A Linear Programming Approach to Motivate knowledge of Sustainability Strategies for Optimizing the End-of-life, Case Study: Hilla City Environment

Ahmed Talib Sahib Auda

Lecturer -Environment Department - College of Engineering- Babylon University

E. Mail: ahmedts61@yahoo.com

Abstract

Our world is changing rapidly and alarming rates of nonrenewable resource consumption provide the impetus for research on sustainability and end-of-life optimization. Linear relationships produced a linear programming for approach to outline boundaries between significant and insignificant processes, seeking to develop methodologies that aid in formulating the end-of-life strategies across a wide range of elements. Aluminum example as case study for using assumption model to maximize value of life cycle shows that reuse without disassembly and disposal plus constraints and can eliminate from consideration.

The collection of data and result outcome pulled out from questionnaire between 2009 and mid of 2013 in Hilla city environment presented that it must develop take on future sustainability practices due to lack of decisions for sustainable optimization of initial lifetime and of end-of-life system, Lack of including sustainability at a strategic in the overall level, and there is no cradle to cradle approach.

Keywords: Sustainability, Optimize, Programming, formulation, lifetime, Recycling

الخلاصة

عالمنا اليوم يتغير بسرعه ودرجات الانذار لاستهلاك المصادر غير المتجددة تعطي الزخم للبحث في مجال الاستدامة وتعظيم الاستمرارية. العلاقات الخطية أنتجت برمجة خطية للاقتراب من المحددات الخارجية بين العمليات المهمة وغير المهمة، محاولةً لتطوير منهج يساعد في ايجاد صيغة لاستراتيجية الاستمرارية عبر مدى واسع من العناصر. وان استعمال مثال الألمنيوم كحالة للدراسة لاستعمال النموذج المفترض لتعظيم قيمة دورة الحياة أظهر أن محددات اعادة الاستعمال بدون تفكيك و الطمر هي زائدة ويمكن اهمالها.

ان جمع المعلومات وحصيلة النتائج المأخوذة من استمارة الاستبيان للفترة بين ٢٠٠٩ و منتصف ٢٠١٣ لبيئة مدينة الحلة بينت ضرورة اتخاذ تطوير لمستقبل الاستدامة عملياً نتيجةً للعجز في قرارات تعظيم الاستدامة عند بداية العمر ونظام الاستمرارية عند النهاية، كذلك العجز في تضمين الاستدامة في الاستراتيجية في كل المستويات، وليس هناك اقتراب من حالة من المهد الى المهد.

الكلمات المفتاحية: الاستدامة، تعظيم، برمجة، صيغة، الاستمرارية، التدوير

Introduction

Future generations and alarming rates of nonrenewable resource consumption provide the impetus for research on sustainability and improving our natural environment (Michelle, 2001) . The advances in science have made our high level of development possible. However, they have created wastes that the environment cannot assimilate (Henry and Gary, 2009). Countries and companies are establishing goals for achieving sustainable development and reducing resource consumption in hopes of preserving the natural environment for future generations. (Ishii *et al.* 1994; Mackenzie 1997; Nilsson,1998)**.** Managing the environment wisely and equitably requires the balancing of a number of conflicting interests (Henry and Gary, 2009). Making sure that material resources are managed sustainably and used efficiently through their life-cycle is vital to economic growth, environmental quality and sustainable development.It would also help reduce the negative environmental impacts associated with the production, consumption and end-of-life management of material resources . A shift from "end-of-life" thinking towards a more integrated life-cycle approach is therefore needed. There are benefits from operating at different levels of the end-of-life strategy hierarchy (Michelle, 2001; Henry and Gary, 2009).

Strategy of recycling was the most popular approach. Theoretically, any waste material can be recycled, but in practice the cost of processing and sorting mixed waste into different material fractions can become so prohibitive that most materials do not get salvaged from the solid waste stream that ends up in landfill. Therefore, claims of " 99 % recyclable "are meaningless unless the products are designed for optimized disassembly with minimum expenditure of time (Ayres, 1999).

The definition of end-of-life is the point in time when the product no longer satisfies the initial purchaser or first user. Others define end-of-life as the point at which the product no longer performs the intended functions due to failure (Brezet and Van, 1997).

