University POLITEHNICA of Bucharest
FACULTY OF POWER ENGINEERING
Workshop On Innovative Techniques, Diversity and Connectivity Program, 2020

Semion Peleskov
Ana-Maria-Ruxandra Reșcanu
Scientific coordinator:
Lect. Dr. Mihai Rebenciuc

The Role Of Wind Farms In Estimating Energy Demand In A Microgrid

CONTENTS

Introduction in Micro Grid

It is a node of a Smart Grid

Advantages:

- Intelligent algorithms of:
    * production;
    * storage;
    * redistribution.
- Easy to mount
- Autonomous

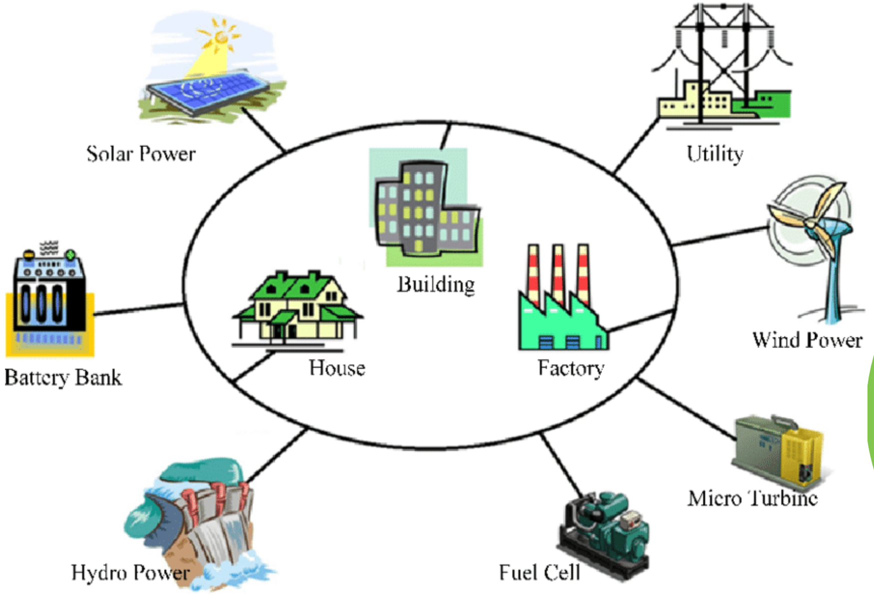


Fig. 1. Micro Grid

MIMICRY IN PROGRAMMING

01 GA

Base of evolutionary algorithms

02 GP

Tree-type structure

03 GE

Arbitrary languages

GRAMMATICAL EVOLUTION

Population's life cycle:

