The task of determining the optimal location of facilities in the regions and their parameters is formulated as follows:

$$\begin{Bmatrix} Find: X_t\,[\text{Decision variables}]^T \\ MINIMIZE\,\{COST\} \rightarrow (Eq.34) \\ s.t.:\{Eq.16 - Eq.33\} \end{Bmatrix} \qquad (37)$$

The problem is an ordinary MILP and can thus be solved using MILP techniques. The present model was developed in the commercial software GAMS [12]. The model chooses the less costly pathways from one set of biomass supply points to a specific plant and further to a set of biofuel demand points. The final result of the optimisation problem would then be a set of plants together with their corresponding biomass and biofuel demand points.

7. CASE STUDY: POTENTIAL BIOETHANOL PRODUCTION IN BULGARIA FOR 2016-2020

Two major types of biomass resources, wheat and corn for production of first generation and wheat straw and corncobs for production of second generation bioethanol are used.

Model input data

Bulgaria has 27 regions. In this case study, each region is considered to be a feedstock production region, a potential location of a biorefinery facility and a demand zone. In other words, the biofuel supply chain network consists of 27 areas for feedstock production, 27 potential biorefinery locations, 27 demand zones, 4 potential solid waste utilization zones and 3 regions for the production of petroleum fuels. For the purposes of this study, data on population, cultivated area, as well as the free cultivated area, which in principle can be used for the production of energy crops for bioethanol production are taken from (Ivanov, Stoyanov,2016). For 2016, the consumption of petroleum gasoline for transportation in the country is 572,000 tons and for the next years it is: 2017→762,000t,2018→980,000t,2019→1,220,000t 2020→1,640,000t. For the purposes of this study, it is assumed that the consumption of gasoline for each region is approximately proportional to its size.

8. DISCUSSION AND CONCLUSION

This paper studies the interactions among biofuel supply chain design, agricultural land use and local food market equilibrium. The study was focused on the eco compatible behavior of the stakeholders in the biofuel supply chain incorporating them into the supply chain design model. The model includes the problem of crop rotation and solid waste utilization. The model is believed to be important for practical application and can be used for design and management of similar supply chains.

Table 1. Flow rate of biomass from growing region to bioethanol plants (Plant-R-XX) and solid waste from Plant-R-XX to solid waste plants (SW-R-XX) for 2020.

Transport → TRACTOR							
	Energy crops	Wheat	Corn	Straw Wheat	Straw Corn	Flow path	Solid Waste
Plant-R-9	R-26 to R-9	1.00	1.00	500.72	1.00	Plant-R-9 to SW-R-26	258.24
Plant-R-8	R-12 to R-8	1.00	1.00	500.72	1.00	Plant-R-8 to SW-R-12	258.24
Plant-R-26	R-9 to R-26			500.72		Plant-R-26 to SW-R-26	258.24
	R-26 to R-26	1.00	1.00		1.00		
Plant-R-12	R-8 to R-12			364.03		Plant-R-12 to SW-R-12	258.24
	R-12 to R-12	1.00	1.00	136.68			
	R-22 to R-12				1.00		
Plant-R-27	R-4 to R-27			47.34		Plant-R-27 to SW-R-18	219.51
	R-27 to R-27			78.11			
	R-18 to R-27	1.00	1.00	298.48	1.00		
	R-2 to R-27				1.00		
Plant-R-18	R-27 to R-18	1.00		374.40		Plant-R-18 to SW-R-18	193.68
	R-22 to R-18				1.00		
	R-18 to R-18		1.00				
Plant-R-22	R-14 to R-22	1.00	1.00	393.66	38.02	Plant-R-22 to SW-R-14	258.24
	R-16 to R-22			70.04			

Table 2. Summary of computational results in case - Minimum Annualized Total Cost