Most communities can identify social, systems and structural shortcomings that affect the quality of their lives. These people are classified as the base of the pyramid (Vezzoli and Manzini, 2008; Vezzoli, 2010). Significantly, sustainable development does not solely on environmental issues, but broadly captures the different dimensions of development and it is a lifelong process (Fox, 1992). Sustainable development that is "development which meets the needs of the present without compromising the ability of future generation to meet their own needs"(Henry and Gary, 2009; WCED,1987).This situation is unlike the "steady-state" attainable in laboratory experiments under controlled conditions (Eckholm, 1982;Clark and Munn, 1986).The main goal is therefore to reduce environmental impacts (Henry and Gary, 2009).

The main focus of this research is Optimization of initial lifetime and of end-of-life system, seeking to develop methodologies that aid in formulating the end-of-life strategies across a wide range to find availability of environment to be sustainable, and what manner of sustainability is appropriate for the kind of practices that are to be seen in cities like Hilla.

Considerations about life cycle analysis

The first stage in the life cycle of any process is the extraction of resources from their natural reservoirs (Graedel and Allenby,1995).There is now a shift toward studies of life cycles with particular emphasis on processes thought to control the behavior of environmental components (Beanland and Duinker, 1983). In order to consider the environmental contributions of recycling in terms of raw materials, wastes and energy, a balance of the process was made. The system under study is shown in figure (1). More in specific the sensitivity of the disassembly time and cost on the selection of the end-of-life strategy must investigated (Feldmann *et al.*, 2001).

Sustainable Development strategies

After centuries of misuse of our environment, due to climate changes, misery and massive residue, sustainability is no more a possible way of life but necessary for human existence. It is also used for analyzing and managing human activities, especially as they relate to nature, resources, and development environmental protection (Beanland and Duinker, 1983; Michelle, 2001).

The challenge is to inspire and motivate public and private organizations to grow with a bigger knowledge of responsibility with the help of technology willing to improve our quality of life. Human development is about to create an environment in which people can develop their full potential and lead productive, creative lives according to their needs and interests. The idea must conduct to real problems resolution and effective changes in the systems of production and consumption, in the sense of promoting a bigger sustainability of these systems (Lewis *et al*, 2001; Sherwin, 2004). Recent answers to this challenge call for an integrated, synergistic approach that considers all phases of the facility life cycle by avoid resource depletion of energy, water, and raw materials; prevent environmental degradation caused by facilities and infrastructure throughout their life cycle; and create built environments

that are liable, comfortable, safe, and productive (Randall, 1999). An environmentally sustainable system must maintain a stable resource base, avoiding over-exploitation of renewable resource systems or environmental sink functions, and depleting non-renewable resources only to the extent that investment is made in adequate substitutes. Concern for spaceship earth, and human endeavor to minimize unidirectional exploitation of resources, is hence viewed as a mandate across the globe today (Jonathan, 2000).
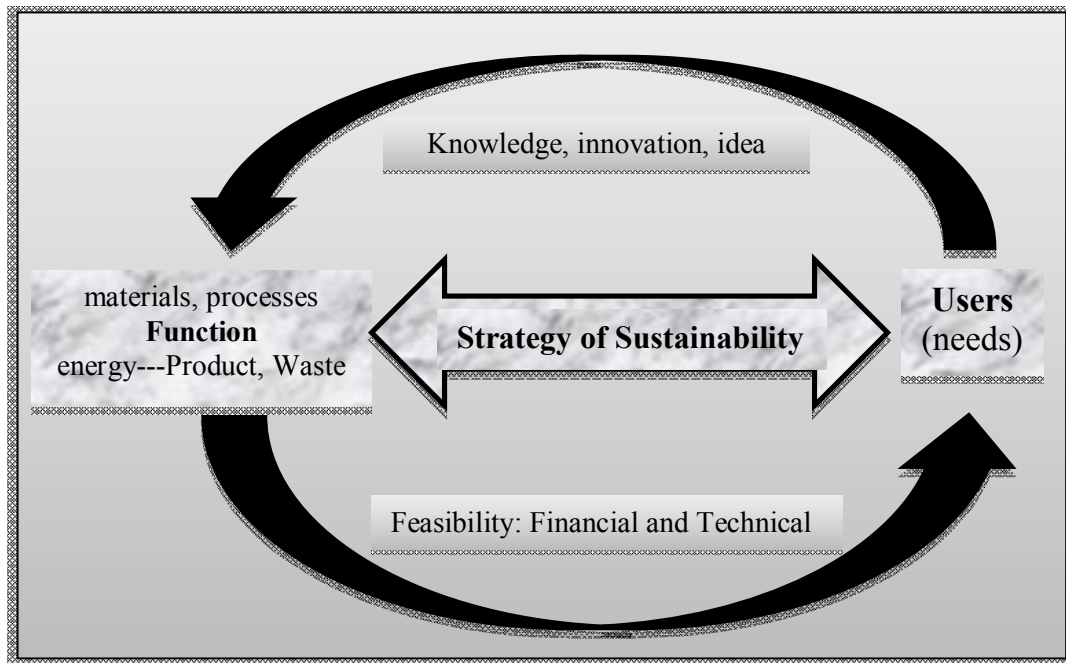
Figure(1):An overview representation of the balance associated to the dimensions of sustainability concept and end-of-life strategies, by the researcher with assistance of (Margolin and Buchanen,1995; Michelle, 2001;Masters and Gilbert, 2005 ; Henry and Gary, 2009).