1. Selection
2. Crossover
3. Mutation
4. Reproduction

RULE = c mod r

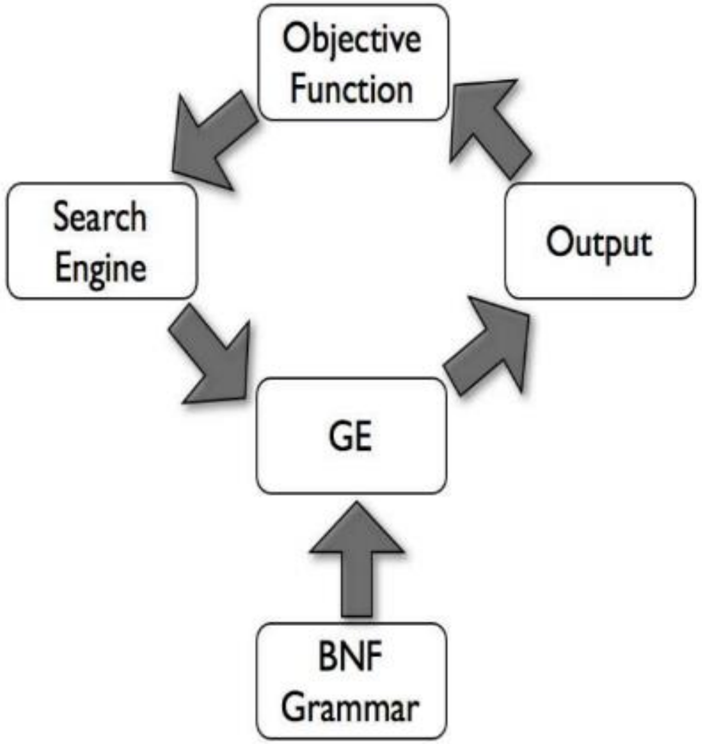


Fig. 3. Modularity of GE

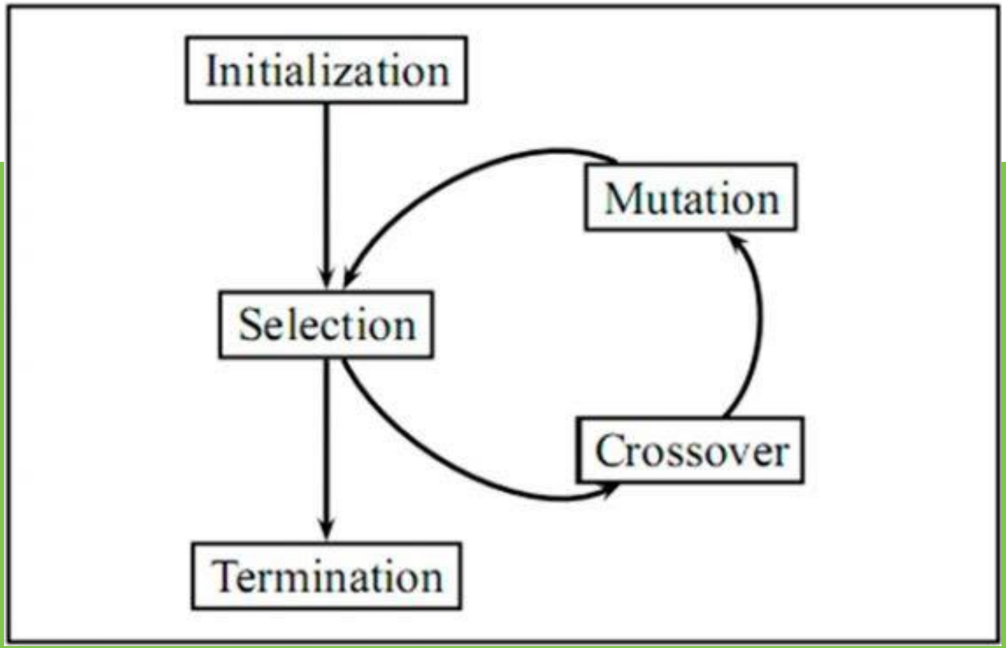


Fig. 2. Life cycle of population

```
G = {N, T, P, S}
N = {<expr>, <biop>, <uop>, <bool>}
T = {and, or, xor, nand, not, true, false, (, )}
S = {<expr>}
```