Years	2016	2017	2018	2019	2020
Investment cost ($/year)$10^6$	1.862	2.793	3.531	4.462	6.248
Production cost ($/year)$10^6$	4.326	6.740	9.907	13.871	20.756
Transportation cost ($/year)$10^6$	3.165	4.457	6.086	8.317	12.854
Carbon tax levied in the work of IBSC ($/year)$10^6$	1.743	2.727	4.014	5.661	12.952
Government incentives for bioethanol production	-2.800	-4.371	-6.453	-9.079	-13.622
TOTAL COST ($/year)$10^6$	8.297	12.346	17.086	23.232	34.778
GHG emission to grow biomass	1422	1413	1978	1792	1792
GHG emission for production bioethanol and waste	64.220	100.238	147.930	208.018	312.033
GHG emission from transportation	228.289	211.298	311.615	266.253	277.120
GHG emission from biofuel usage	37.866	59.113	87.276	122.781	184.219
Total GHG emission for IBSC (kgCO2-eq./year)10^6	1752.468	1783.808	2525.148	2389.185	2565.732
Bioethanol produced from grain (ton/Year)	337	505	674	842	1179
Bioethanol produced from Straw and Maize cobs	32221	50323	74370	104730	157220
TOTAL BIOETHANOL PRODUCTION (ton/year)	32558	50828	75044	105573	158400
TOTAL GAZOLINE NEED (ton/year)	552015	730801	933938	1155199	1542775
Proportion Bioethanol/Gasoline (%)	6%	7%	8%	9%	10%
Social function Job_t $(Number\ of\ Jobs)$	200	100	90	100	200

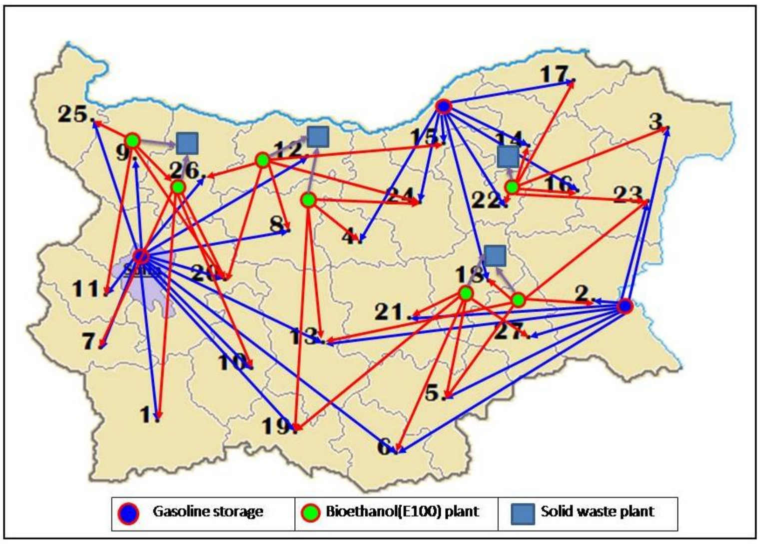

***Fig. 2**. Optimal BG IBSC configuration for 2020*

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МУЛТИПЕРИОДИЧЕН ДЕТЕРМИНИСТИЧЕН МОДЕЛ НА УСТОЙЧИВИ ИНТЕГРИРАНИ ХИБРИДНИ ВЕРИГИ ЗА ДОСТАВКА НА БИОЕТАНОЛ ОТ ПЪРВА И ВТОРА ГЕНЕРАЦИЯ ЗА СИНТЕЗ И РЕНОВАЦИЯ

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(Резюме)

В статията се предлага математичен модел на интегрирана ресурсно-осигурителна верига (РОС) която да отчита икономическите, екологичните и социалните аспекти на устойчивостта. За проектиране на оптимална РОС се предлага модел на смесено линейно програмиране. Производството на биоетанол от възобновяема биомаса е предмет на засилен интерес с оглед намаляване на зависимостта на България от вноса на петрол и намаляване на въглеродните емисии. Ефективността на разходите и опазването на околната среда водят до значителни проблеми, които възпрепятстват увеличеното производство на биоетанол от възобновяема биомаса. Моделът разглежда ключовите дейности по захранващата верига, включително прибирането / преработката и транспортирането на биомаса. Моделът взема пред вид разходите за доставка на суровината, потреблението на енергия и емисиите на парникови газове като критерии за ефективност на системата. Полезността на симулационния модел на захранващата верига се демонстрира чрез разглеждането на захранващата верига за биомаса в съоръжение за биогорива в български мащаб. Резултатите показват, че моделът е полезен инструмент за управление на захранващата верига, включително избор на оптимално местоположение на съоръжението за биоетанол, логистичен дизайн, управление на инвентара и обмен на информация.