Life cycle assessment and analysis

Life cycle assessment (LCA), is a broad methodology for identifying environmental burdens that arise from products through the material suppliers, through manufacture, use and disposal (SETAC 1991, EPA 1993). To make an environmental impact assessment of a given production and consumption system, it is necessary to analyze the relationship between what this system assimilates in terms of environmental resources on one hand (inputs), and on the other hand, what this system release in terms of several emissions (outputs), which can be chemical and / or physical agents, like substances, noise, odours, etc.. Phases**,** possibilities, weak points, tools**,** and assessment through stages include (Michelle, 2001) :

1. Life Cycle Inventory (LCI): the data of the studied system is collected at this step (weight, unit, material, distance, etc.). Therefore, it is built an artificial model similar to the real system studied.
2. Lifecycle Impact Assessment (LCIA): this is the step of assessment itself, in which the data collected in the previous phase is judged in relation to the impact that it causes.
 3. Life Cycle Interpretation: at this stage the results, in form of value, are interpreted for future actions to be taken.

For each input and output system, the appropriate environmental requirements to minimize the impacts and enhance the product lifecycle must be presented. The great

contradiction implicit in promoting growth based on a continually expanding scale of resource use (Daly, 1992).The process requires develop the optimal solution which balances the gains and losses in the following areas: energy usage, material usage, packaging, chemical content and end-of-life (Graedel and Allenby, 1995).

Enterprise Life

Enterprise life refers to the number of years that an activity last and may be assumed to be known or unknown. If enterprise life is unknown and is to be determined in the model, then constraints and activities must be present in the model to keep track of age of the items on hand. One of the very first steps in conducting life cycle assessment (LCA) is system boundaries identification.A binary linear programming (LP) model is proposed to identify boundary between significant and insignificant processes in a LCA study (Gupta and Hira, 1990; Michelle, 2001). Models using alternative enterprise life assumptions are given below in table (1):

Table (1): Assumption model of the Dependent decision variables and constraints for activities to maximize value of life cycle by using linear programming, by the researcher with assistance of (Wu and Coppims, 1981;   Gupta and Hira, 1990 ; Michelle, 2001; Henry and Gary, 2009).

	Recycling	Reuse without disassembly	Reuse with disassembly	Disposal	Value, Profit (C)
Time (X_1)*	a11	a21	a31	a41	C1
Finance (X_2)*	a12	a22	a32	a42	C2
Sustainability (b)	b1	b2	b3	b4	

* Linear Value as a dynamic element (Gupta and Hira, 1990; Michelle, 2001).

$$\text{Max (Z) = f}(X_i) = X_1 + X_2 \quad ……\text{Eq (1)}$$
$$\text{Subject to constraints : a11}X_1 + \text{a12 } X_2 \leq \text{ b1 } ……\text{Eq (2)}$$
$$X_1 , X_2 \geq 0$$

There are four constraints and two decision variables, these means that two of the constraints not exist or plus.