Fig. 4. Example of grammar

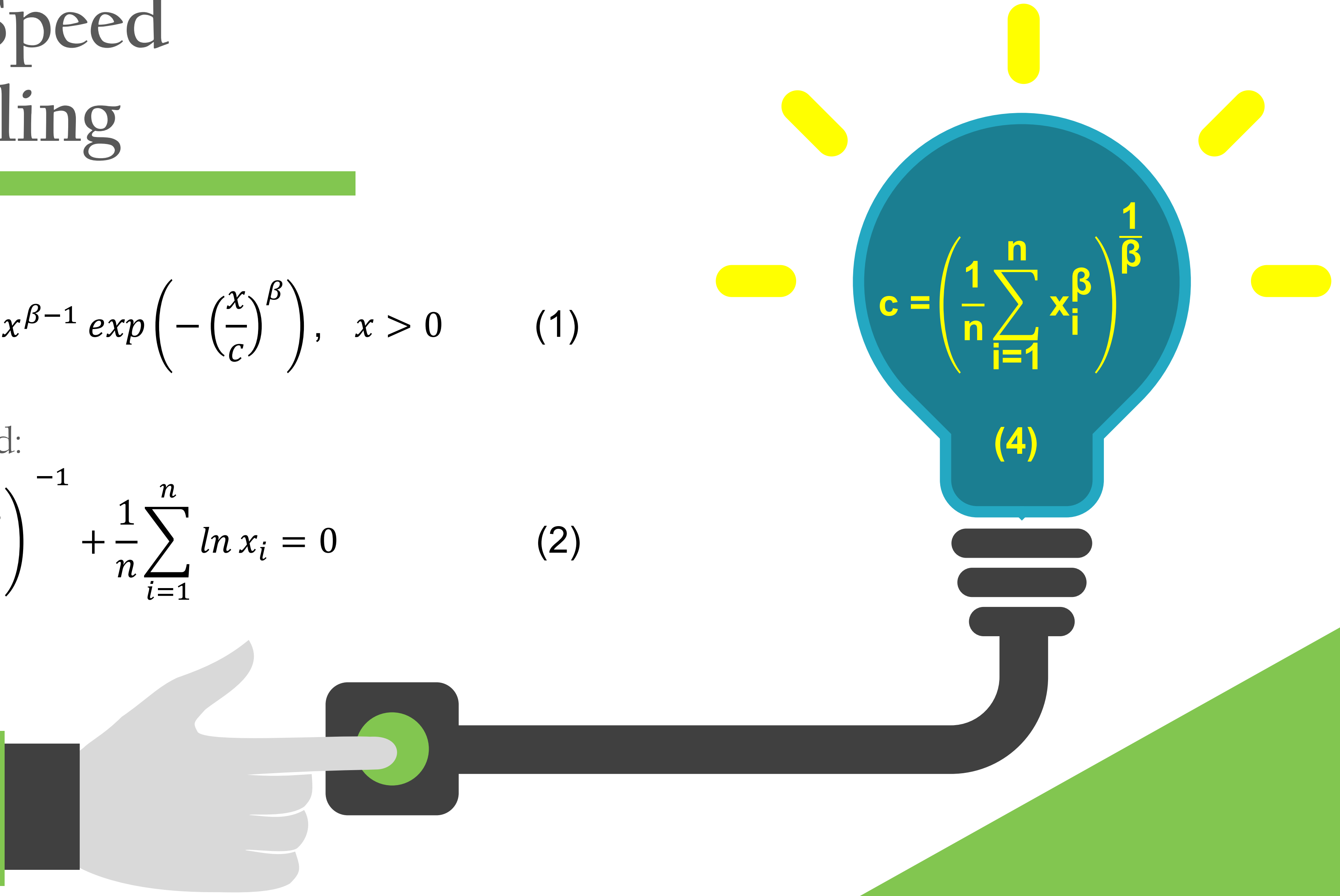
Wind Speed Modeling

Probability density:

$$X(\beta, c) = f(x) = \frac{\beta}{c^{\beta}}\, x^{\beta-1}\, exp\left(-\left(\frac{x}{c}\right)^{\beta}\right), \quad x > 0 \qquad (1)$$

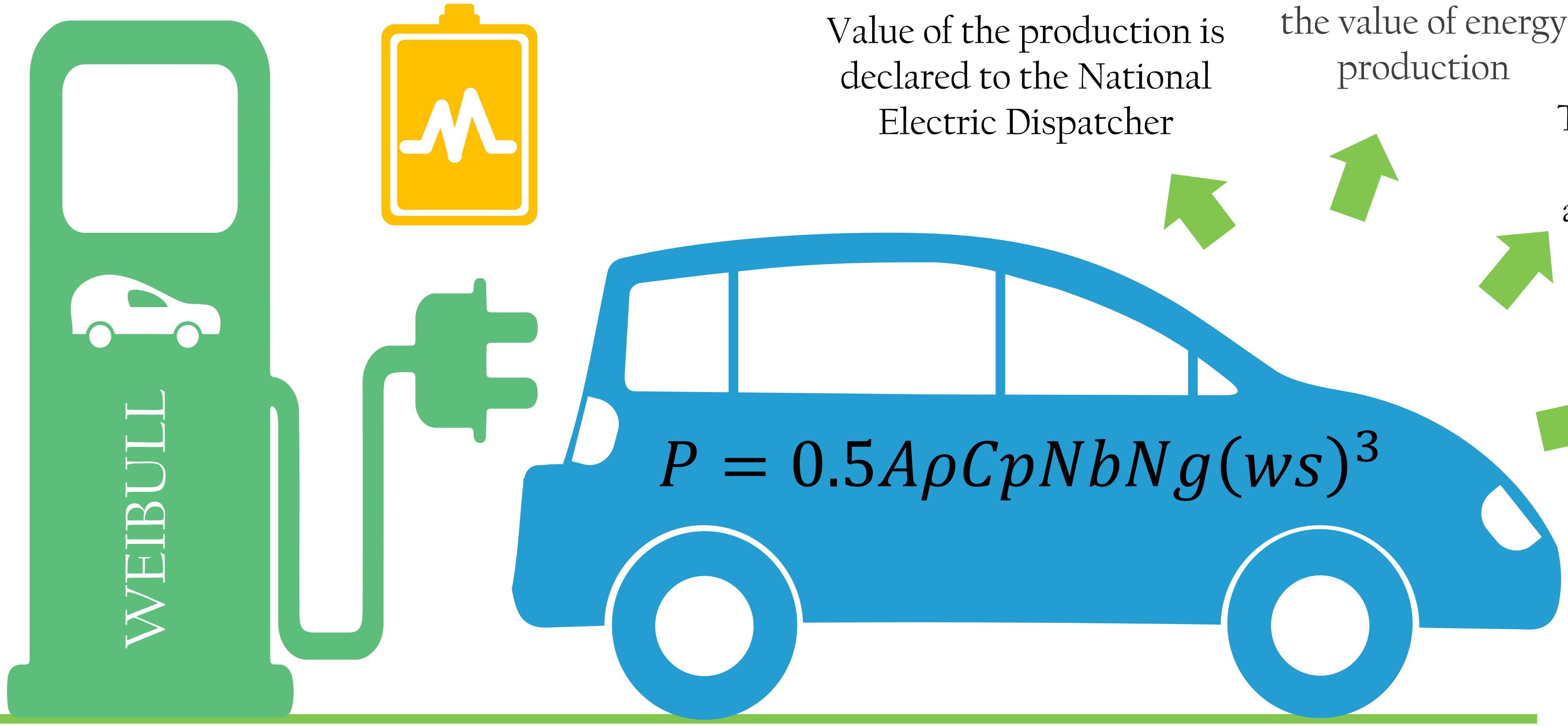
Maximum Likelihood method:

$$\frac{1}{\beta} - \left(\sum_{i=1}^{n} x_i^{\beta}\, ln\, x_i\right)\left(\sum_{i=1}^{n} x_i^{\beta}\right)^{-1} + \frac{1}{n}\sum_{i=1}^{n} ln\, x_i = 0 \qquad (2)$$



Weibull Distribution

ANALYTICAL EQUATION OF WIND ENERGY PRODUCTION



$$P = 0.5A\rho CpNbNg(ws)^3$$

Value of the production is declared to the National Electric Dispatcher

The formula calculates the value of energy production

The dispatcher regulates energy production according to its demand

Wind power plants have a role in estimating energy demand

Table 1 Wind Speed Timișoara

Wind Speed	Time
5.14	00:00
3.09	06:00
3.09	12:00
2.06	18:00

Table 2 Wind Speed Gorbănesti

Wind Speed	Time
0.00	00:00
1.03	06:00
2.06	12:00
2.06	18:00

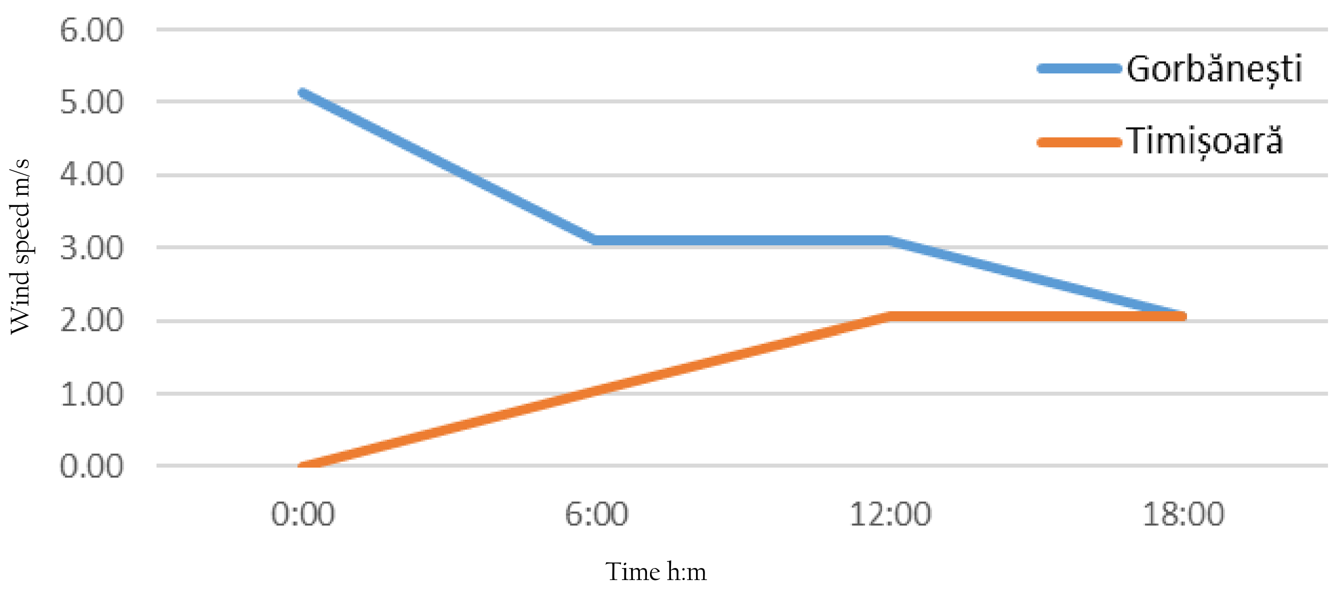


Fig. 5. Variation of wind speed in time

CASE STUDY

- Gorbănești commune from Botoșani county :
  - Continental-temperate climate;
  - Extremely continental influences.

- The city of Timișoară :
  - Moderate-temperate-continental climate;
  - Sub-Mediterranean influences.

Wind speed measured on: 5.05.2020

```python
import numpy as np

def scale_param(ws, time, beta):
    for i in range(len(ws)):
        print(f"Wind speed: {ws[i]}, Recorded: {time[i]}")
    for i in range(len(beta)):
        summ = 0
        shape_param = beta[i]
        print(f"\nShape parameter (beta) = {round(shape_param, 2)}")
        for j in range(len(ws)):
            xjpowerk = ws[j] ** shape_param
            summ += xjpowerk
        c = (1/len(ws) * summ) ** (1/shape_param)
        c = str(c)[:6]
        print(f"Scale parameter (c) = {c}")

ws = [5.14, 3.09, 3.09, 2.06]
time = ["00:00", "06:00", "12:00", "18:00"]
print("Data: 5 May, 2020:")
beta = np.arange(1.5, 3.01, 0.01)
scale_param(ws, time, beta)
```

```
D:\S3N1CH\Soft\Python\python.exe "E:
Data: 5 May, 2020:
Wind speed: 5.14, Recorded: 00:00
Wind speed: 3.09, Recorded: 06:00
Wind speed: 3.09, Recorded: 12:00
Wind speed: 2.06, Recorded: 18:00

Shape parameter (beta) = 1.5
Scale parameter (c) = 3.4357

Shape parameter (beta) = 1.51
Scale parameter (c) = 3.4375

Shape parameter (beta) = 1.52
Scale parameter (c) = 3.4393

Shape parameter (beta) = 1.53
Scale parameter (c) = 3.4411

Shape parameter (beta) = 1.54
Scale parameter (c) = 3.4430
```

Fig. 6. The code block for determining the scale parameter

Weibull Distribution Parameters

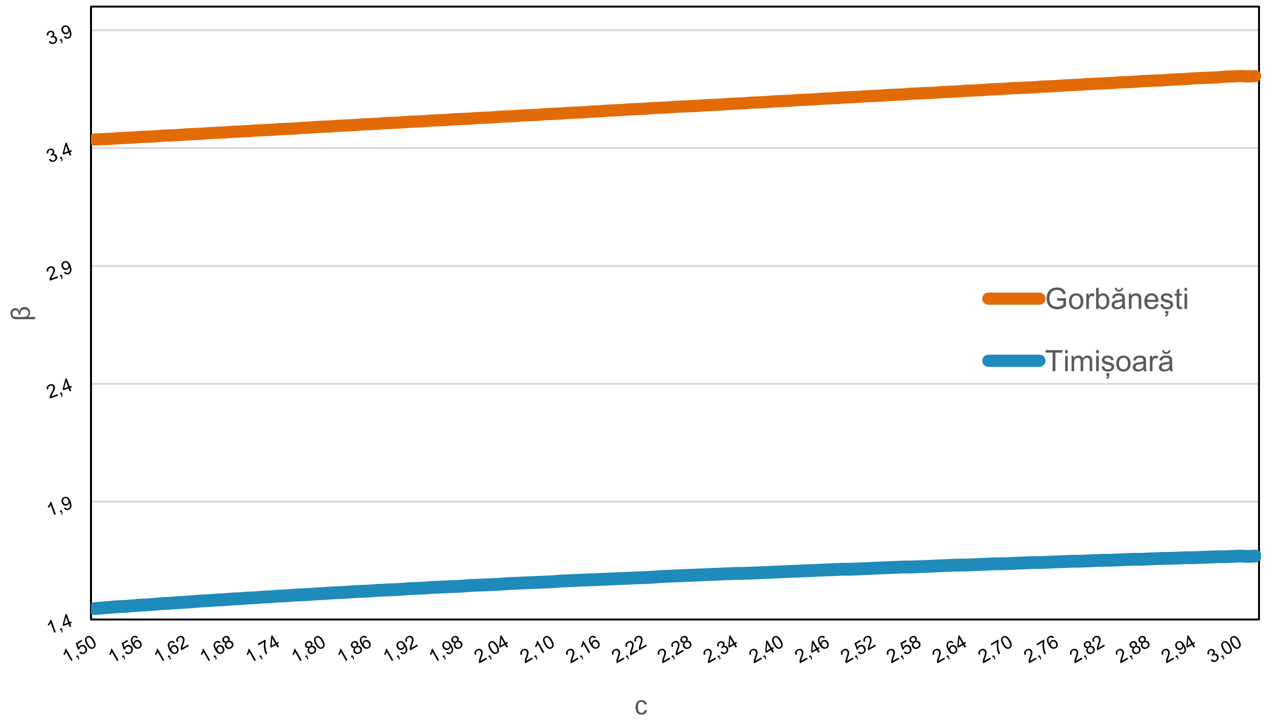


Fig. 7 Dependence of the scale parameter on the shape parameter

β Shape parameter:

- Big values → stable wind;
- Small values → unstable wind.

c Scale parameter:

- Big values → high wind speed;
- Small values → low wind speed

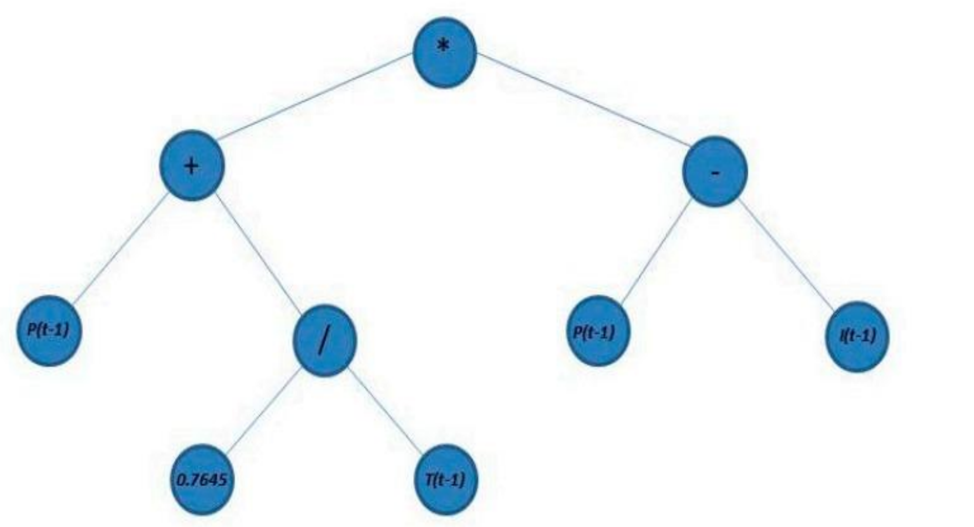
“c” can be determined in the form of a code block

Scale parameter estimation with GE

```
<c> ::= "c = c(t) = " <c_expression>
<operator> ::= "+" | "-" | "*" | "/" | "^"
<character> ::= "I" | "T" | "P"
<integer> ::= [0-9]
             | <integer> <integer>
<float> ::= "0." <integer>
<number> ::= <integer> | <float>
<function> ::= <number> "*" <function>
              | <character> "(t-1)"
              | <character> "^" <number> "(t-1)"
<monomial> ::= "(" <monomial> <operator> <monomial> ")"
              | <function>
<c_expression> ::= <monomial> <operator> <monomial>

```

Fig. 9. Code block of a grammar (BNF)



Prefix notation: (* (+ $P(t\text{-}1)$ (/ 0.76454 $T(t\text{-}1)$)) (- $P(t\text{-}1)$ $I(t\text{-}1)$))

Model: $\lambda(t) = P^2(t-1) + \frac{0.7654P(t-1)}{T(t-1)} - P(t-1)I(t-1) - \frac{0.7654I(t-1)}{T(t-1)}$

Fig. 8. Logic tree-scheme of GP

Example of output:

1) $c = c(t) = 3I(t-1) \cdot \left(\left(I^{0{,}6}(t-1) - T(t-1)\right) - I^5(t-1)\right)$

2) $c = c(t) = P(t-1) + \frac{3.456I(t-1)}{P(t-1)}$

3) $c = c(t) = \frac{I^{T(t-1)}(t-1)}{P^{2.356}(t-1)}$

CONCLUSIONS

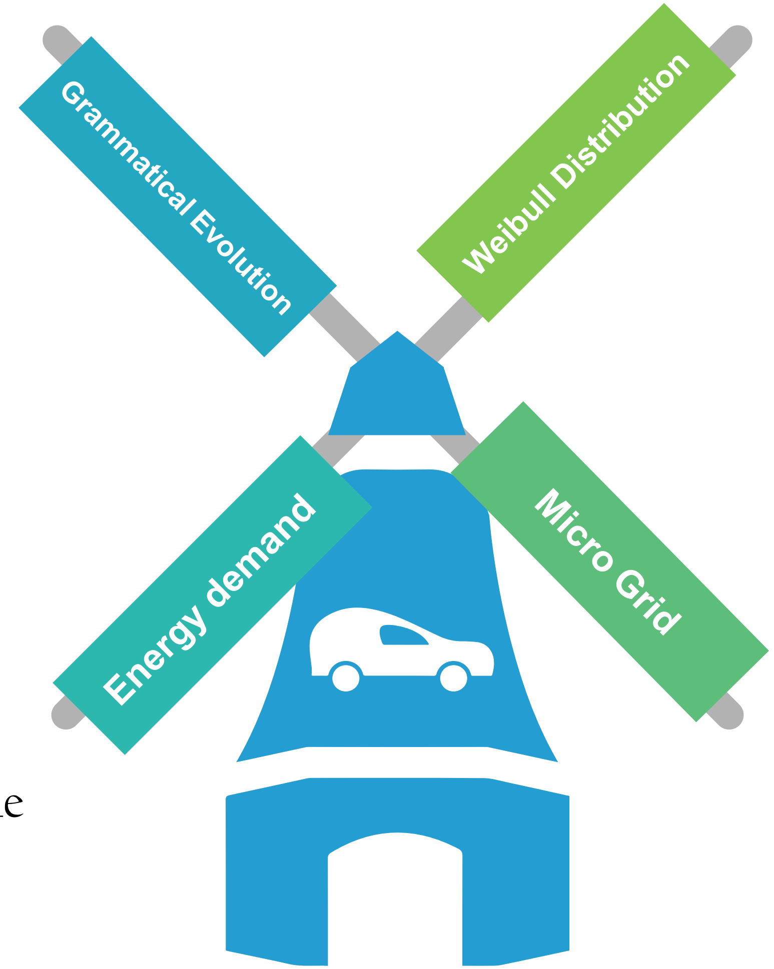
Analytical Equation Of Wind Energy Production

$$P = 0.5A\rho CpNbNg(ws)^3$$

P – engine power (Watt);
A - rotor surface exposed to wind (m/s);
ρ – air density;
ws – wind speed;
Cp – performance coefficent;
Ng – generator efficiency;
Nb - bearing efficiency.

Grammatical Evolution

GP associated with a grammar based on the Weibull distribution returns the most appropriate values.



Wind Farms Role

Necessity in estimating energy demand;
Reducing emissions of pollutants;
Electrification of rural areas;

Inconveniences :

Requires wind speed distribution modeling;
Energy production must be estimated;
Possibility of accidents in NES

Micro Grid

- Autonomy
- Application of intelligent algorithms
- Integration of renewable energy into Smart City
- Electrification of rural areas

Thank you for your attention!