# REVIEW

by **Corresponding Member Lyubka Doukovska, DSc**
from the Institute of Information and Communication Technologies,
at the Bulgarian Academy of Sciences,
on the Thesis for awarding educational and scientific degree **PhD**,
under the Scientific Field: **4. Natural Sciences, Mathematics and Informatics,**
the Professional Area: **4.6. Informatics and Computer Sciences,**
the Scientific Specialty: **Informatics**

Author of the PhD Thesis: **Eng. Danail Dichev Stratiev**

PhD Thesis Title: **Modelling of oil refining processes using generalized nets and intercriteria analysis**

In accordance with Order No. 925 from 21.11.2025 of the Director of the Institute of Biophysics and Biomedical Engineering at the Bulgarian Academy of Sciences, I have been appointed as a member of the Scientific Jury regarding the PhD thesis of **eng. Danail Dichev Stratiev** for awarding the educational and scientific degree "Doctor of Philosophy" (PhD) in the Scientific Field **4. Natural Sciences, Mathematics and Informatics**, the Professional Area **4.6. Informatics and Computer Sciences**, the Scientific Specialty **Informatics**. The scientific advisors are Acad. Krassimir Atanassov, DSc and Acad. Konstantin Hadjiivanov, DSc.

As a member of the Scientific Jury I have received:

1. Order No. 925 from 21.11.2025 of the Director of the Institute of Biophysics and Biomedical Engineering;

2. Application for opening a procedure for acquiring the educational and scientific degree PhD;

3. European Curriculum Vitae;

4. Diplom of Master's degree;

5. Protocols and certificates of passed exams according to the individual study plan of the PhD student;

6. List of the publications included in the PhD thesis;

7. Copies of the publications included in the PhD thesis;

8. List of the citations on the publications included in the PhD thesis;

9. Abstract of the PhD Thesis;

10. Dissertation for the educational and scientific degree PhD.

In order to form the final evaluation of the dissertation, the requirements of the *Development of Academic Staff Act in the Republic of Bulgaria* are implemented the specific requirements in the Act's Institutional Regulation shall be taken into consideration, where the respective norms are:

1. Pursuant to Art. 6 (3) of the *Development of Academic Staff Act in the Republic of Bulgaria*, PhD thesis should contain scientific or scientific-applied results, which represent an original contribution in science. The PhD thesis must indicate that the candidate has in-depth theoretical knowledge of the relevant specialty and ability for independent research.

2. According to Art. 27 (2) of the specific requirements in the Act's Institutional Regulation, PhD thesis should be presented in a form and volume corresponding to the specific requirements of the primary unit. The PhD thesis should contain: a cover page; content; introduction; exhibition; conclusion - a summary of the results obtained with a declaration of originality; bibliography.

**I. Actuality and significance of the PhD thesis.**

The relevance and significance of the PhD thesis are determined by the field of the presented research, namely Artificial Intelligence. Artificial Intelligence is a discipline concerned with the concepts, methods, and tools for creating intelligent models for analysis, and its pervasive adoption and the considerable expansion of its application domains are widely observed.

The PhD thesis submitted for review focuses on the application of generalized networks and intercriteria analysis for modeling the processes involved in petroleum product manufacturing within an oil refinery. This represents a highly topical

interdisciplinary research area that requires expertise in industrial chemistry, specifically petroleum refining, as well as in the economic aspects accompanying production. The study utilizes real operational data from the LUKOIL Neftohim Burgas JSC, which demonstrates a high degree of originality and practical applicability of the obtained results.

The aim of the PhD thesis is „to study the modeling of the production processes of all petroleum products in a modern oil refinery using generalized nets and selection of the crude oil using inter-criteria analysis".

To achieve the goal, the following tasks are defined:

1. To model the production process of different brands of automotive gasoline in an oil refinery using generalized nets.

2. To model the production process of different brands of diesel engine fuels in an oil refinery using generalized nets.

3. To model the production process of different gas fuels, propylene and polypropylene in an oil refinery using generalized nets.

4. To model the production process of different brands of heavy fuel oils and road bitumens in an oil refinery using generalized nets.

5. To model the overall process of transforming crude oil in an oil refinery into final commodity products using generalized nets.