Strategic analysis of life cycle assessment in Hilla city environment

In the early 19th century, less than 10% of the population of Hilla city lived in cities (Katib, 1974). Research and Babylon statistical office (Babylon statistic, 1997), shows many of those living outside of the city Jump ahead to 2013 . By some estimates, over one-half of the world's population, and 80% of the population of the United States lives in urban areas (Vezzoli and Manzini, 2008). The intention of understanding reality, as well as of developing diverse forms of interference in environment, searching for satisfaction of needs and yearnings, has characterized the human evolution process**.** Field surveys questionnaire were used to collect the data undertaken in different inputs and outputs of whole life cycle in Hilla city. The baseline contains an environment of inventory as factual account of environmental conditions in the region at the time reported, see table (2) and figure (2) and (3).
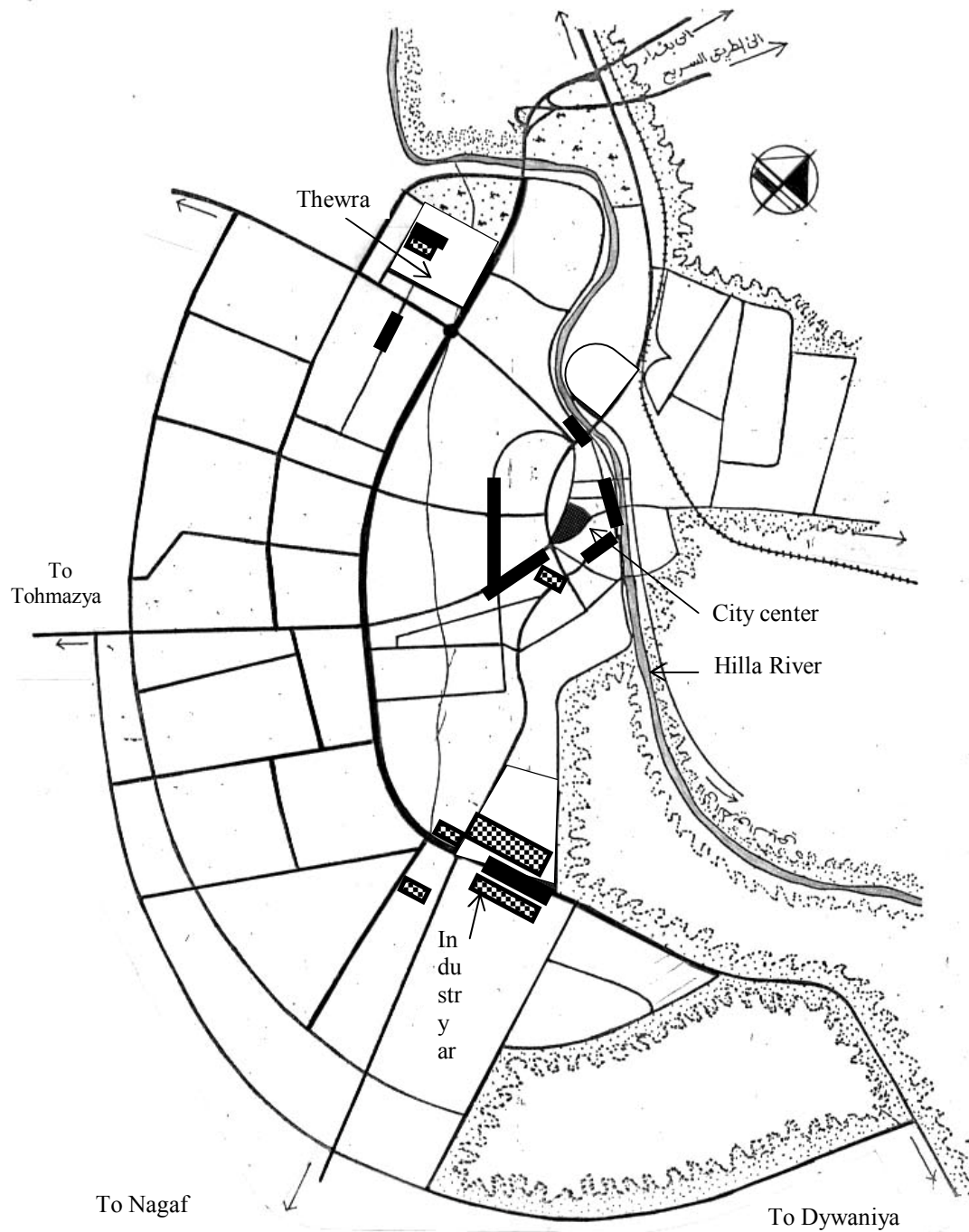
Scale - 1: 40000

