,87	0,16	0,57	0,30	0,76	0,80	1,00	0,09	0,91	0,97	0,16	0,75	12,13
C	I	14	0,80	0,39	0,02	0,11	0,06	0,19	0,48	0,66	0,60	0,03	0,62	0,44	0,09	1,00	0,30	0,70	0,38	0,59	7,46
C	I	15	0,81	0,23	0,70	0,70	0,57	0,45	0,71	0,51	0,59	0,58	0,85	0,90	0,91	0,30	1,00	0,74	0,21	0,31	11,08
F	IP	16	0,95	0,64	0,00	0,33	0,61	0,03	0,73	0,85	0,54	0,10	0,67	0,90	0,97	0,70	0,74	1,00	0,65	0,32	10,73
F	IP	17	0,54	0,50	0,01	0,36	0,11	0,01	0,56	0,41	0,17	0,19	0,27	0,04	0,16	0,38	0,21	0,65	1,00	0,17	5,76
F	IP	18	0,42	0,19	0,45	0,04	1,00	0,65	0,10	0,45	0,71	0,03	0,07	0,32	0,75	0,59	0,31	0,32	0,17	1,00	7,57
Dependence			10,63	7,18	6,43	7,47	8,26	5,14	9,05	7,54	7,91	3,78	8,78	11,24	12,13	7,46	11,08	10,73	5,76	7,57	

Note: Pearson² values are betwen -1 and 1. The closer to +1 or -1 the stronger the correlation between each pair of KPIs´ statistical variance. The closer to 0, the weaker that correlation.

WEIGHT FACTOR:	
QUALITATIVE (%)	50%
QUANTITATIVE (%)	50%

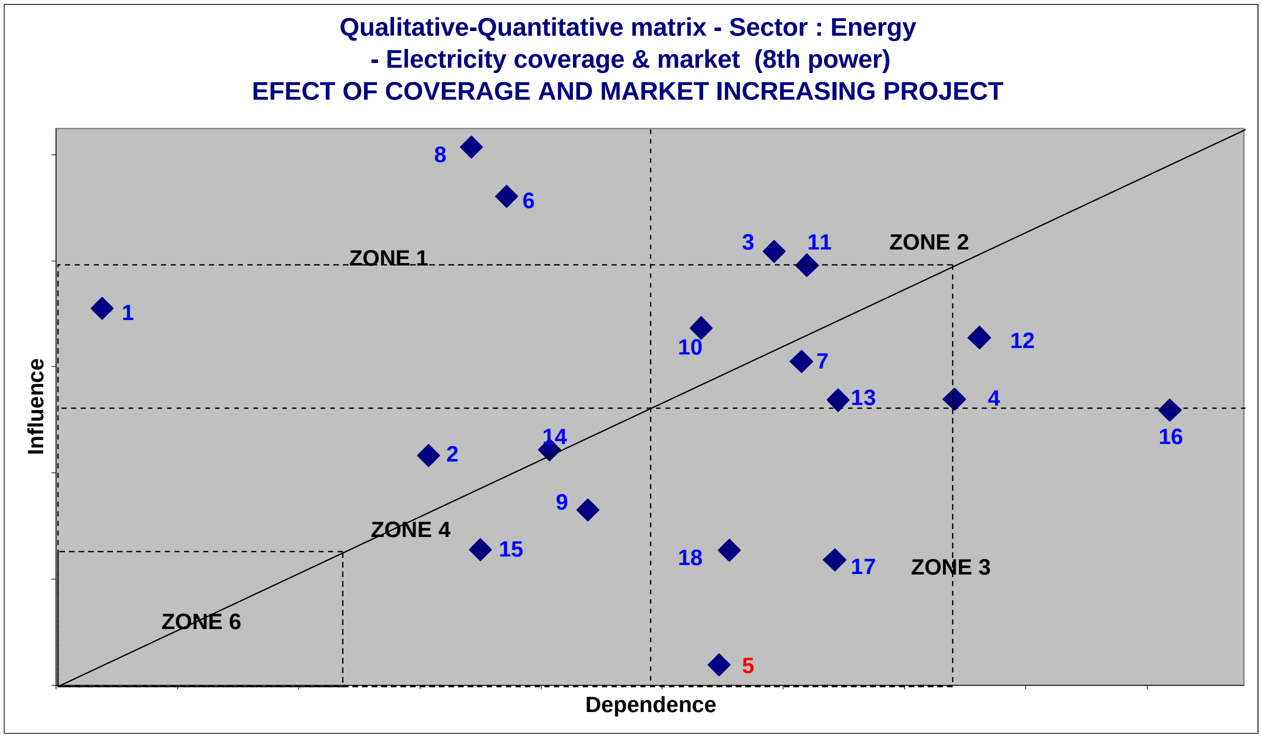
QUANTITATIVE -QUALITATIVE MATRIX (8th power) - EFFECT OF COVERAGE AND MARKET INCREASING PROJECT ON CURRENT SITUATION

KPI code			C	F	F	F	F	P	P	P	P	P	P	P	P	C	C	F	F	F	Influence
			I	R	I	I	I	I	I	R	R	IP	IP	IP	R	I	I	IP	IP	IP	
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
C	I	1	4,2E+155	5,9E+155	7,7E+155	8,7E+155	7,4E+155	6,3E+155	7,9E+155	6,1E+155	6,7E+155	7,3E+155	7,9E+155	8,8E+155	8,1E+155	6,5E+155	6,2E+155	9,8E+155	8,0E+155	7,5E+155	1,31E+157
F	R	2	3,3E+155	4,7E+155	6,1E+155	6,8E+155	5,9E+155	5,0E+155	6,2E+155	4,8E+155	5,3E+155	5,8E+155	6,2E+155	6,9E+155	6,3E+155	5,2E+155	4,9E+155	7,7E+155	6,3E+155	5,9E+155	1,03E+157
F	I	3	4,5E+155	6,4E+155	8,4E+155	9,4E+155	8,0E+155	6,8E+155	8,5E+155	6,6E+155	7,3E+155	7,9E+155	8,5E+155	9,5E+155	8,7E+155	7,1E+155	6,7E+155	1,1E+156	8,7E+155	8,1E+155	1,42E+157
F	I	4	3,6E+155	5,1E+155	6,7E+155	7,5E+155	6,5E+155	5,5E+155	6,8E+155	5,3E+155	5,9E+155	6,4E+155	6,9E+155	7,6E+155	7,0E+155	5,7E+155	5,4E+155	8,5E+155	7,0E+155	6,5E+155	1,14E+157
F	I	5	2,0E+155	2,9E+155	3,8E+155	4,2E+155	3,6E+155	3,1E+155	3,8E+155	3,0E+155	3,3E+155	3,6E+155	3,8E+155	4,3E+155	3,9E+155	3,2E+155	3,0E+155	4,8E+155	3,9E+155	3,6E+155	6,38E+156
P	I	6	4,9E+155	6,9E+155	9,0E+155	1,0E+156	8,6E+155	7,3E+155	9,1E+155	7,1E+155	7,8E+155	8,5E+155	9,2E+155	1,0E+156	9,4E+155	7,6E+155	7,2E+155	1,1E+156	9,3E+155	8,7E+155	1,52E+157
P	I	7	3,9E+155	5,5E+155	7,1E+155	8,0E+155	6,9E+155	5,8E+155	7,3E+155	5,7E+155	6,2E+155	6,8E+155	7,3E+155	8,1E+155	7,4E+155	6,0E+155	5,7E+155	9,0E+155	7,4E+155	6,9E+155	1,21E+157
P	R	8	5,2E+155	7,3E+155	9,5E+155	1,1E+156	9,2E+155	7,8E+155	9,7E+155	7,6E+155	8,3E+155	9,0E+155	9,7E+155	1,1E+156	9,9E+155	8,1E+155	7,6E+155	1,2E+156	9,9E+155	9,2E+155	1,62E+157
	R	9	3,0E+155	4,2E+155	5,5E+155	6,2E+155	5,3E+155	4,5E+155	5,6E+155	4,4E+155	4,8E+155	5,2E+155	5,6E+155	6,2E+155	5,7E+155	4,6E+155	4,4E+155	7,0E+155	5,7E+155	5,3E+155	9,31E+156
P	IP	10	4,1E+155	5,7E+155	7,5E+155	8,4E+155	7,2E+155	6,1E+155	7,6E+155	6,0E+155	6,5E+155	7,1E+155	7,7E+155	8,5E+155	7,8E+155	6,4E+155	6,0E+155	9,5E+155	7,8E+155	7,3E+155	1,27E+157
P	IP	11	4,4E+155	6,3E+155	8,2E+155	9,2E+155	7,9E+155	6,7E+155	8,4E+155	6,5E+155	7,2E+155	7,8E+155	8,4E+155	9,3E+155	8,6E+155	6,9E+155	6,6E+155	1,0E+156	8,5E+155	8,0E+155	1,39E+157
P	IP	12	4,0E+155	5,7E+155	7,4E+155	8,3E+155	7,1E+155	6,0E+155	7,5E+155	5,9E+155	6,5E+155	7,0E+155	7,6E+155	8,4E+155	7,7E+155	6,3E+155	5,9E+155	9,4E+155	7,7E+155	7,2E+155	1,26E+157
P	R	13	3,6E+155	5,1E+155	6,7E+155	7,5E+155	6,4E+155	5,5E+155	6,8E+155	5,3E+155	5,8E+155	6,4E+155	6,8E+155	7,6E+155	7,0E+155	5,7E+155	5,4E+155	8,5E+155	7,0E+155	6,5E+155	1,14E+157
C	I	14	3,3E+155	4,7E+155	6,1E+155	6,9E+155	5,9E+155	5,0E+155	6,3E+155	4,9E+155	5,4E+155	5,8E+155	6,3E+155	7,0E+155	6,4E+155	5,2E+155	4,9E+155	7,8E+155	6,4E+155	6,0E+155	1,04E+157
C	I	15	2,7E+155	3,9E+155	5,0E+155	5,7E+155	4,9E+155	4,1E+155	5,1E+155	4,0E+155	4,4E+155	4,8E+155	5,2E+155	5,7E+155	5,3E+155	4,3E+155	4,0E+155	6,4E+155	5,2E+155	4,9E+155	8,56E+156
F	IP	16	3,6E+155	5,0E+155	6,6E+155	7,4E+155	6,3E+155	5,4E+155	6,7E+155	5,2E+155	5,8E+155	6,3E+155	6,7E+155	7,5E+155	6,9E+155	5,6E+155	5,3E+155	8,4E+155	6,9E+155	6,4E+155	1,12E+157
F	IP	17	2,7E+155	3,8E+155	4,9E+155	5,5E+155	4,7E+155	4,0E+155	5,0E+155	3,9E+155	4,3E+155	4,7E+155	5,0E+155	5,6E+155	5,1E+155	4,2E+155	3,9E+155	6,3E+155	5,1E+155	4,8E+155	8,36E+156
F	IP	18	2,7E+155	3,8E+155	5,0E+155	5,6E+155	4,8E+155	4,1E+155	5,1E+155	4,0E+155	4,4E+155	4,8E+155	5,1E+155	5,7E+155	5,2E+155	4,3E+155	4,0E+155	6,4E+155	5,2E+155	4,9E+155	8,53E+156
Dependence			6,6E+156	9,3E+156	1,2E+157	1,4E+157	1,2E+157	9,9E+156	1,2E+157	9,6E+156	1,1E+157	1,2E+157	1,2E+157	1,4E+157	1,3E+157	1,0E+157	9,7E+156	1,5E+157	1,3E+157	1,2E+157	

Note : absolute values are irrelevant. Relevance is griven through relative values against maximun and minimum figures on influence and dependence. Total values on dependence and influence for each KPI are drawn in an x-y graph to have the influence-dependence graph

Source: own elaboration. Numbers at major columns and rows are KPIs´ codes as classified in Figure 26

Figure 37.
Influence-dependence graph on effect of Figure 34´s project on electricity coverage and its market.



Zone 1. Input- dominant KPIs

1	Total population (urban & rural)
6	Effective generation capacity installed
8	SIN coverage

Zone 2. Relay- conflict KPIs

3	Electricity public investmet
4	Electricity private investmet
7	Effective generation capacity installed
10	Electricity demand annual growth
11	Residential electricity demand
12	Electricity exports
13	Electricity international interchange

Zona 4: Independent KPIs

2	Real GDP growth
9	ZNI coverage
14	SIN subscribers
15	ZNI subscribers

Zone 3: Results KPIs

5	ZNI public investments (executed
16	Average electricity residential tariffs
17	Average electricity stock market prices
18	Average electricity contracts prices

Zone 5: Middle cluster or standard KPIs

1	Total population (urban & rural)
2	Real GDP growth
3	Electricity public investmet
5	ZNI public investments (executed
7	Effective generation capacity installed
9	ZNI coverage
10	Electricity demand annual growth
11	Residential electricity demand
13	Electricity international interchange
14	SIN subscribers
15	ZNI subscribers
17	Average electricity stock market prices
18	Average electricity contracts prices

Zone 6: Marginal KPIs

19	Sewerage rural subscribers

Source: own elaboration. Numbers in the graph are codes representing each KPIs as classified in Figure 26.