6. To study the relationships between the bulk properties and properties of the fractions of a large number of crude ois and the degree of similarity between them by applying intercriteria analysis.

7. To model the crude oil selection process using intercriteria analysis and the generalized net toolkit.

I find that the stated objective and formulated tasks reflect both the relevance and importance of the presented PhD thesis, as well as the potential for practical implementation of the results.

**II. Summary of the PhD thesis.**

The PhD thesis comprises 150 pages and includes: a list of abbreviations and symbols, an introduction, six chapters, a conclusion summarizing the obtained results, a section outlining the contributions of the dissertation, a declaration of originality of the

results, a bibliography with 239 sources, a list of publications related to the dissertation, and a list of observed citations.

The introduction presents the essence of petroleum refining and the necessity of mathematical modeling of the processes involved in converting crude oil into final petroleum products, aiming to enhance the overall efficiency of the refinery. The research objective is formulated, and the main scientific tasks to be pursued in order to achieve this objective are described.

Chapter One, "Literature Review," traces the progress in the scientific domain and the motivation for the dissertation research. It defines fundamental concepts for the study, such as Petri Nets (PN), Generalized Nets (GN), and mentions Intercriteria Analysis (ICA).

Chapter Two, "Modeling of the Automotive Gasoline Production Process Using Generalized Nets," presents results obtained through the application of GN for modeling the production of various gasoline types (A-95N; A-95 B-9; A-98N; A-98N B-9), based on real data from the LUKOIL Neftohim Burgas JSC. The chapter examines processes occurring in parallel, yielding different gasoline components such as: reformate, hydrotreated gasoline from catalytic cracking, methyl tert-butyl ether, alkylate, hydrotreated straight-run gasoline, C5 fraction, isobutane, as well as other components like bioethanol and imported nine-component methyl tert-butyl ether, which are purchased from the market depending on demand and specifications of the ordered gasoline types. A generalized net model of automotive gasoline production at the LUKOIL Neftohim Burgas JSC is presented and simulated in the GN IDE environment.

Chapter Three, "Modeling of the Diesel Fuel Production Process Using Generalized Nets," analyzes refining processes such as hydrotreating of primary and secondary light and heavy middle distillates, along with the incorporation of imported biodiesel, cetane improvers, lubricity and antistatic additives. These processes occur in parallel, supplying components for the production of five types of automotive diesel fuels at the LUKOIL Neftohim Burgas JSC. The constructed generalized net model comprises 19 transitions, 58 places, and 7 tokens, representing the seven brands of diesel fuels produced at the refinery.

Chapter Four, "Modeling of the Production Process of Fuel Gas, LPG, Propylene, and Polypropylene Using Generalized Nets," investigates the production of gaseous products in an oil refinery, such as fuel gas, liquefied petroleum gas (propane-butane),

and propylene, which can either be exported as finished products or used as feedstock for polypropylene production at the LUKOIL Neftohim Burgas JSC. The developed generalized net model includes 17 transitions, 55 places, and 47 tokens.

Chapter Five, "Generalized Net Model of Heavy Oil Production in an Oil Refinery," presents the modeling of the production process for heavy petroleum products, which are residual oil fractions remaining after the atmospheric distillation of crude oil. These fractions are processed at the LUKOIL Neftohim Burgas JSC to extract additional quantities of light petroleum products and to produce secondary heavy petroleum products such as boiler fuel, marine fuels, and bitumen for road paving. The generalized net model consists of 8 transitions, 35 places, and 8 tokens.

Chapter Six, "Generalized Net Model of Processes in an Oil Refinery," analyzes the processes occurring during the production of petroleum products at the LUKOIL Neftohim Burgas JSC. All straight-run distillate fractions from crude oil feedstock are simultaneously processed through upgrading and conversion operations. In addition to straight-run fractions, distillate fractions obtained from conversion processes, such as hydroprocessing of feedstock for catalytic cracking, fluid catalytic cracking, and hydrocracking of vacuum residue (H-Oil) are further upgraded or converted through hydrotreating and cracking processes. These processes are inherently parallel, and it is demonstrated that the apparatus of generalized nets can be employed to optimize them, leading to improved process management. The constructed generalized net model comprises 23 transitions and 90 places.

This chapter also applies Intercriteria Analysis (ICA) to evaluate 244 crude oils across 151 criteria. The aim of this study is to analyze the results obtained from ICA in exploring the relationships between the general physicochemical properties of crude oil and the properties of 244 crude oil fractions, and to determine the degree of similarity among these types of oil. The process of crude oil selection is also presented, with the goal of optimizing refinery operations. The objective of this research is to develop a generalized net model for the crude oil selection process in an oil refinery. The resulting generalized net model includes 7 transitions, 18 places, and 15 tokens.

In the conclusion, a summary of the obtained results is presented, which are summarized into seven conclusions.

The cited sources are sufficiently diverse and for the most part they are written by foreign authors. The presence of Bulgarian authors in the literature used also makes a good impression.

**III. Evaluation of the PhD thesis's contributions.**

During the achievement of the main goal and solving the tasks related to it, the following main results were obtained, and in summary:

1. For the first time, a GN model has been developed for the production of automotive gasolines in a modern oil refinery.

2. For the first time, a GN model has been developed for the production of automotive diesel fuels in a modern oil refinery.

3. For the first time, a GN model has been developed for the production of gas products (fuel gas, propane-butane, propylene) and polypropylene in a modern oil refinery.

4. For the first time, a GN model has been developed for the production of all oil products in a modern oil refinery.

5. A GN model of the crude oil selection process in an oil refinery has been developed, which includes an inter-criteria analysis, allowing the selection of a suitable crude oil to be carried out by applying this GN model and using historical information on the processing of different types of crude oil in a modern oil refinery.

I accept that the contributions so formulated could be considered to have scientific and common application. This separation would allow detailing the results obtained in accordance with the specificity of their significance.

**IV. Assessment of the submitted publications.**

The presented list of publications on the PhD thesis includes eight papers. Seven of the publications are co-authored. Four publications are in the journal "Mathematics" of MDPI with IF, one publication in the Springer series "Lecture Notes in Networks and Systems" with SJR, one paper at the International Scientific Conference "Education, Science, Economics and Technology", one paper in the proceedings of the Twenty Third International Workshop on Intuitionistic Fuzzy Sets and Generalized Nets - WIFSGN'2025 and one publication accepted for publication in the journal "Comptes

rendus de l'Academie bulgare des Sciences" of the Bulgarian Academy of Sciences with IF.

The published results are original and I am not aware of any legally proven plagiarism in scientific works. A list of 10 citations for the dissertation work is also presented.

The data presented in this way give me reason to conclude that the research has been given the necessary publicity among the scientific community.

**V. Evaluation of the PhD abstract.**

The PhD abstract is consisting of 81 pages. It reflects the essence and content of the dissertation, including the purpose, subject, object and tasks of dissertation research and the ways of their realization.

**VI. Remarks and recommendations.**

In order to form the final evaluation of the PhD thesis, the requirements of the *Development of Academic Staff Act in the Republic of Bulgaria* and its Implementation Rules are to be taken into account, according to which I have the following remarks and recommendations:

1. Style errors are noted in the text of the PhD thesis.
2. The number of points in the report for fulfilling the requirements of the Institute of Biophysics and Biomedical Engineering at the Bulgarian Academy of Sciences for awarding educational and scientific degree PhD is underestimated.
3. The PhD student should direct his efforts to increase his contributions to reputable international publications.

**VII. Conclusion.**

I accept that the requirements of the *Development of Academic Staff Act in the Republic of Bulgaria* and the specific requirements in the Act's Institutional Regulations for its implementation, the Rules for the conditions and the order for acquiring academic degrees and for the occupation of academic positions in the Bulgarian Academy of Sciences (BAS) and the Rules for the specific conditions for acquisition of academic degrees and occupation of academic positions at the Institute of Biophysics and Biomedical Engineering - BAS are accomplished.

After my introduction to the PhD thesis and its publications, an analysis of their significance and the contributions they make, I give my positive assessment and I recommend to the Honorable Jury to award the educational and scientific degree "Doctor of Philosophy" (PhD) to **eng. Danail Dichev Stratiev** in the Scientific Field **4. Natural Sciences, Mathematics and Informatics**, the Professional Area **4.6. Informatics and Computer Sciences**, the Scientific Specialty **Informatics**.

16.01.2026
Sofia

Signature: ..... .....
/Corr. Member Lyubka Doukovska/