Figure (2) The map of Hilla city showing utilization pattern.
by the researcher with assistance of (Babylon Physical planning, 2005)

Legend:

Residential		Commercial	▓▓	Industrial	▓▓

The research in this field is fragmented and disorganized, making it difficult for companies to find quick, simple solutions they can implement for a wide variety of interaction (Michelle, 2001).

Table (2): Frequency of end-of-life strategy from research of timeline in Hilla city, by the researcher with assistance of (Ishii *et al.* 1994; Mackenzie 1997; Nilsson 1998; Masters and Gilbert, 2005; Henry and Gary, 2009)

No	End-of-life optimization[1]	Year Frequency[3] / Percent									
		2009		2010		2011		2012		2013[2]	
1	Avoid	3	2.0	3	2.0	1	0.6	2	1.2	1	0.8
2	Reduce	18	11.7	16	10.5	17	10.8	18	11.1	14	12.3
3	Reuse	10	6.5	7	4.6	7	4.4	4	2.5	3	2.6
4	Recycle	30	19.5	31	20.3	33	20.8	37	22.8	22	19.3
5	Dispose	81	52.6	82	53.6	87	55.0	88	54.3	66	57.9
6	Continues	12	7.7	14	9.1	13	8.2	13	8.0	8	7.0
	Total	154	100	153	100	158	100	162	100	114	100

[1]Dependent variables used as input ranges are categorical and not continuous.

[2] From 1 January to end of June.

[3] For 20 selected products in industrial area.

Questionnaire items No.
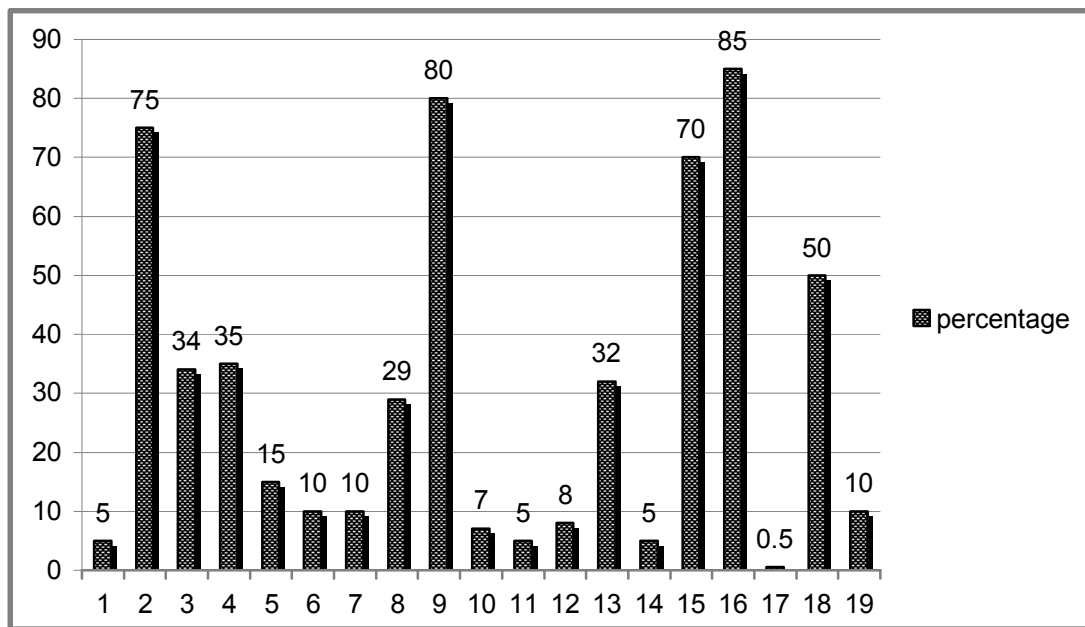
Figure (3) : Average calculation for general survey of the end-of-life optimization in Hilla city environment from 2009 to mid of 2013, pull out from Questionnaire, by the researcher.