6.4 Module 3: Forecasting simulation analysis.

According with Figure 19, the first step on this module's implementation is identifying those KPIs that may optimize a forecast analysis due to their particular role within the electricity sector. To do this, a set of selected KPIs was chosen from those previously identified as key to characterize the electricity coverage and market (see Figure 26). This set includes KPIs having a dominant role within the current situation analysis as well as KPIs with a conflict role within the historical trends analysis (as was explained in Figure 17). This selection provides KPIs that are both determinants within the present dynamics of the sector as well as a high potential to be determinants to its future. In the first case, these KPIs are characterized by the excellent cost/benefit ratios they generate when actions over them are taken.

In the second case, these KPIs have demonstrated a sustainable dynamics on its importance within the sector which is the best guarantee for a high probability on a dominant role for their future effect within the sector. Complementary to this set of KPIs a third group of KPIs chosen came from those variables describing the new project whose short term's impact was studied in Module 2. They were considering essential to the design of future scenarios closer to the goals already defined by the government because they will provide excellent ex-ante results on the policy impacts behind the project's implementation. The following are the KPIs chosen by applying the three criterions mentioned:

- 1-Total population - urban & rural (2) [54]
- 3-Electricity public investment (1,3).
- 5- ZNI public investments-executed resources (3)
- 6 - Effective generation capacity installed - hydraulic (1,2)
- 7 - Effective generation capacity installed – thermal (1)
- 8 - SIN coverage (1,2)
- 9 - ZNI coverage (3)
- 10– Electricity demand annual growth (1)
- 11– Residential electricity demand (1)
- 12- Electricity exports (1)

Once forecasting KPIs were chosen, a general diagnosis on those KPIs was achieved in order to generate inputs for the future scenarios design. By applying a three side process that combined PEST, SWOT and Macro-Trends analysis as explained in Figure 16, this diagnosis results can be summarized through an internal diagnosis on major trends to the KPIs chosen to the forecast analysis (Figure 38), and through an external diagnosis on those macro-trends outside the electricity sector by itself but considering external determinants to the sector (Figure 39).

The following step in the forecasting analysis is the scenarios design. Its objective is to help structured and strategic thinking on the potential futures to the sector, to reduce inconsistencies in the formulation of policies and to create language patterns on forecasting analysis across sector's specialists and decision makers. The design of scenarios included the definition of heavier trends on selected KPIs and the related formulation of hypotheses. The heavier trends included a three side integrated vision of optimist, pessimist and intermediate trends on five KPIs chosen from the 10 forecasting KPIs initially chosen. Each trend is characterized by specific growth ratios on each KPI.

[54] Number within parenthesis indicates the criteria used to chose the KPI according to;
1. Conflict KPIs within the historical trends analysis (Module 1);
2. Dominant KPIs within the current situation analysis (Module 2).
3. KPIs describing the electricity coverage and market increasing project (Module 2)

Figure 38
Electricity coverage & market trends on selected forecasting KPIs

KPI*	Historical trends
(I) 1 - Total population (urban &	· Growthing & stable trend · Crecimiento bruto período 1970-2006 : 118,97% · Crecimiento anual promedio 1970-2006 : 2,21%
(R) 2 – Real GDP growth	· Tendencia estable entre 2% y 5% con dos años de crisis al final del milenio. · Gross growth 1995-2006 :-23,11% · Annual average growth 1995-2006 : -89,92%
(I) 3 - Electricity public	· Decreasing trend the last 15 years · Gross growth 1991-2004: -30,11% · Annual average growth 1991-2004: -7,75%
(I) 4 – Electricity private investmet	· Stable trend with important increasing-decreasing cycles every 2-3 years. · Gross growth 1994-2004 : 46,06% · Annual average growth 1994-2004 : 11,75%
(I) 5 – ZNI public investments	· Unstable growth . · Gross growth 2003-2006 : 336,57% · Annual average growth 2003-2006 : 202,25%
(I) 6 - Effective generation capacity	· Moderate growth the last 35 years with increasing periods every 5-8 years. · Gross growth 1972-2006: 367% · Annual average growth 1972-2006: 4,92%
(I) 7 - Effective generation	· Slow but stable growth the last 35 years. · Gross growth 1972-2006 : 510,13% · Annual average growth 1972-2006 : 5,69%
(R) 8–SIN coverage	· Stable gowth, moderated the last 10 years · Gross growth 1995-2005 : 20,70% · Annual average growth 1995-2005 : 1,91%
(R) 9- ZNI coverage	· Growing trend but marginal the last 5 years. · Gross growth 2002-2005 : 4,80% · Annual average growth 2002-2005 : 1,59%
(IP) 10–Electricity demand annual	· stable growth around 5% the last 30 years, with unstable increasing-decreasing cycles every 5-8 years. · Gross growth 1971-2005 : - 60,80% · Annual average growth 1971-2005 : - 47,81%
(IP) 11 - Consumo residencial per-cápita de energía	· Moderated and stable growth the last 25 years, followed by status-quo an decreasing tredn the last 10 years. · Gross growth 1972-2005 : 178,75% · Annual average growth 1972-2005 : 0,04%
(IP) 12- Electricity exports	· Stable growth since 4 years ago · Gross growth 2003-2005 : 55,67% · Annual average growth 2003-2005 :26,74%
(R) 13- Electricity international	· Moderated growth, unstable since 4 years ago · Gross growth 2003-2006 : 66,67% · Annual average growth 2003-2006 : 19,44%
(I) 14-SIN subscribers	· Moderated growth, stable the last 15 years · Gross growth 1990-2006 : 91,35% · Annual average growth 1990-2006 : 4,20%
(I) 15-ZNI subscribers	· Marginal growth the last 4 years. · Gross growth 2002-2005 : 4,72% · Annual average growth 2002-2005 : 1,58%
(IP) 16- Average electricity residential	· Stable decreasing 10 years ago, followed by a recovery the last 5 years · Gross growth 1995-2006 : 2,79% · Annual average growth 1995-2006 : 0,66%
(IP) 17- Average electricity	· Marginal but stable growth the last 5 years. · Gross growth 1999-2005 : 77,64,2% · Annual average growth 1999-2005 : 11,88%
(IP) 18- Average electricity	· Marginal but stable growth the last 5 years. · Gross growth 1999-2005: 17,76% · Annual average growth 1999-2005: 3,01%

Note: According with Figure 9, letters within parenthesis (I, A, R or IP), indicate whether the KPI measures inputs, activities, results or impacts of the objective analyzed, respectively.

Source: own elaboration

Optimist trends included those growth ratios that guaranteed the achievement of long term goals expected by the government at *DNP, 2006a*. Pessimist trends were related with the projection of *status quo* ratios on each KPI. Intermediate or medium trends were represented by average ratios between optimist and pessimist ratios on each KPI. Figure 40 summarizes specific trends on each of the selected KPIs. This is known as the morphologic universe to the success area studied, which represents all the possible combinations among KPIs trends. In this case (5 KPIs and 3 possible trends on each KPI), the morphologic universe includes 243 possible combinations ($3^5 = 243$). To simplify such complexity to the analysis, the model defines three major hypotheses to work, represented by the 3 major configurations that Figure 40 shows (optimist, pessimist and intermediate). These configurations are shown through the boxes connected by arrows.

Figure 39.
External macro-trends affecting Electricity coverage & market.

Macro- trends in
Competitiveness
Under an integral concept, competitiveness will mainly impact on those electricity operators able to maximize their expansion options, modernize their technologies, apply efficient business systems, portfolio services and financial management, as well as improve their quallity and enviromental commitments to keep a sustainable growth within the market.
Technological development
More focused on operative optimization than on new technologies development, mainly affecting business support technologies, electricity transactions, institutional management and structure as well as productivity of electricity service`s operators
Institutional change
Social, trade and political pressures, will drive eletricity operators towards institutional rearrangements in order to get competitive advantage within a south and central american integrated market. It will also push public institutions related towards optimize their organizational structure specially on definitions about planning and regulation boundaries.
Economic markets joint-ventures and alliances
China and Europe will together increase their partiicipation within the world GDP, affecting production and markets of those nations looking for trade alliances with them such as Colombia. This will particularly boost production and transport demands, wich leads to more competitive electricity demand , as well as increasing domestic electricity consumption because of the increasing size of the international market.
Globalization:
It will mainly affect SIN´s production and capacity demands, as well as the service`s efficiency at ZNI because of the pressure of new commercial agreements.

Source: own elaboration

Figure 40.
Morphological analysis to the electricity coverage and market in Colombia.

Posible configuration of components

Components	**Scenario 1** Configurations: A1-B1-C1-D1-E1-F1 **Focus: Pessimist**	**Scenario 2** Configurations: A2-B2-C2-D2-E2-F2 **Focus: Optimist**	**Scenario 3** Configurations: A3-B3-C3-D3-E3-F3 **Focus: Intermediate**
Finance of electricity investment needs	**A1** Stabillity to the past trend of public and private investments within the sector, which means a continuing reduction that leads to achieve 49% of total investments expected by the programme Colombia 2019 for electricity coverage & market. (1)	**A2** All the investments necessary to achieve 100% of coverage and market goals of Colombia 2019, are in place. Therefore a reductionist trend is avoided, stability to the investors is generated although investments growth it is not necessary reached (2)	**A3** Colombia 2019´s goals on private investment, electricity coverage and market size are achieved. However public investments keep their reductionist trend from the past, reaching 80% of Colombia 2019´s investment goals. (3)
Electricity service´s coverage within the interconnected national system - SIN	**B1** Consistently with investments reached at A1, Colombia 2019´s goals on coverage are covered by its 49% . This means 94% to the gross SIN coverage ,	**B2** It is reached 100% of electricity coverage goals at the Colombia 2019 programme. SIN coverage reaches 97%	**B3** Consistently with investments of A3, Colombia 2019´s goals on coverage are covered by its 80%. SIN coverage reaches 95,7%
Electricity service´s coverage at not interconnected zones - ZNI	**C1** Consistently with investments at A1, Colombia 2019´s goals on coverage are covered by its 49% . ZNI coverage reaches 54,7%	**C2** It is reached 100% of electricity coverage goals at the Colombia 2019 programme. ZNI coverage reaches 74,7%	**C3** Consistently with investments of A3, Colombia 2019´s goals on coverage are covered by its 80%. ZNI coverage reaches 66,9%
Electricity market development via international connections and energy exports	**D1** By keeping international electricity connections as they are today (2005), electricity exports reach 44% of the Colombia 2019´s goal (4)	**D2** Electricity export goals expected by Colombia 2019 are 100% achieved. Three more international connections are built. (to have 6 international connections in total).	**D3** Electricity exports are covered by 76% of the Colombia 2019´s goal, by using the three international connections existing today.
Generation capacity expansion (hydraulic and none hydraulic)	**E1** Electricity generation capacity (hydraylic + none hydraulic) achieves 83,2% of the Colombia 2019´s goal, reaching 14.390 MW (8.957 MW hydraulic and 5.433 MW none hydraulic)	**E2** Electricity generation capacity (hydraylic + none hydraulic) achieves 100% of the Colombia 2019´s goal, reaching 17.306 MW (9.844 MW hydraulic and 7.463 MW none hydraulic)	**E3** Electricity generation capacity (hydraylic + none hydraulic) achieves 86,3% of the Colombia 2019´s goal, reaching 14.942 MW (9.070 MW hydraulic and 5.872 MW none hydraulic)

Notes:

(1.) Past trend to the public invesment within the sector has been drecreasing the last 15 years. Private investments have had increasing and decreasign cycles with a gross trend also decreasing. These treands will lead to have investments bellow the Colombia 2019´s goal. Accumulated investments to the period 2005-2019 will only reach 48,93% of Colombia 2019´s expectations. This will affect private investments more because their accumulated value will only reach 14% of the relateted programme´s goal and it will even desapear from year 2014 on. Public investments will reach 72,3% of te programme´s goals.

(2.) Assumptions on 2005-2019 investments growth rates are as follows ;public investments 6,25% (annual average), private investments 27,6% and total sector investments 4,32% (annual average). These ratios help to generate investments stabillity, and benefit private investments particularly considering their previous unstable trend.

(3.) This scenario combines a crisis on public investments placement with 100% achievement on Colombia 2019´s private investments goals. This do not necessary means that total investments need can be supplied via private sector. Under this circumstances 80,28% of Colombia 2019´s total investments goals within the sector are achieved. This meanch to reach 72,3% of its public investments related goasl and 100% of the private investments ones

(4.) Historical trends analysis demonstrated strong relationships between electricity exports and SIN coverage (see Figures 31 y 35). Therefore, electricy exports scenarios (D1, D2, D3) were calculated considering specific coverage scenarios (B1, B2, B3 respectively). Beacuse past exports of electricity have already create a growing demand, even in the pessimist case, a marginal growth was considered according to the capactity of the three international connections that exist today (2005).

Source: own elaboration from Godet et al, 2000a

According to Figure 19 the next step in the KPIs forecasting simulation is the analysis of the scenarios previously proposed through the structural analysis tool. To do this, each scenario was characterized by a set of quantitative, qualitative and quantitative-qualitative matrixes just as it was done to the Module 1 and Module 2`s process. (Figures 27, 32 and 36) Inputs to these matrixes are the time series related to both the 10 KPIs chosen as key to the forecasting analysis and the 8 additional KPIs that complete the whole group of 18 indicators chosen as the better proxy to characterize the electricity coverage and market. (Figure 26)

Results from the process are two mainly; i) series of forecasts to each of the 18 KPIs on each scenario conditions and, ii) influence-dependence graphs for each scenario including roles played by each of the 18 KPIs. Both results were analyzed by the following criterions:

i. Major trends to the whole success area
ii. Trends KIP by KPI
iii. Trends scenario by scenario.

In the first case simulation results provide a holistic approach of the macro trends to the electricity coverage and market as an integral success area of the sector, providing useful insights for long term planning and the more structural decision making associated to its implementation and development.

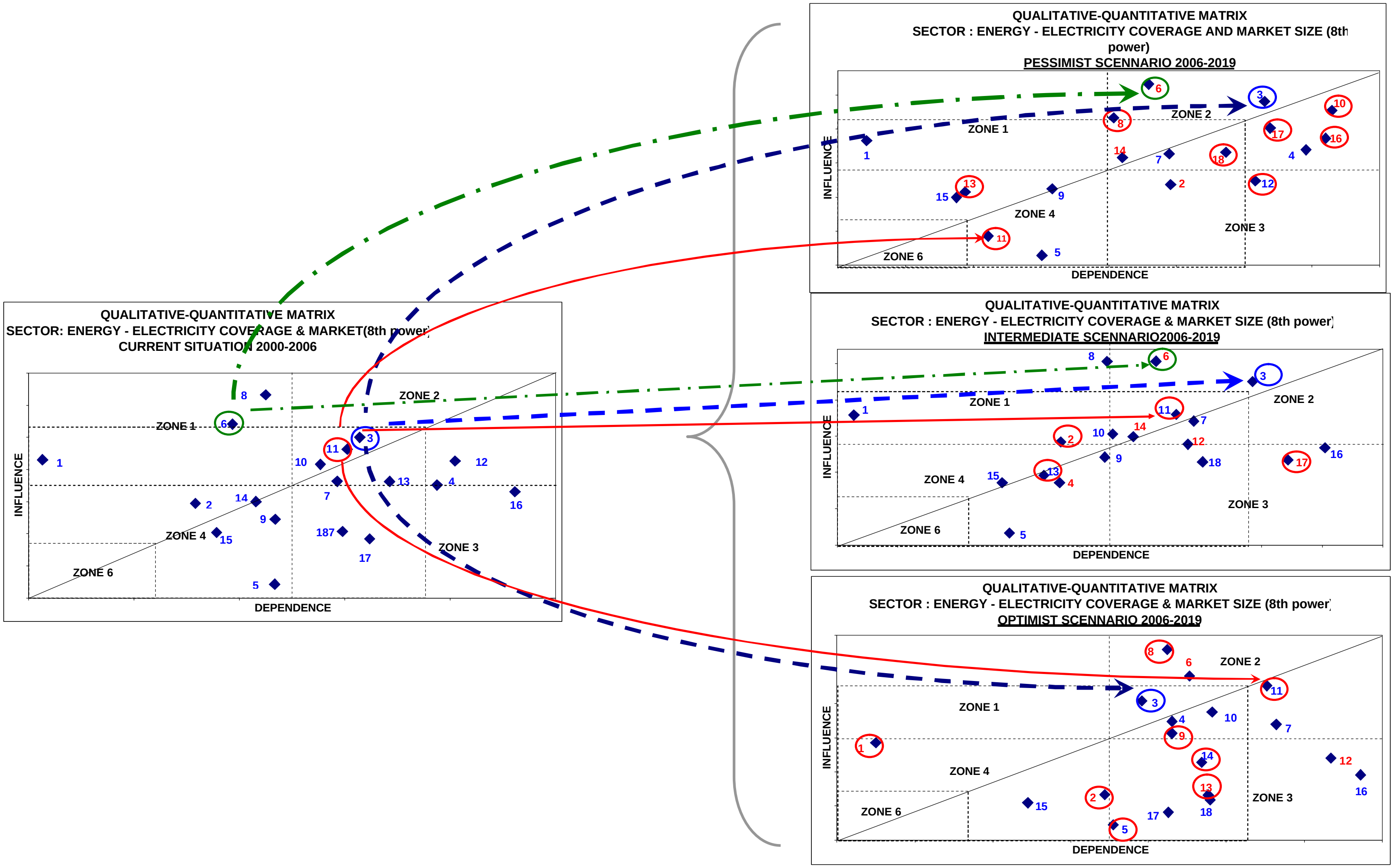
In the second case, by describing potential forecast and roles played by each KPIs independently, the analyst is provided in this case by inputs on those variables that will be more important to define future dynamics within the sector as well as the strategic decisions that will optimize cost / benefit ratios for future action plans on electricity coverage and market issues.

In the third case, model's results allow the analyst toe implement a comparative study on advantages, disadvantages, opportunities, actions and strategic decisions within the implementation of any of the three scenarios designed (optimist, pessimist and intermediate). It represents a powerful tool for policy design and strategic action that provides with an ex-ante focus value added to the proactive and pre-active decision making process within the electricity sector. Through a flexible approach that combines qualitative and quantitative information of the sector, these results helps to relate both technical forecasting and managerial information, key to implement future policies, programmes and projects in a integrated way that goes beyond outputs of traditional prospective analysis.

In order to give consistency with major government's goals and strategies on the electricity sector (DNP, 2006a), the time frame to the prospective forecast was 15 years from year 2005 to year 2019. Years 2005 and 2006 were included as part of the forecast because of lacks of data for some KPIs to these years. This took the model to generate simulated values by applying criteria explained at Figure 13.

Figure 41 helps to describe main results through the influence-dependence graph for each scenario designed. Graph at its left represents the current situation as described in Figure 33. Arrows indicate major changes on the role of some KPIs from the current situation to the implementation of each scenario. From this Figure, major conclusions on the forecasting analysis can be summarized as follows.

Figure 41
Influence-dependence comparative analysis on future scenarios to the electricity coverage and market size



Source: own elaboration.

Major trends to the whole success area

Independent from the scenario, zones concentrating more structural changes are those including conflicting and dependent KPIs (Zones 2 and 3 respectively). Regarding the SIN and ZNI coverage (KPIs 8 and 9 respectively), there are not structural changes on their role within any of the three scenarios designed, although dependence level of the SIN coverage growths at the optimist and pessimist scenarios enough to move it from a dominant role up to a conflicting one. This means that if 2005-2019´s investments to increase electricity coverage and market size, reaches whether 50% or 100% of government expectations (DNP, 2006a), the SIN coverage turns into a variable to watch out carefully. That new condition emerges from its new conflicting role from which decisions or actions taken in the future to change this variable might generate inertial and non expected side effects over any other indicator included in the analysis.

On the other side, ZNI coverage keeps its independent and relatively marginal role across pessimist and intermediate scenarios. However, to the optimist scenario, which aims to reach 74,4% of ZNI coverage, this variable gets a bigger relevance within the sector, turning into a conflicting KPI, over which direct decisions and actions can be recommended under controlled conditions. Because it will be a conflicting role, it is strongly recommended that these decisions must seek for long term change, or marginal short-term changes as it most. This could be the only way to avoid side-effects that commonly may come when conflicting KPIs change.

Regarding those KPIs representing increases in the electricity international market, impact from scenarios designed vary broadly. Electricity exports from one side get weaker over both pessimist and optimist scenarios. Its originally conflicting role, where controlled actions can be strongly recommended, turns into a dependent one. By being dependent KPIs, they are ideal to visualize results of the sector as part of a monitoring system, but actions over them are strongly not recommended because they generate very low benefit/cost ratios. Only under the intermediate scenario, electricity exports keep their conflicting role, in which case benefit/cost ratios related are considerably better therefore actions over them although carefully controlled, turn into strongly recommended. Electricity international connections from the other side, reveal a quite expected behaviour. Under a pessimist scenario, where future international connections are the same existing today (2006), both its influence and dependence levels drop enough to transform this KPI into an independent one. The same behaviour occurs under an intermediate scenario. Only to the optimist scenario, when international connections reach the number of 7 as Colombia 2019`s expectations, it is possible to transform this variable into a dependent one, ideal to monitor trend changes within the sector.

Finally, the power zone, where more dominant KPIs are located (Zone 1), was the less changing zone of all, showing not only a quite reduced number of dominant KPIs able to generate controllable and efficient changes to the electricity sector (two essentially), but also the inflexible sector's structure to discover new dominant patterns in its future development. Population, SIN coverage and the hydraulic effective generation capacity are and will remain as dominant KPIs up to year 2019. Decisions, as well as strategic actions over these KPIs are strongly recommended considering the strong benefit/cost rations the will generate to the sector.

Trends KIP by KPI:

- **Real DDP growth** (No. 2): currently, do not generate important impacts on the electricity service coverage and market size, considering its independent role[55]. Under the pessimist scenario's implementation it turns into a variable key to visualize results

[55] Its dependence level growths due to the implementation of the optimist scenario's implementation, but not enough to change its original role.

within the sector, while the intermediate scenario transforms it in a powerful and dominant variable over which direct actions are strongly recommended.

- **Public investments at ZNI** (No. 5): only under a optimist scenario, where both ZNI´s coverage and related investments reach 100% of Colombia 2019´s goals, this variable changes turning into a highly dependent KPIs ideal to visualise future trends within the electricity sector.

- **Hydraulic generation capacity** (No. 6): its level of dependence will increase under any of the three scenarios` implementation, turning it into a conflicting KPI. Because of this, those decisions that this variable will need in the future, should have a step-by-step focus, seeking long term changes rather than short term effects. These decisions will additionally need to include detailed monitoring systems in order to avoid unexpected side-effects over other KPIs included within the analysis.

- **SIN coverage** (No. 8): its reactions are similar to those from hydraulic generation capacity. Its dependence level growths under pessimist and optimist scenario's implementation, transforming its role from dominant currently to conflicting in the future. Therefore, monitoring actions over decisions that directly affect this KPI will increasingly need to be more detailed. Under the intermediate scenario's implementation, this KPI do no change its current role within the sector.

- **Residential electricity demand (per-capita)** (No. 11): under the pessimist scenario's implementation, it lost considerable both influence and dependence compared to its current levels, passing from a conflicting role to an independent one in the future. This turn it into a marginal KPI since it lost totally its capacity to generate structural transformations to the sector. On the other hand, its current conflicting role does not change under the optimist and intermediate scenarios´ implementation.

- **Electricity exports** (No. 12): under the implementation of both the optimist and pessimist, its level of influence reduces enough to transform its role from a conflicting one currently to a dependent one to the future. Within that new role, direct actions under this KPI are strongly not recommended. Instead, it turns ideal to be used a monitoring variable to visualize major trends within the sector.

- **Electricity international connections** (No. 13): Pessimist and intermediate scenarios have the effect of reduce levels of both influence and dependence to this KPI. Under this change, it turns into a marginal variable to the sector. Under the optimist scenario's implementation, it is useful to visualize results as part of a monitoring system of the sector.

- **SIN subscribers** (No. 14): it suffers changes under the implementation of any of the scenarios designed. Pessimist and intermediate scenarios transform it from a marginal to a conflicting KPI, increasing considerably its level of both influence and dependence. Therefore, two important recommendations on future actions and decisions directly affecting this KPI are: i) close monitoring to avoid side-effects and, ii) a step-by step focus that seeks for long term and structural changes rather than short term and operational effects to the sector.

- **Electricity prices at residential, stock market and contract levels** (No. 16-17-18): currently these KPIs are ideal to visualize results rather than to take direct decisions over them. Under the implementation of the optimist and intermediate scenarios, there will not being structural changes on this role. However under the implementation of the pessimist scenario, where price increases over competitive values are expected, these KPIs enter to the group of the conflicting ones and decision directly affecting then are recommended as long as they keep controlled and under a step-by-step long term focus.

Trends scenario by scenario

The effects of a pessimist scenario on electricity coverage and market. (Figure 42) This scenario was designed to represent a potential future of the sector where most of the KPIs representing it, could developed trends considered as pessimist or negative under an integrated approach. The major characteristics of this scenario are:

Total investments in electricity tend to decrease between 2006 and 2019, mainly affecting private investments. Consistently SIN and ZNI coverage as well as demand's KPIs (such as total demand and residential demand per-capita), tend to growth marginally along the same period. There wont be built new international connections, therefore electricity exports will have only a marginal growth by using current physical facilities. Generally speaking investment, coverage and demand will only achieve 50% of goals defined at Colombia 2019´s strategic. Total investments in electricity between years 2005 and 2019 reached US$5.691 millions. (A1, B1, C1, D1, E1 Figure 40)

Main effects from the pessimist scenarios´ implementation:

- Both private and public investments to the sector, keep their role as conflicting KPIs, therefore direct actions over them also keep strongly recommended as long as they include close monitoring systems and seek for step-by-step and conservative changes.

- Hydraulic installed capacity (effective) reduces relatively its influence within the sector considering that future actions over it, might generate unexpected side-effects over other KPIs.

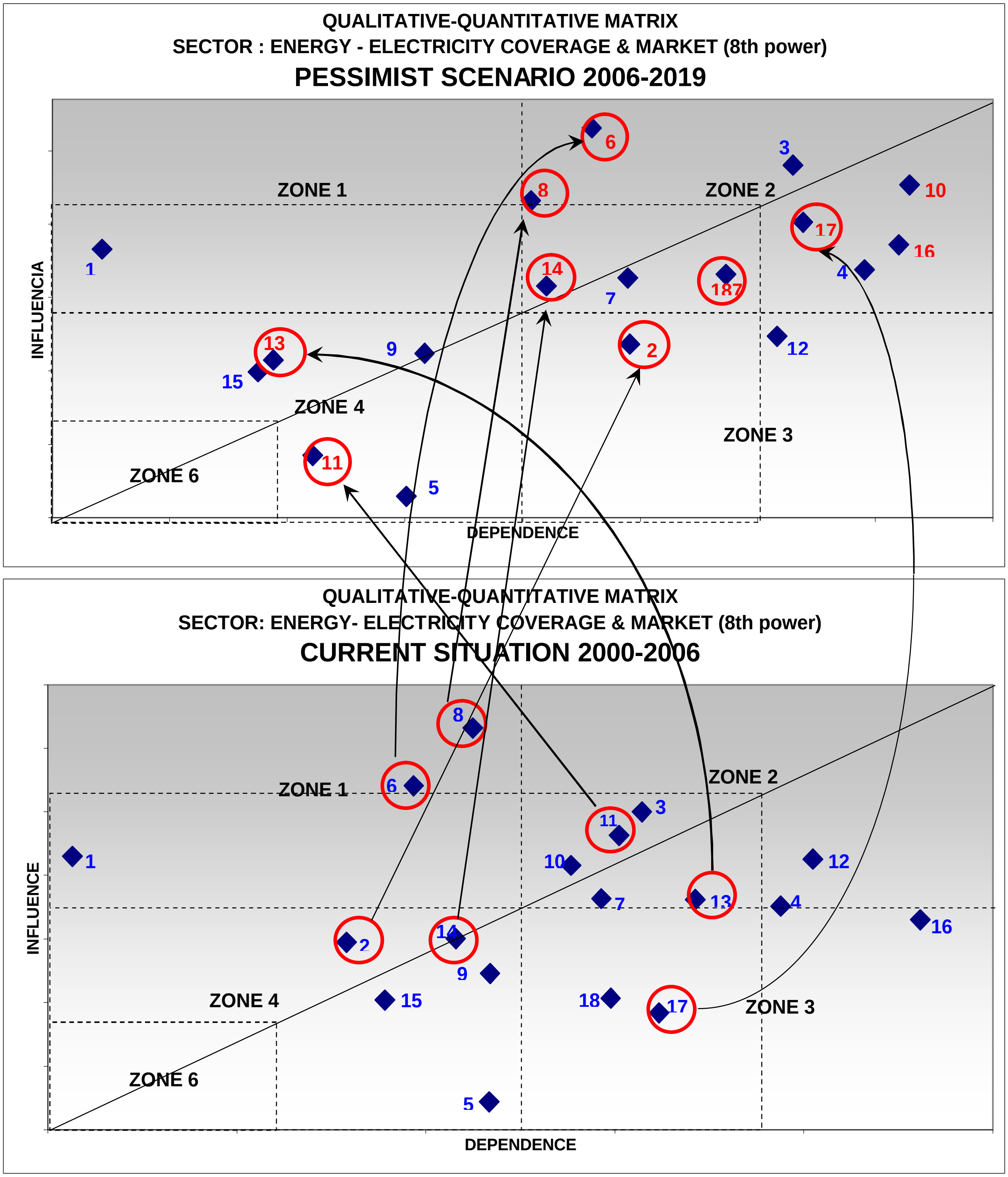
- SIN coverage will increase its dependence level within the sector, by keeping as important as currently to generate strategic decisions and changes. However instability on these decisions and changes will increase.

- Demand's variables will have a wide variety of future trends. While total consumption growth's radio will increase significantly their both influence and dependence level, the important of residential demand (per-capita) will drop dramatically.

- The three KPIs related to international expansion of the electricity market, will loose their importance within the sector, although trends are different. While electricity exports will turn into an ideal KPI to visualize future sector's trends, it will also loose its capacity to generate strategic actions and changes within the sector. International connections form the other side will loose its influence and dependence levels within the sector by having a marginal role in the future.

- Electricity prices, when having growths over competitive levels, will increase their influence within the sector, maintaining it level of independence. Because of these, they transform from being dependent KPIs to have the capacity of key changes to the sector when direct actions over then will be taken, as long as they keep a step-by-step focus and include monitoring systems.

Figure 42.
Effect of pessimist scenario from the influence-dependence change's trends.



Source: own elaboration

The effects of an optimist scenario on electricity coverage and market. (Figure 43)

This scenario was designed to represent a potential future of the sector where most of the KPIs representing it, could developed desired and optimal trends which will be considered as optimist under an integrated approach. The major characteristics of this scenario are:

All goals expected in terms of coverage and market size of the electricity sector at Colombia 2019´s programme are fully achieved. Investments change their decreasing historical trend, gaining stability although their positive growth ratios are significant. SIN and ZNI coverage reach 97% and 74,7% respectively in 2019, while total investments within the sector, reach USD$11,820 millions between 2005 and 2019. (A2, B2, C2, D2, E2 Figure 40)

Main effects from the pessimist scenarios´ implementation:

While population will loose its importance as a dominant KPI within the sector, PIB growth will increase its importance as a key variable to visualize future trends of this sector.

Although public and private investments related with electricity coverage and market, have trends quite different to those from the pessimist scenario, they will keep their conflicting role within the optimist scenario's implementation. However ZNI investments resulted much more positively affected, increasing considerably its level of importance within the sector by changing its role from marginal to being key on the sector result's visualization.

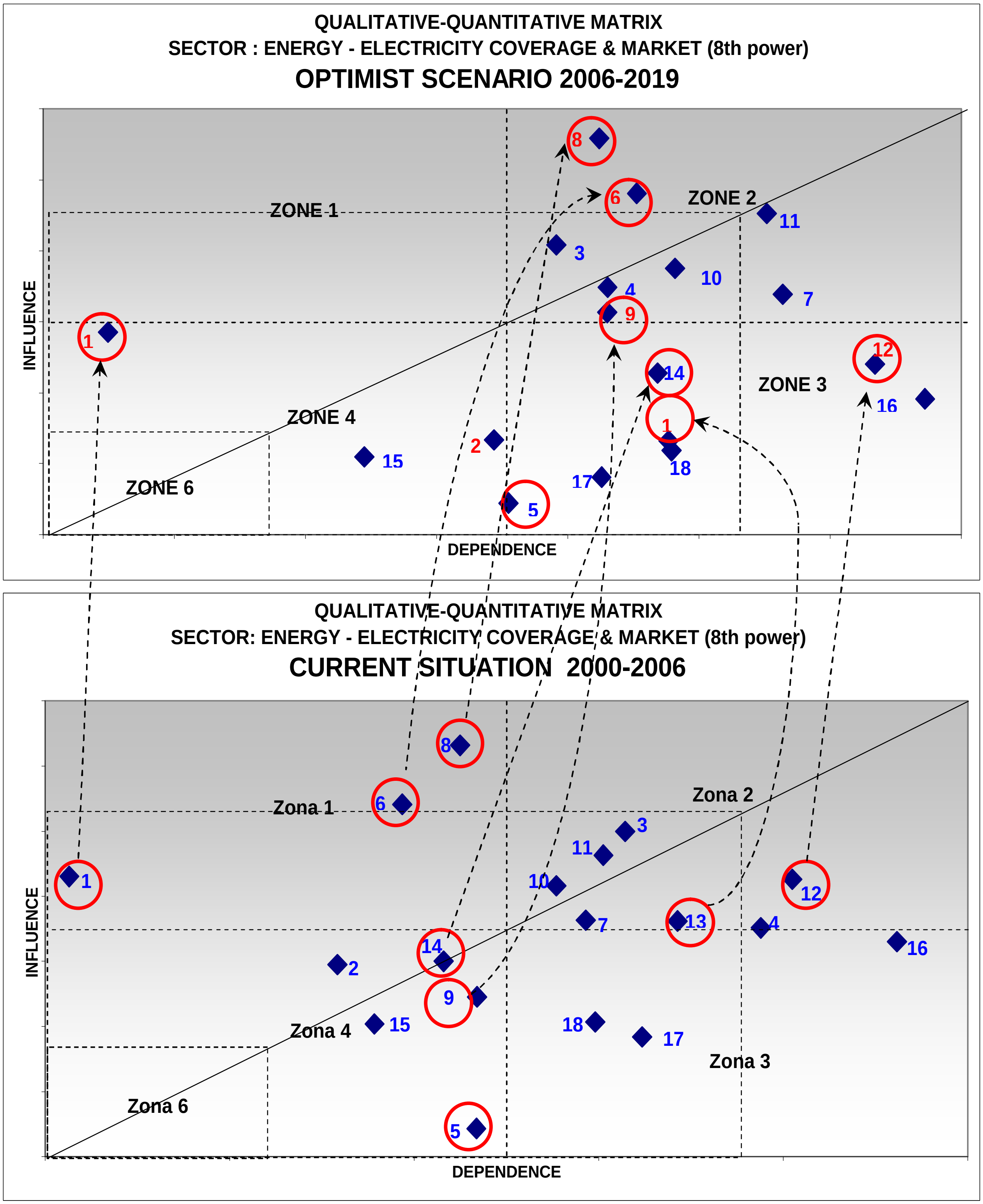
Coverage related KPI on the other side, will change their role similarly to the way investments change. While SIN coverage will slightly reduce its importance as a dominant KPI by turning it into a conflicting one, ZNI coverage will considerably increase its level of importance by changing its role from being almost marginal to be a conflicting role, key to the implementation of long term policies and step-by-step strategies within the electricity sector.

Electricity generation capacity will suffer an internal change related with the source of energy. While the none-hydraulic generation will get closer to be a dominant KPI, the hydraulic one will seemingly loose its impact over the sector, changing from a dominant KPI to a conflicting one.

International electricity market, on the other hand, will increase its importance level from their electricity exports´ point of view. These exports change their role from dependent to a conflicting one, becoming ideal not only to visualization of results and future trends, but also to generate key decision making process within the sector. However, the importance of the electricity market will relatively decrease from international connections´ point of view. Because Colombia 2019´s goals on the construction of these connections is fully achieved in this case, the importance of this KPI as a strategic variable will become less importance, at least relating to the decision making processes, considering that it will keep its value as visualization's KPI.

Finally, electricity prices will not their change significantly, keeping their "visualization" role within the sector. This will occur to residential, stock market and contract prices.

Figure 43
Effect of optimist scenario from the influence-dependence change's trends



Source: own elaboration.

The effects of the intermediate scenario on electricity coverage and market. (Figure 44). This scenario was designed to represent a potential future of the sector where most of the KPIs representing it, could developed trends considered as an intermediate situation between an optimal trend and a pessimist trend under an integrated approach. In some cases this situation represents continuity on stable growth while in other cases it means improvements from unsatisfactory trends below a level of the more optimist improvement. The major characteristics of this scenario are:

While private investments will growth as Colombia 2019´s expectations, public investments will keep it decreasing historical trend. In this way, electricity coverage will reach 80% global expectations of Colombia 2019 which means 95,7% coverage of the SIN and 66,9% electricity coverage to the ZNI to the year 2019. The effective generation capacity will reach 14,942 MW, which means achieving 86% of Colombia 2019´s related goal to the same year. Electricity exports will reach 76% of the same programme's goal on this issue. (A3,B3,C3,D3,E3, Figure 40)

Main effects from the intermediate scenarios´ implementation include:

- Even, when trends on electricity public investments will remain decreasing, private investment's growth will keep Colombia 2019´s increasing expectations, which will also help to increase the importance of the PIB`s growth to the dynamics of the electricity coverage and market. This is because PIB growth's role will be transformed from an independent one to a power one because of the intermediate scenario's implementation.

- Despite of this, private investments´ growth seems to acquire its own inertial dynamics, passing from a conflicting role to an independent one. This means that under this scenario's implementation, those decisions directly affecting private investments related with the electricity coverage and market growth actually will not have structural effects over coverage and market.

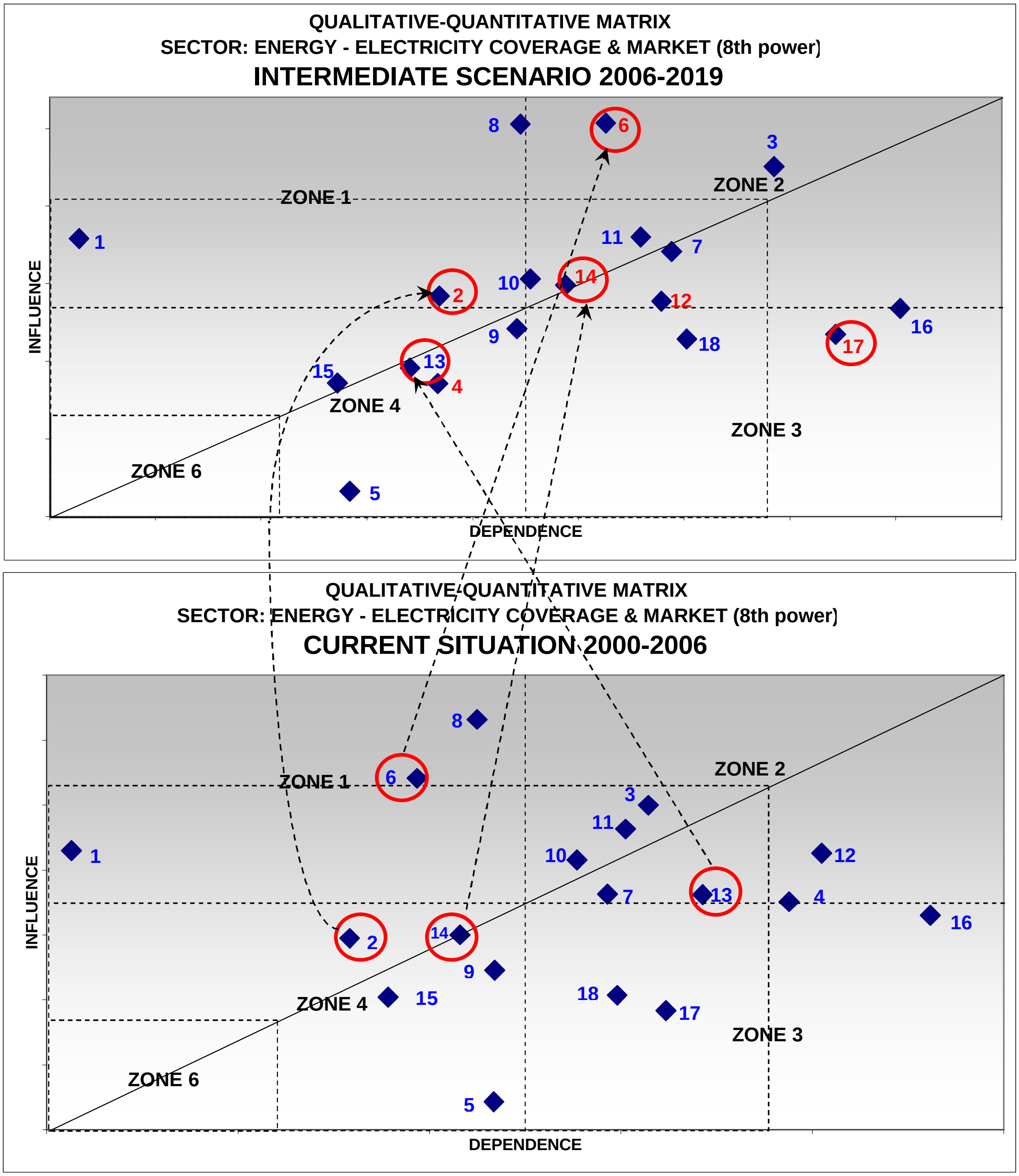
- From other side, coverage at ZNI will relative increase its importance within the sector due to its transformed role from an independent to a visualization one.

- Those aspects related with the electricity international market will not be significantly affected, at least in terms of the sector exports, which will keep their role as a conflicting variable. However, just as it will happen under the pessimist scenario's implementation, once electricity international connections growth up to certain level as the intermediate scenarios implies, electricity exports will not be a critical issue to solve within the sector, gaining more independence on its role within the sector.

- Finally, those variables related with electricity prices, will only have marginal changes on their influence and dependence levels within the sector, without compromising their major role currently played. This means, electricity prices (at residential, stock market or contract levels), will remain as visualization KPI, important to be part of a monitoring system due to their high sensitivity to show internal changes of the sector dynamics.

Detailed forecast on each scenario are in Figures 45, 46 and 47

Figure 44
Effect of intermediate scenario from the influence-dependence change's trends



Source: own elaboration

Figure 45. Electricity coverage and market size – Pessimist scenario forecasts

Variable	INDICATOR	Code (3)			Unit	2005	2006	2007	2008	2009	2010
Population & GDP	Total population	C	I	1	inhabitants	***46.039.144***	***46.772.286***	47.520.862	48.256.722	48.982.063	49.665.343
	Real GDP growth	F	R	2	%	3,20	3,20	3,44	3,60	3,60	4,00
Investments $USD	Electricity public investmet	F	I	3	$USD Mill 2005 (2)	$ 493,94	$ 472,52	$ 451,11	$ 429,69	$ 408,27	$ 386,85
	Electricity private investmet	F	I	4	$USD Mill 2005 (2)	$ 132,78	$ 116,27	$ 99,76	$ 83,24	$ 66,73	$ 50,22
	ZNI public investments (executed resources)	F	I	5	$USD Mill 2005 (2)	$ 5,00	$ 23,27	$ 23,09	$ 22,91	$ 21,31	$ 5,21
Infrastructure and production	Effective generation capacity installed	P	I	6	MegaWatts	8.719,6	8.736,2	8.752,9	8.769,6	8.786,4	8.803,2
	Effective generation capacity installed	P	I	7	MegaWatts	4.617,1	4.670,1	4.723,9	4.778,4	4.833,8	4.889,9
	SIN coverage (1)	P	R	8	%	90,4	90,6	90,9	91,2	91,4	91,7
	ZNI coverage	P	R	9	%	35,4	36,5	37,7	38,9	40,1	41,3
	Electricity demand annual growth	P	IP	10	%	***4,10%***	1,81%	1,81%	1,81%	1,81%	1,81%
	Residential electricity demand	P	IP	11	Gigawatts/hour/inhab	***354,21***	353,54	355,09	356,65	358,22	359,80
	Electricity exports	P	IP	12	GWh	1.757,87	1.537,49	1.594,17	1.651,01	1.708,01	1.765,17
	Electricity international interchange	P	R	13	connection	***5***	5	5	5	5	5
Users tariffs	SIN subscribers	C	I	14	subscribers	***8.285.460***	***9.412.816***	9.154.957	9.274.283	9.393.959	9.513.989
	ZNI subscribers	C	I	15	users	***128.300***	129.182	130.137	131.093	132.049	133.007
	Average electricity residential tariffs	F	IP	16	$ USD 2005 / kwh	***0,121***	***0,117***	0,109	0,105	0,101	0,097
	Average electricity stock market prices	F	IP	17	$ USD 2005 / kwh	***0,033***	0,035	0,036	0,037	0,039	0,040
	Average electricity contracts prices	F	IP	18	$ USD 2005 / kwh	***0,031***	0,033	0,033	0,034	0,035	0,035

Code (3)			Unit	2011	2012	2013	2014	2015	2016	2017	2018	2019
C	I	1	inhabitants	50.387.701	51.120.064	51.838.186	52.542.134	53.182.964	53.874.343	54.574.709	55.284.180	56.002.875
F	R	2	%	4,24	4,40	4,64	4,80	4,80	4,80	4,80	4,80	4,80
F	I	3	$USD Mill 2005 (2)	$ 365,43	$ 344,01	$ 322,59	$ 301,17	$ 279,76	$ 258,34	$ 236,92	$ 215,50	$ 194,08
F	I	4	$USD Mill 2005 (2)	$ 33,71	$ 17,20	$ 0,69	$ -	$ -	$ -	$ -	$ -	$ -
F	I	5	$USD Mill 2005 (2)	$ 5,15	$ 5,08	$ 4,99	$ 4,95	$ 4,85	$ 4,75	$ 4,65	$ 4,53	$ 4,57
P	I	6	MegaWatts	8.820,0	8.837,0	8.853,9	8.870,9	8.888,0	8.905,1	8.922,2	8.939,4	8.956,7
P	I	7	MegaWatts	4.946,9	5.004,7	5.063,3	5.122,8	5.183,1	5.244,3	5.306,5	5.369,5	5.433,5
P	R	8	%	91,9	92,2	92,4	92,7	93,0	93,2	93,5	93,7	94,0
P	R	9	%	42,6	44,0	45,4	46,8	48,3	49,8	51,4	53,0	54,7
P	IP	10	%	1,81%	1,81%	1,81%	1,81%	1,81%	1,82%	1,82%	1,82%	1,82%
P	IP	11	Gigawatts/hour/inhab	361,38	362,98	364,58	366,19	367,81	369,44	371,08	372,72	374,38
P	IP	12	GWh	1.822,49	1.879,97	1.937,61	1.995,42	2.053,38	2.111,51	2.169,80	2.228,25	2.286,87
P	R	13	connection	5	5	5	5	5	5	5	5	5
C	I	14	subscribers	9.634.376	9.755.124	9.876.236	9.997.717	10.119.570	10.241.800	10.364.410	10.487.404	10.610.786
C	I	15	users	133.964	134.923	135.882	136.842	137.803	138.764	139.726	140.689	141.653
F	IP	16	$ USD 2005 / kwh	0,094	0,092	0,089	0,086	0,083	0,081	0,079	0,076	0,074
F	IP	17	$ USD 2005 / kwh	0,042	0,043	0,045	0,047	0,048	0,050	0,052	0,054	0,056
F	IP	18	$ USD 2005 / kwh	0,036	0,037	0,037	0,038	0,039	0,040	0,040	0,041	0,042

Notes:
(1) SIN= National interconnected system (urban and major sub-urban areas);
ZNI = not interconnected zones (rural areas outside the national interconnected electricity system-sin)
(2) $COL Mill = Millions of Colombian Pesos at December 2005. (1 US$ Dollar = $ 2.284,22 Colombian pesos. Source Central Bank of Colombia.)
(3) Alphanumeric identification for each KPI based on its BSC dimmension and indicator type, regarding the objective frame.
BSC dimmensions; C = clients, F = financial, P = internal processes
Indicator type; I = input, A = activities, R = results, IP = impacts
(4) Values highlighted were directly taken by time-series available
(5) Population forecasts from DNP-DDS-DDUPA based on DANE. GDP growth forecasts from DNP-DEE

Source: own elaboration

Infrastructure forecast modelling I Torres –Gracia.D [2007]

Figure 46. Electricity coverage and market size – Optimist scenario forecasts

Variable	INDICATOR	Code (3)			Unit	2005	2006	2007	2008	2009	2010
Population & GDP	**Total population**	C	I	1	inhabitants	***46.039.144***	***46.772.286***	47.520.862	48.256.722	48.982.063	49.665.343
	Real GDP growth	F	R	2	%	***4,80***	***4,80***	5,16	5,40	5,40	6,00
Investments $USD	**Electricity public investmet**	F	I	3	$USD Mill 2005 (2)	$ 879,68	$ 861,24	$ 934,95	$ 791,30	$ 864,00	$ 704,51
	Electricity private investmet	F	I	4	$USD Mill 2005 (2)	$ 312,43	$ 296,73	$ 391,62	$ 269,15	$ 363,02	$ 243,15
	ZNI public investments (executed resources)	F	I	5	$USD Mill 2005 (2)	$ 5,00	$ 23,45	$ 23,46	$ 23,48	$ 23,28	$ 5,78
Infrastructure and production	**Effective generation capacity installed**	P	I	6	MegaWatts	8.576	8.693	8.847	8.862	8.877	8.890
	Effective generation capacity installed	P	I	7	MegaWatts	4.822	4.861	4.867	5.012	5.160	5.311
	SIN coverage (1)	P	R	8	%	90,39%	90,89%	91,43%	91,89%	92,37%	92,81%
	ZNI coverage	P	R	9	%	35,41%	36,80%	38,28%	39,83%	43,79%	45,80%
	Electricity demand annual growth	P	IP	10	%	***4,10%***	7,22%	7,22%	7,22%	7,23%	7,23%
	Residential electricity demand	P	IP	11	Gigawatts/hour/inhab	***354,21***	459,12	463,36	467,64	471,95	476,30
	Electricity exports	P	IP	12	GWh	1.758	1.592	1.712	1.817	1.924	2.022
	Electricity international interchange	P	R	13	connection	***5***	5	6	6	7	7
Users tariffs	**SIN subscribers**	C	I	14	subscribers	***8.285.460***	***9.412.816***	9.253.801	9.477.176	9.706.322	9.941.484
	ZNI subscribers	C	I	15	users	***128.300***	129.690	131.163	132.647	134.143	135.649
	Average electricity residential tariffs	F	IP	16	$ USD 2005 / kwh	***0,121***	***0,120***	0,114	0,111	0,109	0,107
	Average electricity stock market prices	F	IP	17	$ USD 2005 / kwh	***0,033***	0,033	0,032	0,032	0,031	0,031
	Average electricity contracts prices	F	IP	18	$ USD 2005 / kwh	***0,031***	0,032	0,032	0,032	0,032	0,032

Code (3)			Unit	2011	2012	2013	2014	2015	2016	2017	2018	2019
C	I	1	inhabitants	50.387.701	51.120.064	51.838.186	52.542.134	53.182.964	53.874.343	54.574.709	55.284.180	56.002.875
F	R	2	%	6,36	6,60	6,96	7,20	7,20	7,20	7,20	7,20	7,20
F	I	3	$USD Mill 2005 (2)	$ 701,97	$ 686,98	$ 680,02	$ 692,72	$ 715,00	$ 742,38	$ 787,68	$ 833,88	$ 896,19
F	I	4	$USD Mill 2005 (2)	$ 251,62	$ 245,73	$ 245,60	$ 246,62	$ 253,37	$ 261,47	$ 283,04	$ 300,25	$ 327,34
F	I	5	$USD Mill 2005 (2)	$ 5,79	$ 5,81	$ 5,83	$ 5,87	$ 5,90	$ 5,92	$ 5,96	$ 5,99	$ 6,25
P	I	6	MegaWatts	8.995	9.101	9.207	9.312	9.419	9.525	9.631	9.737	9.844
P	I	7	MegaWatts	5.521	5.738	5.962	6.193	6.432	6.677	6.931	7.193	7.463
P	R	8	%	93,49%	94,06%	94,59%	95,06%	95,49%	95,83%	96,29%	96,62%	97,04%
P	R	9	%	47,98%	50,37%	52,97%	55,56%	58,67%	62,10%	65,87%	70,04%	74,68%
P	IP	10	%	7,24%	7,24%	7,24%	7,25%	7,25%	7,26%	7,26%	7,27%	7,27%
P	IP	11	Gigawatts/hour/inhab	480,67	485,08	489,53	494,02	498,54	503,11	507,71	512,36	517,04
P	IP	12	GWh	2.172	2.300	2.420	2.523	2.619	2.696	2.798	2.873	2.966
P	R	13	connection	7	7	7	7	7	7	7	7	7
C	I	14	subscribers	10.182.900	10.430.851	10.685.607	10.947.456	11.216.694	11.493.634	11.778.590	12.071.909	12.373.935
C	I	15	users	137.167	138.697	140.238	141.792	143.357	144.935	146.525	148.129	149.745
F	IP	16	$ USD 2005 / kwh	0,105	0,103	0,100	0,098	0,097	0,095	0,093	0,091	0,089
F	IP	17	$ USD 2005 / kwh	0,031	0,031	0,031	0,031	0,032	0,032	0,032	0,032	0,033
F	IP	18	$ USD 2005 / kwh	0,032	0,032	0,032	0,032	0,032	0,032	0,032	0,032	0,032

Notes:
(1) SIN= National interconnected system (urban and major sub-urban areas);
ZNI = not interconnected zones (rural areas outside the national interconnected electricity system-sin)
(2) $COL Mill = Millions of Colombian Pesos at December 2005. (1 US$ Dollar = $ 2.284,22 Colombian pesos. Source Central Bank of Colombia.)
(3) Alphanumeric identification for each KPI based on its BSC dimmension and indicator type, regarding the objective frame.
BSC dimmensions; C = clients, F = financial, P = internal processes
Indicator type; I = input, A = activities, R = results, IP = impacts
(4) Values highlighted are generated by Lagrange`s linear interpolation when previous to 2005 and generated by Module 3´s forecating process after that year.
(5) Population forecasts from DNP-DDS-DDUPA based on DANE. GDP growth forecasts from DNP-DEE

Source: own elaboration

Infrastructure forecast modelling I Torres –Gracia.D [2007]

Figure 47
Electricity coverage and market size – intermediate forecasts

Variable	INDICATOR	Code (3)			Unit	2005	2006	2007	2008	2009	2010
Population & GDP	Total population	C	I	1	inhabitants	46.039.144	46.772.286	47.520.862	48.256.722	48.982.063	49.665.343
	Real GDP growth	F	R	2	%	4,00	4,00	4,30	4,50	4,50	5,00
Investments $USD	Electricity public investmet	F	I	3	$USD Mill 2005 (2)	$ 493,94	$ 472,52	$ 451,11	$ 429,69	$ 408,27	$ 386,85
	Electricity private investmet	F	I	4	$USD Mill 2005 (2)	$ 312,43	$ 296,73	$ 391,62	$ 269,15	$ 363,02	$ 243,15
	ZNI public investments (executed resources)	F	I	5	$USD Mill 2005 (2)	$ 5,00	$ 23,61	$ 23,77	$ 23,92	$ 22,58	$ 5,60
Infrastructure and production	Effective generation capacity installed	P	I	6	MegaWatts	8.720	8.744	8.768	8.793	8.818	8.842
	Effective generation capacity installed	P	I	7	MegaWatts	4.617	4.695	4.774	4.856	4.938	5.023
	SIN coverage (1)	P	R	8	%	90,39%	90,76%	91,13%	91,51%	91,88%	92,26%
	ZNI coverage	P	R	9	%	35,41%	37,05%	38,78%	40,58%	42,47%	44,45%
	Electricity demand annual growth	P	IP	10	%	4,10%	7,22%	7,22%	7,23%	7,23%	7,23%
	Residential electricity demand	P	IP	11	Gigawatts/hour/inhab	354,21	459,12	463,37	467,65	471,97	476,32
	Electricity exports	P	IP	12	GWh	1.758	1.564	1.647	1.730	1.814	1.898
	Electricity international interchange	P	R	13	connection	5	5	5	5	5	5
Users tariffs	SIN subscribers	C	I	14	subscribers	8.285.460	9.412.816	9.253.813	9.477.193	9.706.344	9.941.508
	ZNI subscribers	C	I	15	users	128.300	129.351	130.478	131.607	132.739	133.874
	Average electricity residential tariffs	F	IP	16	$ USD 2005 / kwh	0,121	0,119	0,112	0,109	0,107	0,104
	Average electricity stock market prices	F	IP	17	$ USD 2005 / kwh	0,033	0,034	0,035	0,036	0,037	0,038
	Average electricity contracts prices	F	IP	18	$ USD 2005 / kwh	0,031	0,033	0,033	0,034	0,034	0,035

Code (3)			Unit	2011	2012	2013	2014	2015	2016	2017	2018	2019
C	I	1	inhabitants	50.387.701	51.120.064	51.838.186	52.542.134	53.182.964	53.874.343	54.574.709	55.284.180	56.002.875
F	R	2	%	5,30	5,50	5,80	6,00	6,00	6,00	6,00	6,00	6,00
F	I	3	$USD Mill 2005 (2)	$ 365,43	$ 344,01	$ 322,59	$ 301,17	$ 279,76	$ 258,34	$ 236,92	$ 215,50	$ 194,08
F	I	4	$USD Mill 2005 (2)	$ 251,62	$ 245,73	$ 245,60	$ 246,62	$ 253,37	$ 261,47	$ 283,04	$ 300,25	$ 327,34
F	I	5	$USD Mill 2005 (2)	$ 5,62	$ 5,62	$ 5,61	$ 5,64	$ 5,61	$ 5,57	$ 5,53	$ 5,47	$ 5,60
P	I	6	MegaWatts	8.867	8.892	8.917	8.942	8.968	8.993	9.018	9.044	9.070
P	I	7	MegaWatts	5.110	5.198	5.288	5.380	5.474	5.571	5.669	5.769	5.872
P	R	8	%	92,64%	93,02%	93,40%	93,78%	94,17%	94,55%	94,94%	95,33%	95,72%
P	R	9	%	46,52%	48,68%	50,95%	53,32%	55,80%	58,39%	61,11%	63,95%	66,93%
P	IP	10	%	7,24%	7,24%	7,25%	7,25%	7,26%	7,26%	7,26%	7,27%	7,27%
P	IP	11	Gigawatts/hour/inhab	480,70	485,12	489,57	494,07	498,59	503,16	507,76	512,41	517,09
P	IP	12	GWh	1.983	2.068	2.153	2.238	2.324	2.410	2.497	2.584	2.671
P	R	13	connection	5	5	5	5	5	5	5	5	5
C	I	14	subscribers	10.182.939	10.430.898	10.685.662	10.947.514	11.216.754	11.493.692	11.778.651	12.071.968	12.373.995
C	I	15	users	135.011	136.151	137.295	138.440	139.589	140.741	141.896	143.053	144.214
F	IP	16	$ USD 2005 / kwh	0,102	0,100	0,098	0,096	0,094	0,092	0,090	0,088	0,087
F	IP	17	$ USD 2005 / kwh	0,039	0,040	0,041	0,042	0,043	0,044	0,045	0,047	0,048
F	IP	18	$ USD 2005 / kwh	0,035	0,036	0,036	0,037	0,037	0,038	0,038	0,039	0,039

Notes:
(1) SIN= National interconnected system (urban and major sub-urban areas);
ZNI = not interconnected zones (rural areas outside the national interconnected electricity system-sin)
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(4) Values highlighted are generated by Lagrange`s linear interpolation when previous to 2005 and generated by Module 3´s forecating process after that year.
(5) Population forecasts from DNP-DDS-DDUPA based on DANE. GDP growth forecasts from DNP-DEE

Source: own elaboration

Infrastructure forecast modelling I Torres –Gracia.D [2007]

7. Major emerging issues and further steps

Central issues on the implementation of a prospective model such as the IGF model proposed are mainly related with; i) its actual options of being applied within the organization context and culture, and ii) the development of mitigation procedures to reduce risks related with its implementation process. In the first case, it is essential to emphasize on the threefold nature of the IGF model to integrate past, current and future trends of a sector within a systematic tool to practically support from short to long term decision-making processes. In the second case, it is necessary a proper group of measures as well as a clear understanding of the cultural changes confronted within the implementation process. This section, includes final reflections and suggests practical actions on both issues

7.1 Practical objectives and applications over infrastructure planning processes in Colombia

The IGF model introduced in this document was specially design to support DNP-DIES and SAPSB´s short, medium and long term planning processes on their infrastructure policies, programmes and projects. This threefold objective is achieved throughout the implementation of three individually but interconnected modules whose specific objectives can be summarized as follows:

Module 1. Historical Trends analysis:

- To answer questions like; *¿where the PPP comes from? ¿why does it come from there?, ¿why is it here today?, ¿what past successes/mistakes could teach to its future planning?*
- To find some variable's dominant forces, understood as potential issues to manage its future trends.
- To evaluate relevance and effects of previous processes of decision making related
- To pre-actively and proactively identify, potential impacts coming from future decisions by understanding the effect of comparable decisions in the past

Module 2. Current situation and short term effects from new PPPs:

- To answer questions like; *¿where is the PPP now? (its baseline), ¿how did it get there? ¿what could happened (in the short term) if a new PPP it is implemented today?*
- To implement pre-feasibility analyses on technical and financial issues, from the results of the short term impact study due to the implementation of new PPPs.

Module 3. Forecasting analysis:

- To answer questions like; *¿where is the PPP going to?, ¿what might happen once a particular trend Is in progress?, ¿how to measure its effect on strategic issues to the sector?, ¿What issues will turn into strategic, marginal o neutral aspects to the sector once that trend is in progress?, ¿How those roles will evolve along that trend process?, ¿what future decisions should be needed to optimize positive results once the trend is in place?, ¿what future decisions should be take to avoid negative impacts?*
- To quantify the development of probable futures to the sector as a key input to review, evaluate, reinforce, amend or take pre-active and proactive decisions over policies and plans under current implementation.
- To orient, formulate, design and implement new policies, programmes or projects based on quantified and agreed scenarios.

These aspects have several implications on the day-to-day work of units dedicated to the infrastructure planning, implementation and evaluation. Although the following are specifically thought on the DNP-DIES case, many of them apply to a wide range of institutions and strategic business offices related:

In terms of the Module 1, its major application is the detailed study of a PPP evolution based on the integration of those qualitative and quantitative aspects that played a key role on that evolution. That sort of study could include:

- Systematic and standard ex-post evaluations
- Quantified cause-effect analysis among key variables
- Gap analysis based on its standard process that integrates qualitative and quantitative criterions
- Cross-policy analyses between two complimentary or opposite strategic initiatives
- Alert schemes to take pre-active decisions once a non-expected trend can be identified in advance
- Data bases on implemented and potential PPP scenarios and their implications, useful to further and deeper policy analyses
- Visual aid on future trends and KPIs roles as support to technical concepts, negotiation processes, internal documents or policy documents such as CONPES`s documents.
- Ratifications, amendments or cancellations of policy decisions on progress supported on technical and policy analyses
- Analysis criteria to support future evaluations

In terms of the Module 2, its major application is to enhance DNP´s capacity on technical analyses of new PPP´s proposals, whether they come from DNP´s owns initiative or from other national, sub-national or private initiative. This capacity includes aspects as important as:

- A solid and technical answer to new PPPs implementation proposals.
- Pro-active and pre-active analysis on the potential effects of a new PPP`s implementation within the sector.
- Integral criteria on technical assistance needs to promote development of new PPPs that have been previously studied by the IGF model
- Short-term plans and strategies to improve the implementation of PPPs in current process of development, based on technical analyses, and qualitative-quantitative criterions.
- Concrete recommendations on short-term decision making process as well as policy amendments, supported on pre-active simulations and analyses demonstrating the need and implications of those decisions.

In terms of the Module 3, its major application is to reinforce analysis tools on medium and long term infrastructure planning. This means development of analytical instruments provided by the model that will support those tools, such as:

- Feasibility analysis on specific policies, programmes or projects implementation based on quantified results of qualitative and quantitative criterion.
- Technical concepts on the convenience or inconvenience associated the implementation of new policies, programmes or projects.
- Technical parameters definition to the implementation of current infrastructure policies, as input to their sustainable development.
- Ex-ante quantification of the technical, financial, political and social effects that may come from the implementation of pre-designed future scenarios to a particular infrastructure sector.
- Monitor exercises that on annual basis can implement detailed trends analyses of technical, financial or operational strategic aspects of a sector. According with their results, they can also facilitate structured

processes to amends and decision-making to the policies, programmes or projects under evaluation.
- Improve formality to nowadays informal processes of infrastructure planning, allowing DNP to enhance the systematic combination of qualitative and quantitative data into an integral decision making tool for infrastructure.
- To evaluate recent policy implementations within prospective simulations in order to evaluate their effects on time, and to help in the decision-making processes needed to boost the expected impacts from them.
- Generally speaking, to improve DNP´s tools on technical and financial planning, strategic thinking, decision-making, institutional coordination, decision –action consistency, and evaluation.

7.2 Limitations and risks to the model's implementation

One of the major advantages of the IGF model proposed is that it can be easily adapted ands implemented throughout many public or private institutions with responsibilities on infrastructure planning, implementation or evaluation. However, this implementation should consider the following limitations:

Quality of input data

As any other simulation model, input data is vital to achieve good quality on its analysis and final results. Moreover a model that combines qualitative criterion analysis with time-series needs strict protocols to follow the proposed methodology, in order to build up a reliable database, and therefore guarantee quality results. On the qualitative data, this means institutional agreements on the design and content of the qualitative matrix (what and how many KPIs). The process should keep in mind *why* and *what for* is the modelling process needed. Panel discussions, unstructured or semi-structured interviews, as well as technical meetings among all the actors responsible on the KPIs chosen, are strongly suggested in order to build a detailed consensus over the qualitative matrix. On the quantitative data, this means time-series having at least between 2 and 3 years with reliable data, sustainability on its future generation, strong consistency with success areas to be analyzed, and no more than 25% of missing or unreliable data. However, it is important to insist, the IGF model allows the analyst to avoid negative effects from unreliable data by doing sensibility analysis under different levels of importance to qualitative and quantitative data. This is a powerful option that traditional models, usually supported on quantitative data exclusively, do not offer.

Data processing

The IGF model is not a technical detailed model. This means, it has not been designed to support the analysis of thousands of technical variables that the implementation of a policy, programme or project surely can includes. This is a model designed to focus on highly relevant and high impact variables to the PPP under analysis, in order to support policy macro decision-making processes. In Colombia, other public institutions have specific responsibilities and models on detailed technical analyses and scenarios forecasting, such as UPME´s models on energy demand, CRT´s models on telecommunications market growth, CRA models on water demand or MT models on transport operations and investments. The IGF model can use outputs from those technical models and be complementary to them, turning those. Because of this, the operative tool of the IGF model it is supported on basic applications that almost any commercial spreadsheet includes. In this sense, the number or KPIs to include within the analysis it is prioritized by applying the BSC process explained, and in any case should not be more than 20 strategic variables. More variables could compromise not only data processing quality, but also results interpretation. Because the model allows easy and fast sensitivity analysis, if a

PPP have more than 20 strategic variables, this limitation can be avoided through 2 or 3 preliminary iterations with different combinations of KPIs up to eliminate all the KPIs classified as marginal or very independent. This process not only helps to systematically discard none-strategic variables, but also to focus the analysis only on the most relevant issues for the analyst.

Result's scope

Just as inputs quality determines results scope, this scope cannot be applied at any level of detail different that KPIs chosen can provide. This is, KPIs roles and forecast, which are the major products of the model, are strictly valid within the o context of the whole group of the KPIs chosen. To armour outputs from aspects that have not been considered within the analysis, those variables need to be quantitatively and qualitatively characterized through KPIs capable to be included in the structural process analysis. This applies not only to the PPP or sector analyzed but also to the new PPP whose implementation's effects wants to be quantified. If this new PPP cannot be characterized by specific KPIs as the model demands, its impact cannot be studied.

To the implementation of the IGF model, there are other risks related with the process of implantation by itself and with the planning culture within the institution or sector to be applied. These risks can be summarized as follows:

Risk if the Model is implemented:

There are some risks involved in implementation of a new focus in infrastructure forecast modelling as the IGF model proposes. Some of them come from an expected reaction to change within the infrastructure planning culture at national agencies in Colombia, while other may come from the proper application of the IGF methodology and the interpretation of its results. This section seeks to summarize these major risks as well as includes some of their mitigation mechanisms.

- *Short-term focus in the planning process of strategic infrastructure PPPs.* Sometimes, planning agencies can be drown enough in day-to-day issues that tools seeking to empower their medium and long term planning capacity, tend to be underestimated. A training programme, as part of the implementation of the IGF model, on costs and negative consequences from lacks on long term planning can be easily designed on each case, as well some incentives to promote long term on the planning focus, can be designed by administrative areas of the organization. Using the IGF model within the short range, through the applications of Modules 1 and 2, can also mitigate this risk. These modules can generate immediate results on ex-post analyses and evaluations, as well as on short-term effects coming from the implementation of new PPPs.

- *Misunderstanding of the role that qualitative data might has within the model*. Because it is traditionally assumed that models are approximations of reality, analyst tend to consider that some qualitative issues such policy pressures, strategic actors interest or other social issues that affect infrastructure PPP cannot be included within a modelling analysis, This risk can be reduced if a clear understanding that any qualitative aspect of the PPP analyzed, when properly characterized, can be included within the structural analysis process. The model even allows preliminary analysis exclusively based on qualitative data in order to generate prioritization criterions to further analysis over selected quantitative data. This is also a competitive advantage that traditional forecasting models do not offer.

- *Under/over estimation of the IGF results*. Model's results are more reliable when they complement other planning processes already used to build diagnosis, or study impact analyses with forecasting purposes within the organization. If tools such as the IGF model are available but ignored, the reliable information to short, medium and long-term decisions could be wasted. In the same way, there will emerge high costs from ignoring those decisions within a context of financial and human resources high constraints (including political, technical, financial or opportunity cost related). This risk can be undermined by developing an adequate implementation process of the model including pilot and supporting analyses within the organization, complimentary analyses on strategic issues and studies under development, as well as long term implementation strategies on training to all specialists and decision-makers.

- *Unethical use of IGF results*. Model's results are designed to support decision-making processes based both in quantitative forecasts and KPIs roles analysis. Outputs related with these roles are particularly sensitive to unethical use. Those roles provide strategic information about what to do, what should not be done, consequences of actions taken, and consequences from actions avoided. This information could be used to generate negative effects or to constraint positive effects. In both cases, this risk can be reduced through control points along the data processing and results analysis. These controls can be implemented via structure or unstructured methods. A structured focus can be developed by the operational system or the software used in the operation of the model, through e-mailing protocols within the analysis team. A unstructured method cab be applied by control meetings were actors involved in the process of matrixes building, get also involved within the data processing and the results analysis.

Risks if the Model it is not implemented:

There are a group of issues that can be identified as inconvenient if opportunities to reinforce the infrastructure planning capacity, such as the one offered by the implementation of the IGF model, are no taken. They are mainly related with aspects that the model seeks to improve or develop a different and more pro-active focus.

- A causal and reactive focus to planning could be the exclusive criterions to the development of infrastructure sectors future policies, forecasting or vision exercises, loosing opportunity costs derived from proactive and pre-active decision making processes, and improving the risks of lacks of long-term vision in infrastructure projects.

- Political and unstructured criterions could increase their role within decision-making processes without a proper technical support to both evaluation and prospective analysis. This may generate instability and unpredictability to investments decisions, inertial losses to the implementation processes related, and strong limitations on the goals achievement of sectors policies.

- Control of political criterions throughout decision-making processes will reduce reliability on DNP-DIES role, constraining its participation in future PPP process of design and implementation.

- Outputs from nowadays time-series available on strategic KPIs, could remain underestimated, and limited to quantitative forecasts unconnected to decision-making processes.

- Economies of scale could be lost from the collecting and databases building process generated by the IGF model's implementation process.

Risks during the IGF´s implementation process:

- *Underestimation of the BSC´s role within the phase of KPIs identification*. The BSC tool has traditionally considered as an administrative tool rather than a technical support instrument to the decision-making process, and administrative issues tend to be underestimated by technical divisions within the organization. First of all, that is a wrong vision on BSC potential, considering that it is more a strategic tool, and strategic means it can include both administrative and technical issues within the organization. Second, technical applications within the BSC are not necessarily the tool from which BSC is mostly know precisely because of the traditional resistance to implement it within their strategic planning unites, not because BSC cannot improve their technical planning capacity. This is why, if tools such as BSC are not used within a process of KPIs identification, the method to identify them could be extremely simplified and underestimated up to turn it into a random choice process, debilitating further model's processes, and reducing quality outputs coming form the indicators chosen in this way.

- *Shift from long-term visions to short term implementation processes*. Nowadays, the development of exercises such as Colombia 2019, the IAPC or the PND2006-2010, have represented a boost on forecasting-type of exercises at DNP. The implementation of those processes recommendation is now starting, which could reduce some interest on forecasts. As explained before, Module 2´s model was particularly designed to support the implementation of new PPP within the short term, therefore this risk can be reduced by reinforcing training on Model 2´s advantages and added value to the day-by-day decisions.

7.3 Further research and other applications

From the analyses of pilot results of the model within the energy, transport, telecommunications and water supply sectors, some further piece of research and applications can be suggested as follows:

Quantification of regulatory effects:

- Further prospective analyses should include KPIs directly related with regulatory issues. Many regulatory issues are not easy to quantify through traditional coverage, investments or service quality KPIs. Therefore a further analysis could add such regulatory issues within the group of more technical and financial KPIs originally analyzed, and evaluate them only through the qualitative matrix. This will help identify from the original KPIs, those mostly affected by the regulatory issues added[56]. Results coming from this type of analysis of regulatory issues could be used in two different ways:

  - KPIs mostly affected by regulatory issues could be eliminated from future prospective exercises. Therefore related results will be isolated from the regulatory effect, and the quality of results on technical modelling could not be judged from unclear effects of regulatory issues over them.

  - KPIs mostly affected by regulatory issues may suggest by themselves a proxy of alternative KPIs to measure those issues. These alternative KPIs could be included in further analyses that could need considerations on regulatory aspects of the sector. This is a systematic and constructive focus to solve some lacks on the quantification

[56] In Colombia, although pilot results highlighted this issue especially within the electricity sector, the role of regulation is equally important within the telecommunications and water supply sectors. Within the transport sector, a detailed pre-analysis on KPIs associated with a potential regulatory frame to the sector.

of regulatory issues, quite common across some infrastructure public services.

Estimation of the period needed to have expected effects from new investments:

- Investment related forecasts, are directly affected by the period of the project-implementation cycle which can change significantly from transport projects to telecommunications projects[57]. Due to this, further analyses including investment KPIs may develop a sensitivity process which could include:

  - A base scenario where investments time-series are equally related (year by year) with other technical or operative KPIs analyzed.

  - A second scenario where investments time-series are shifted upwards a number of years equal to half of the period estimated as the minimum period expected for those investments to have their first impacts[58].

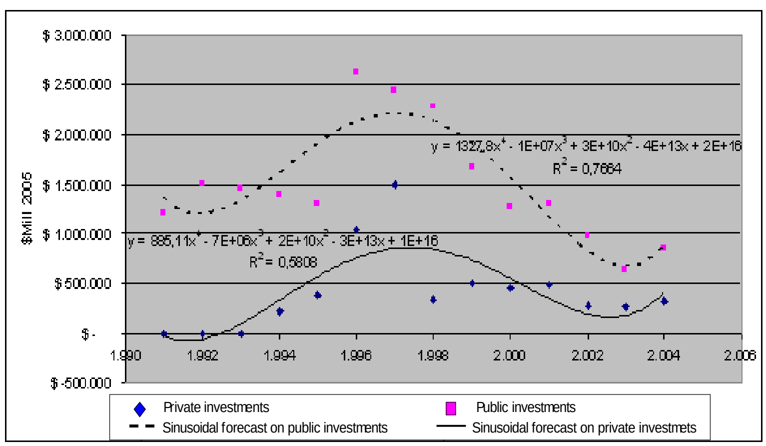
  - A third scenario where investments time-series are shifted upwards a number of years equal to the period estimated as the minimum period expected for those investments to have their first impacts.

  This process could be iterative up to find a shifting period from where non-investments KPIs roles change significantly. This information is strategic in two ways; it can be used as a time proxy of expected impacts where new investments are in place. It also can be an input for further forecasts seeking to include this investments delay-time within their analyses.

Effects of infrastructure investments trends over general performance of a sector

- The evolution of infrastructure investments in Colombia, tend to have oscillatory dynamics (historically). This is, 2 to 3 years of investments growths, followed by 1 to 3 years of decreasing and then a similar period of new growths. Because prospective forecasts of the IGF model are not exclusively based on oscillatory-type of functions (see Criterion 1 at Figure 13), the effect of these types of forecasts cannot always be properly evaluated. However, the model is able to focused forecast in sinusoidal terms therefore the effect of oscillatory trends can be evaluated. A preliminary analysis was carried out to study this issue within the electricity pilot. By comparing originals forecasts in the optimist scenario, showed at Figure 46[59], against sinusoidal forecasts, it was demonstrated that oscillatory trends in public and private investments within the sector, will not change significantly the future role played by the group of KPIs considered within the analysis. Figure 48 shows sinusoidal functions used for this analysis.

Figure 48. Sinusoidal forecasts on electricity **investments**



Source: own elaboration.

[57] Highways concessions can have 30 to 60 years lifetime and their high initial investments could have its first impacts around 5 to 10 years after the construction start. Some telecommunications projects on the contrary can have only 5(or less) to 10 years lifetime periods, with less than 2 years of visible outputs after their implementation starts.

[58] The shift is related to the time-series of other non-investments KPIs.

[59] These forecasts predicted stable growths to both public and private investments within the sector (with a linear and an Euler's dynamics respectively).

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Annexe 1

Studies on infrastructure – development relationships[60]

Studies focussed on infrastructure and production relationships[61]

Focus	General actions	Specific mechanisns of action	Examples - studies related
1.1 It affects production	It reduces input costs	Better quality of infrastructure services, reduces industry's unitary costs (productivity effect)	By using telecommunication services instead of alternative inputs. USA´s industry saved up to 20% in real expediture during 1965-1982 (Croning et al, 1993).
	It increases productivity of capital and labour	It promotes general productivity	Infrastructure facilities and services make possible the direct action to the productive capital (DNP, 1995b)
			Telecommunications, electricity and gas are potential contributors in GDP and gross capital formation (Easterly et al, 1993, Baffes et al, 1992)
			A quarter of productivity gains could be atributed to telecommunications in USA (Cronin et al, 1993)
			Industrial share of total electricity demand has strong correlation with real per capita GNP in industrialised countries (shares tend to decline as GNP rises) (Kim et al, 1989)
			Improvement in land infrastructure promotes agricultural growth - Japan (Akino, 1979)
			Improvements in irrigation systems increases 36% to 83% production in ton/hec-Philippines (Rao, 1986)
			Elasticities between 0.30 - 0.40 with respect to public infrastructure capital - using time series (Holtz - Eakin, 1998; Aschauer, 1989, Munnell, 1990)
			Elasticities of 0.45 average to Total factor productivity with respect to change in infrastructure (Ford et al, 1991)
			Investments on infrastructure have positive impact on "state level" economic measures like output (Munnell, 1992)
			Public infrastructure has a little but positive multiplier effect on output- Mexican context (Shah, 1992)
			Transport and communications´ infrastructures are important factors in aggregate agricultural productivity in LDC´s, plus labour and capital (Antle, 1983)
			A 1% increase in the public capital stock, causes a 3% increase in manufacturing output (Eberts, 1986)

[60] Classified according to their modelling focus.
[61] Source: Torres – Gracia D. 2001 and 2002.

Focus	General actions	Specific mechanisns of action	Examples - studies related
1.1 It affects production	It increases productivity of capital and labour	It promotes general productivity	A 1% increase in the infrastructure stock per person is related with a 1% increase in the GDP per person across more than 60 countries in Europe, Asia, Middle East, Caribean, Africa, Latin América and the Pacific (Word Bank, 1994, DNP 1997B, DNP, 1997e)
			A 1% increase in the infraestructure stock is related with 0.3%, 0.8%, 1.5% and 1.7% increases in the household´s acces to safe water, pavemented roads, electricity and telecomunnications respectively, across more than 60 contries in Europe, Asia, Middle East, Caribean, Africa, Latin América and the Pacific (Word Bank, 1994)
			A 1% increase in the infraestructure stock, causes a 0.13% increase in the productivity in Colombia (Roa et al, 1995)
			A 1% increase in the telephone installed capacity, causes a 0.23 increase in the productivity in Colombia (Roa et al, 1995)
		It enhances private sector productivity	A 1% increase in non-military public investment, causes a permanent increase in return to private capital which increases the level of net private stock by 4.5% (Aschauer, 1990)
			Increase in the public stock of capital, also increases the return to private capital (Aschauer, 1989)
			Public investment in infraestructure has a positive effect on private investment, while not-infraestructural public investments are negatively affected (Chhibber et al, 1990, Seven et al, 1992)
		It provides more job opportunities	Investments on infrastructure have positive impact on "state level" economic measures like output (Munnell, 1992)
		It attracts foreign and local investment	Infrastructure investements= 1/3 to 1/2 of public investments (Kessides, 1993)
			Infrastructure investements= 3% to 6% of GDP (Kessides, 1993)
			Infrastructure investments=20% total investments among 12 low-middle income countries (Easterly et al, 1993)
			Infrastructure investments=40% to 60% public investments among 12 low-middle income countries (Easterly et al, 1993)
			Investments on infrastructure have positive impact on "state level" economic measures like investments (Munnell, 1990)

Focus	General actions	Specific mechanisns of action	Examples - studies related
1.1 It affects production	It is positively related with economic growth	It attracts foreign and local investment	In the European Union, Levels of income are comelated to leves of infrastructure development (transportation, energy, water, health services, etc) (Biehl et al, 1986)
			Infrastructure is a condition for high rates of growth rather than a factor of production (Canning et al, 1993b)
			The availability of infrastructure per person is positively related with the individual level of income across more than 60 countries in Europe, Asia, Middle East, Caribean, Africa, Latin America and the Pacific (World Bank, 1994)
			There is a causation relationship in this way: the development of infrastructure by investing in it first, with higher grouh and wealth accumulation second (Nitzov et al, 1997)
			Elasticies of infrastructure capital at state level between 0.15 to 0.20 in USA and Japan (Munell, 1990, costa et al, 1987, Mera, 1973)
			Elasticities of infrastructure capital al state level between 0.0040 to 0.0045 (Erberts, 1986, Garcia-Mila et al, 1987)
			Elasticities of infrastructure capital (transport, water, sewerage, electricity) between 0.31 and 0.44 in Isralel (Bregman et al, 1993)
			Electricity represents 9% of total on manufacturing cost in Nigeria (Lee et al, 1992)
			Transport represents 26% of business expenses in formal/informal sectors in Zimbawe (Kranton, 1991)
			Not all kind of infrastructure is positively related with economic growth. Energy, water, transportation, communications, and education infrastructures induce growth while investing public funds in health care, enviromental protection, and cultural facilities either induces far less growth or prosperity or shows negative correlation to GDP (Nitzov et al, 1997)
	It changes the production structure	It may readjusts industry´s demand for labour	Infrastructure investments have a signifficant effect on labour requeriments at both levels of total manufacturing and the aggregate busisness sector - Sweeden (Bernt et al, 1991)

Focus	General actions	Specific mechanisns of action	Examples - studies related
1.1 It affects production	It changes the production structure	It may readjusts industry´s demand for physical capital	Cost elasticities between -0.11 and -0.21 with respect to infrastructure capital across varios industries (Nadiri et al, 1994)
			Whether being subtitutes of, or complements to production, infrastructure services may readjust industry´s demand for labour, intermediate inputs and physical capital (Berndt et al 1991, Levin et al 1984, Carmichael 1981, Scott 1984, Lichtenberg, 1988, Jaffe 1989)
	Reduction of productivity of communties when inadequate avalability or faiture of existing infraestructur		Transport and comunications´ infrastructures are part of major constraints in LDC´s to raise their production (Antle, 1983)
			Shortage of electricity infrastructure reduces industrial production significantly - Northeast China (Baransky, 1985).
			Energy shortages causes 25% - 30% underutilisation of manufacturing capacity wich causes significant GNP reduction in China. (Liu 1999, Zhu, 1992, Zhan, 1995).
			Underutilisation of industrial capacity due to a shortage of power, caused a reduction of 5% of India´s GDP. (Pachauri, 1982).

Source: Torres-Gracia, D (2001 and 2002).

Studies focused on relationships between infrastructure, consumption and other issues[62].

Focus	General actions	Specific mechanisns of action	Examples - studies related
1.2 It affects consumption	It improves quality of life, increasing real income and reducinf environmental pollution	It provides clean water	The provision of facilities such as safe water and roads, doubles rural´s land values after controlling for the distance of plots from the city centre (Dowall, 1991)
		It provides sanitation	
		It provides electricity	
		It provides transport	Better availability of roads and transportation facilities, helps bring product in market, wich may increase competition, which may affect prices (Ghafoor, 1998)
			Highway capacity and pavement quality have significant positive effects on income growth across several regions (Aschauer, 1990)
		It provides communication facilities	
1.3 Reduction in quality of life when inadequate availability or failure of existing infraestructure			When the quantity and quality of infrastructure services provided does not met the requirents of growing demands, they not only create negative effects on the evironment but also reduce the total productivity of other factors (Kessides, 1993, World Bank, 1994)
	It is related with poverty		Inadequate transport facilities is one of the main factors in world poverty (Hilling, 1978)
			Individuals are poor because they do not have access to infraestructure services with a propper quality level(Kessides, 1993)
			Construction and improvement of infrastructure such as roads and waterworks, contribute to poverty reduction by providing direct employment (World Bank, 1994)
1.4 It affects the environment	Intensive infraestructur utilisation may contribute to pollution		Dam´s construction and innadequate mangement of water caused waterlogged and salinisation of water in India an Egypt (Joshi et al, 1984, 19897, Biswas, 1984)
			10 years of operation of modern irrigation systems raised the water table 7 to 9 meters above long-term records levels since 1835 on some cannals in Pakistan, 1984)
			Poor management of solid waste complicates urban streets drainage and is linked with malaria (World Bank, 1994)

[62] Source: Torres – Gracia D. 2001 and 2002.

Focus	General actions	Specific mechanisns of action	Examples - studies related
1.4 It affects the environment	Its quality and availability is related with diseases and health in general		Improvements in water supply and sanitation generate reduction between 22% to 76% on several diseases such as diarrhoea, roundworm, guinea worm, and schistosomiasis(Esrey et al, 1990, World Bank, 1994)
			Electricity transmission and distribution is related to aestethic impact of line placement, electrocution of birds, and electromagnetic radiation of people (OECD, 1994)
			Availabillity of electricity and natural gas in rural areas can save deforestation, plantations along road side protect soil erosion and improve quality of life, duckweed ponds can serve as waste - water treatment and source of high quality protein feed stock for animals. (Ghafoor, 1998)

Source: Torres-Gracia, D (2001 and 2002).