 Aluminum example as case study for using assumption model

     By most measures, the most valuable collectable in a municipal recycling program is aluminum cans and aluminum parts (Masters and Gilbert, 2005). An attempt to quantify environmental sustainability targets, assumption model to maximize value of life cycle for aluminum was used. Formulation of linear programming model of this problem include Exploring diversities, defining priorities and making compromises for aluminum life cycle, table (3).

Table (3): Assumption model of the Dependent decision variables and constraints for Aluminum example to maximize value of life cycle by using linear programming, by the researcher.

	Recycling	Reuse without disassembly	Reuse with disassembly	Disposal	Value, Profit (C)
Time (X_1)	25	20	65	100	45
Finance (X_2)	50	10	30	25	75
Sustainability (b)	85	60	65	90	

* All numbers represent percentage value, and linear relationships.

$$\text{Max (Z)} = 45X_1 + 75X_2$$

$$\text{Subject to constraints : } 25X_1 + 50X_2 \leq 85$$
$$20X_1 + 10X_2 \leq 60$$
$$65X_1 + 30X_2 \leq 65$$
$$100X_1 + 25X_2 \leq 90$$
$$X_1 , X_2 \geq 0$$

There are four constraints and two decision variables, these means that two of the constraints not exist or plus. Solving these equations by pivoting give:
$X_1 = 2.87$, $X_2 = 0.26$ and objective function = 148.65 for the first two constraints, and $X_1 = 0.78$, $X_2 = 0.4$ and objective function = 65.1 for the second two constraints. The region of feasible solutions occurs always at corner point which can be seen at the points A (0.28 , 1.56) with *f = 129.6*. Recycling and reuse with disassembly form part of the boundary of feasible solutions. Thus, reuse without disassembly and disposal plus constraints, and can eliminate from consideration, figure (3).
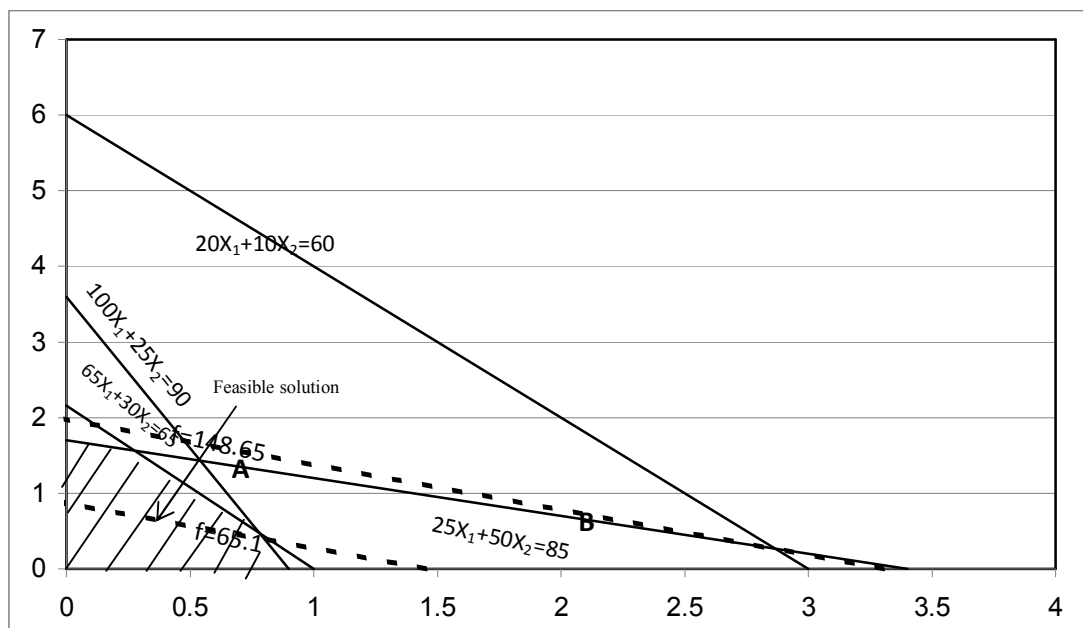
Figure (4) : G raphical interpretation of linear programing for the example formulation, explain set of feasible solution, by the researcher.

Conclusions

1. Linear relationships produced a linear programming for approach to outline boundaries that aid in formulating the end-of-life strategies across a wide range of elements.

2. Assumption model to maximize value of life cycle for aluminum example shows that reuse without disassembly constraint and disposal plus and can eliminate from consideration.

3. Data collection and result outcome pulled out from questionnaire between 2009 and mid of 2013 in Hilla city environment presented that it must develop take on future sustainability practices due to lack of decisions for sustainable optimization of initial lifetime and of end-of-life system, Lack of including sustainability at a strategic in the overall level, and there is no cradle to cradle approach.

4. Environmental requirements and sustainability strategies promoting a new image for Hilla city and Enhanced environmental protection.

5.One method to understand and interpret differences and similarities is by looking through the lens of cultural dimensions.

6. The search for the reversion in unsustainability rules requires a strong on the part of political, social, cultural and economic forces.

7. The scientific problems are equally intractable, particularly on the global scale.

 Recommendation

1. Hilla must preparing itself for radical changes to how regeneration projects and how methods of effective collaboration at community level will be encouraged.

2. Improve the quality of life and a search for innovative solutions that lead to sustainable improvements.

3. Recycling of waste streams would be 100% , and build for long useful service life.

4. The need to prepare future with the competencies to address issues beyond traditional eco- process and life-cycle models. New emphasis must be placed on finding creative solutions to social problems.

5. Develop take on future sustainability practices need a larger frame of reckoning, one in which key emerging forms of contemporary practice are included.

6. A regular feature of most projects these days are depictions of altered contexts and possible worlds. While ecodesign was a flat material discourse of the environment and when combined with life cycle thinking afforded quantitative analysis, these forms of design practice are more impenetrable to pure material reduction exercises.

7. Extending material life**,** optimization of techniques**,** end-of-life optimization, life cycle strategies periodization**,** using a morphologic matrix, and a creativity tool.

8. Culture should tends to look overall of things, and put the changes in the external environment and internal structure as priority**.**

9. reduction materials use by creativity techniques**.**

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Appendix: Questionnaire of the End-of-life Optimization for Hilla City Environment.

Questionnaire

Babylon University / College of Engineering / Department of Environment

Note 1: This Research for scientific purpose**.**

Note 2: At the start of the project, each individual was asked semi-structured questions about the ways in which they work as part of their current practice.

No. (   )   **Date**   / / 20….

Research title: A Linear Programming Approach to Motivate knowledge of Sustainability Strategies for Optimizing the End-of-life, Case Study: Hilla City Environment

Researcher name: Ahmed Talib Sahib Auda

First: General information

A. Organization Name …………………………, Field of specialization …………….

B. Date of beginning   …………………………

C. Do you have any problem in persistence: Yes   (   ) , No. (   ).

General survey (percentage)

No		
1	Organization can offer New concept development	
2	Workers can define sustainability	
3	Organizations	
4	Organization was already aware of sustainability	
5	general population is well informed about such topics	
6	What is your current thinking/understanding about sustainable achieved	
7	Decisions for sustainable achieved	
8	We have learned about environmental aspects from the other country	

Questions on overall evaluation (If yes give percentage)

9. Has your perspective changed with time: Yes (   ), No. (   ).

10. The sustainability forefront of developing new strategies: Yes (   ), No. (   ).

11. Is Sustainability identified as a concern for your customers: Yes (   ), No. (   ).

12. Do you or your company see Sustainability as a tool for Commercial advantage: Yes (   ) , No. (   ).

13. Are you succeeded in addressing 'environmental aspects' in your project: Yes (   ) , No. (   ).

14. Optimizing product End-of-life :   Yes (   ) , No. (   ).

15. Lack of including sustainability at a strategic level in the overall approach: Yes (   ) , No. (   ).

16. Lack of tool to measure holistic sustainability against indicators: Yes (   ), No. (   ).

17. Cradle to Cradle Approach: Yes (   ) , No. (   ).

18. Value chain organized appropriately: Yes (   ) , No. (   ).

19. It enables to put in evidence the critical factors of the project: Yes (   ), No. (   ).

Third: Frequency of end-of-life and timeline

1. Recycling ……………….. 2. Disposal …………………

3. Reuse without disassembly ………….. , Reuse with disassembly …………………

Four : Any necessary information or details: