PROBABILITY AND STATISTICS

CASE STUDY

ON

STUDY OF ANNUAL ELECTRICITY CONSUMPTION THEORETICAL AND PRACTICAL EXAMINATION

BY

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UNDER THE GUIDENCE OF

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SUBMITTED TO

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Question: Test whether the electric consumption is same throughout year.

Collect the monthly electricity bills of a household for the past one year. (List both bill amount and the number of units consumed every month)

■ Use Chi-Square test to determine whether the electricity consumed is same every month

■ Also, Construct a linear relationship between the electricity bill and the no. of units consumed every month

Here is the collection of monthly electricity bills of a household for the past one year both bill amount and the number of units.

MONTH'S SERIAL NUMBERS	BILL AMOUNT (PER MONTH)	NUMBER OF UNITS (PER MONTH)
1	193	51
2	82	221
3	502	95
4	666	65
5	2471	379
6	1567	226
7	1696	293
8	2766	376
9	846	72
10	860	137
11	572	40
12	208	45

CHI-SQUARE TEST BETWEEN BILL AMOUNT AND THE UNITS CONSUMED PER MONTH

Let O_i be Bill Amount Per Month and E_i be Expected frequencies of given O_i's

O_i	Ei	Oi-Ei	$(Oi-Ei)^2$	$\frac{(Oi-Ei)^2}{Ei}$
51	166.67	-115.67	13379.54	80.27
221	166.67	54.33	2951.74	17.71
95	166.67	-71.67	3136.58	30.81
65	166.67	-101.67	10336.78	62.01
379	166.67	212.33	45084	270.49
226	166.67	59.33	3520.04	21.11
293	166.67	126.33	15959.26	95.75
376	166.67	209.33	43819.04	262.90
72	166.67	-94.67	8962.40	53.77
137	166.67	-29.67	880.30	5.28
40	166.67	-126.67	16045.28	96.26
45	166.67	-121.07	14803.58	88.8

X^2=1085.

CHI-SQUARE TEST:

If set of events $A_1, A_2, .., A_n$ are Observed to occur with Frequencies $O_1, O_2, .., O_n$ respectively and $A_1, A_2, .., A_n$ are expected to occur with Frequencies $E_1, E_2, .., E_n$

The Test Statistics under X^2 Distribution is,

$$X^2 = \sum_{i=1}^{n} \left(\frac{(Oi - Ei)2}{Ei} \right)$$

O_i=Observed E_i =

Expected

$\bar{O}_i$ are given as,

E_i=mean of Oi =

$(O_1 + O_2 + .. + O_n)$

n

Given Oi's=observed frequency

=51,221,…….,45.

Ei's= expected frequency

$$= \frac{51+221+\cdots+45}{12}$$

$$= \frac{2000}{12}$$

= 166.67

1.NULL HYPOTHESIS:

H0: μ1= μ2

i.e; there is same electricity consumption every month

2.ALTERNATIVE HYPOTHESIS:

H1: μ1≠ μ2

i.e,There is different electricity consumption every month

3.level of significance $(\alpha = 0.05)$

4.Test statistics:

According to chi-square Test,

$$\sum_{i=1}^{12} \left(\frac{(Oi-Ei)2}{Ei} \right)$$

n= no of pairs = 12

Degree of freedom:

Dof = v = n-1

12-1 =11

Tabulated x^2 values :

At degree of freedom(dof),

V=n-1 & α=0.05 is , $x_\alpha^2 = x_{0.05}^2$

With dof , v=12-1=11 => 19.675

Clearly, $|x^2| \not\leq x_\alpha^2$

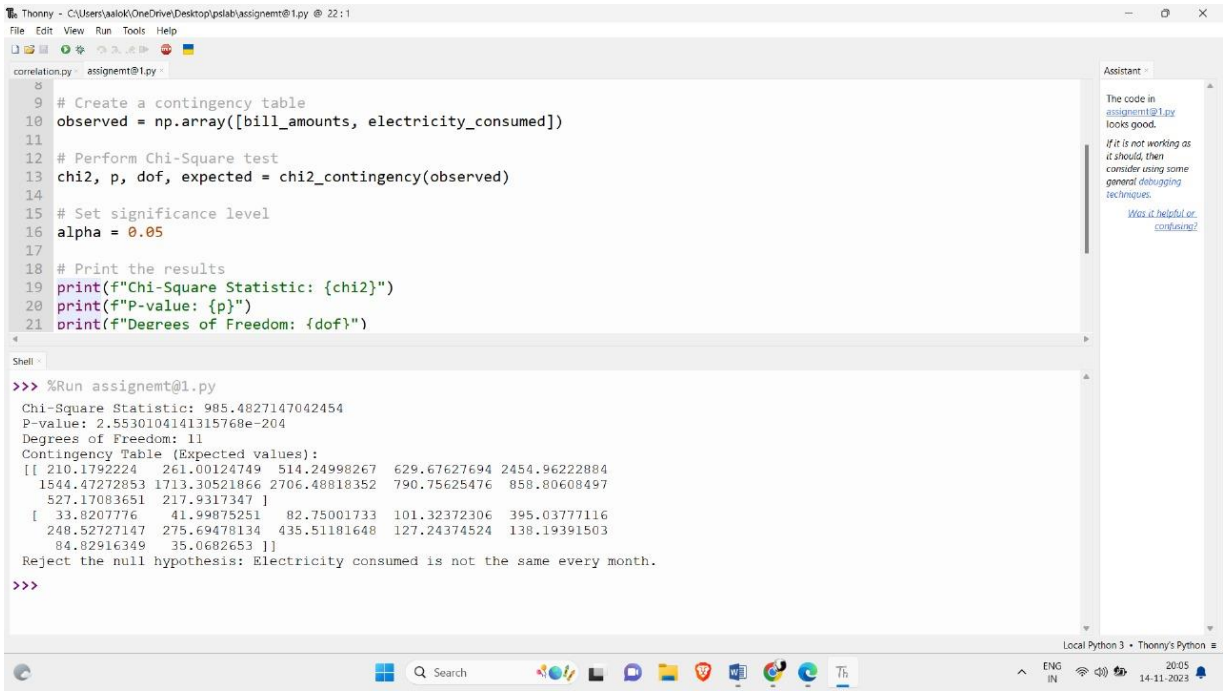
H0 is not accepted i.e, the elect

CODE:

```
import numpy as np

from scipy.stats import chi2_contingency

# Sample data: bill amounts and electricity consumed for 12 months

# Replace this with your actual dataset

bill_amounts = [193, 82, 502, 666, 2471, 1567, 1696, 2766, 846, 860, 572, 208]

electricity_consumed = [51, 221,95,65,379, 226, 293, 376, 72, 137,40, 45]


# Create a contingency table

observed = np.array([bill_amounts, electricity_consumed])


# Perform Chi-Square test

chi2, p, dof, expected = chi2_contingency(observed)


# Set significance level

alpha = 0.05


# Print the results

print(f"Chi-Square Statistic: {chi2}")

print(f"P-value: {p}")

print(f"Degrees of Freedom: {dof}")

print("Contingency Table (Expected values):")
```

```
print(expected)


# Interpret the results
if p < alpha:
    print("Reject the null hypothesis: Electricity consumed is not the same every month.")
else:
    print("Fail to reject the null hypothesis: There is no evidence to suggest that electricity consumed varies monthly.")
```

OUTPUT:


Thonny - C:\Users\aalok\OneDrive\Desktop\pslab\assignemt@1.py @ 22 : 1
File Edit View Run Tools Help
correlation.py
assignemt@1.py
# Create a contingency table
observed = np.array([bill_amounts, electricity_consumed])
# Perform Chi-Square test
chi2, p, dof, expected = chi2_contingency(observed)
# Set significance level
alpha = 0.05
# Print the results
print(f"Chi-Square Statistic: {chi2}")
print(f"P-value: {p}")
print(f"Degrees of Freedom: {dof}")
Assistant
The code in assignemt@1.py looks good.
If it is not working as it should, then consider using some general debugging techniques.
Was it helpful or confusing?
Shell
>>> %Run assignemt@1.py
Chi-Square Statistic: 985.4827147042454
P-value: 2.5530104141315768e-204
Degrees of Freedom: 11
Contingency Table (Expected values):
[[210.1792224 261.00124749 514.24998267 629.67627694 2454.96222884
1544.47272853 1713.30521866 2706.48818352 790.75625476 858.80608497
527.17083651 217.9317347]
[33.8207776 41.99875251 82.75001733 101.32372306 395.03777116
248.52727147 275.69478134 435.51181648 127.24374524 138.19391503
84.82916349 35.0682653]]
Reject the null hypothesis: Electricity consumed is not the same every month.
>>>
Local Python 3 • Thonny's Python
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Linear relationship between the electricity bill and The number of units consumed every month

x	y	xy	x
193	51	9843	37249
82	221	18122	6724
502	95	47690	252004
666	65	43290	443556
2471	379	936509	6105841
1567	226	354142	2455289
1696	293	496928	2876716
2766	376	1040016	7650756
846	72	60912	715716
860	137	117820	739600
572	40	22880	327184
208	45	9360	43264
12429	2000	3157512	21653799

Let y=a+bx →i

n = no of pairs = 12

normal equation of i by least square method

$$\Sigma y = na + b\Sigma x \rightarrow ii$$

$$\Sigma xy = a\Sigma x + b\Sigma x^2 \rightarrow \text{iii}$$

2000=12a + 12429b → $\frac{2000-12429b}{12} = a$

3157512 = 12429a + 21653799b

$3157512=12429(\frac{2000-12429b}{12})+21653799b$

$3157512=\frac{12429(2000-1242ab)+12(2165379a)b}{12}$

3157512×12 = 12429×2000-(12429×12429)b+12(21653799)b

37,890,144 = 24,858,000 – 154,480,041 + 259,845,588b

37,890,144 = 24,858,000 + 105,365,547b

$$\frac{37890144-24858000}{10536547}=b$$

$$\frac{13032144}{105365547}=b$$

b = 0.12368506

315751 = 124299 + 21653799(0.12368506)

3157512 = 124299 + 2678215.43

479260.57=124299

$$\frac{479260.57}{12424}=a$$

a=38.5598656

value of a & b are 38.55 and 0.123 respectively substitute them in equation →i

i.e,y = a + bx

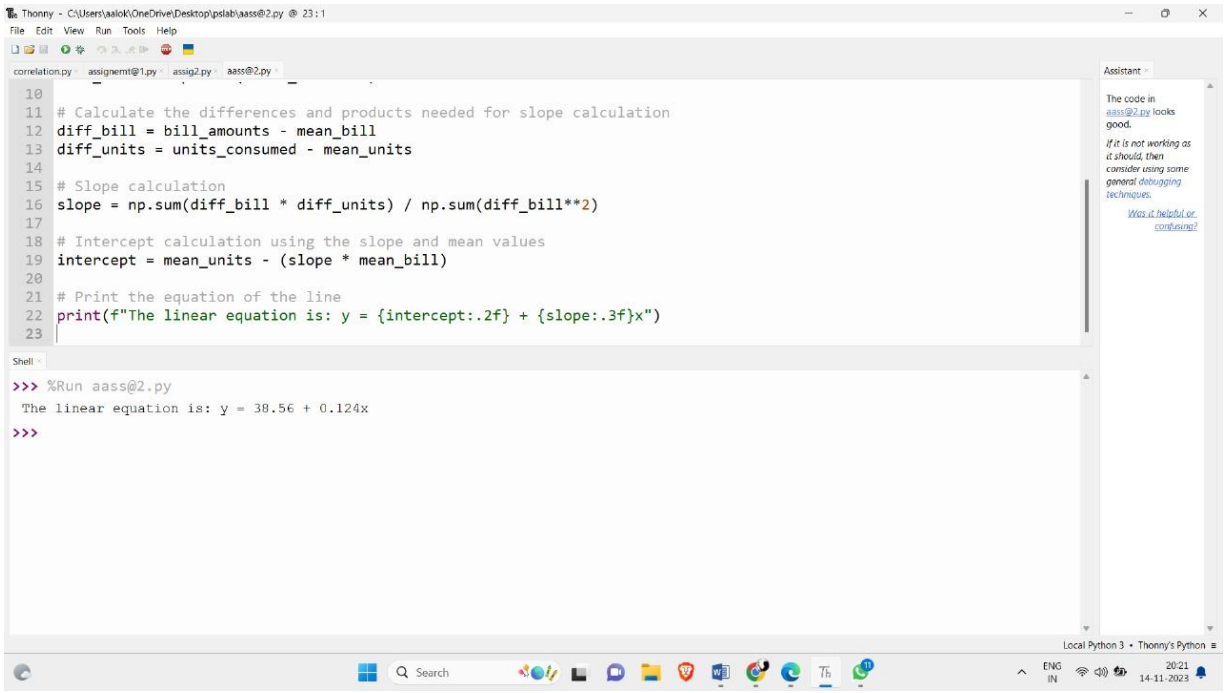
=> y = 38.55+(0.123)x

The linear relationship between the electricity bill & no of units consumed every month y= 38.55(0.123)x

CODE:

```
import numpy as np


# Input data
bill_amounts = np.array([193, 82, 502, 666, 2471, 1567, 1696, 2766, 846, 860, 572, 208])
units_consumed = np.array([51, 221, 95, 65, 379, 226, 293, 376, 72, 137, 40, 45])


# Calculate the mean of bill amounts and units consumed
mean_bill = np.mean(bill_amounts)
mean_units = np.mean(units_consumed)


# Calculate the differences and products needed for slope calculation
diff_bill = bill_amounts - mean_bill
diff_units = units_consumed - mean_units


# Slope calculation
slope = np.sum(diff_bill * diff_units) / np.sum(diff_bill**2)


# Intercept calculation using the slope and mean values
intercept = mean_units - (slope * mean_bill)


# Print the equation of the line
print(f"The linear equation is: y = {intercept:.2f} + {slope:.3f}x")
```

OUTPUT:


Thonny - C:\Users\aalok\OneDrive\Desktop\pslab\aass@2.py @ 23 : 1
File Edit View Run Tools Help
correlation.py assignemt@1.py assig2.py aass@2.py
10
11 # Calculate the differences and products needed for slope calculation
12 diff_bill = bill_amounts - mean_bill
13 diff_units = units_consumed - mean_units
14
15 # Slope calculation
16 slope = np.sum(diff_bill * diff_units) / np.sum(diff_bill**2)
17
18 # Intercept calculation using the slope and mean values
19 intercept = mean_units - (slope * mean_bill)
20
21 # Print the equation of the line
22 print(f"The linear equation is: y = {intercept:.2f} + {slope:.3f}x")
23
Assistant
The code in aass@2.py looks good.
If it is not working as it should, then consider using some general debugging techniques.
Was it helpful or confusing?
Shell
>>> %Run aass@2.py
The linear equation is: y = 38.56 + 0.124x
>>>
Local Python 3 • Thonny's Python
Search
ENG IN
20:21 14-11-2023

Reference:

These are references collected from the past one year electricity Bills

TSNPDCL

ELECTRICITY BILL
CUM NOTICE

Ir Ver-0.93 BNo:0851
SBM ID:D5866G21
ERO :2122 SEC:07
GRP :M CYCLE:M1
DATE:10-10-2022 11:49
AREA :BALASAMUDRAM

USCNO:15836352
SCNO:22 37 31052
NAME:P,Narayana Reddy

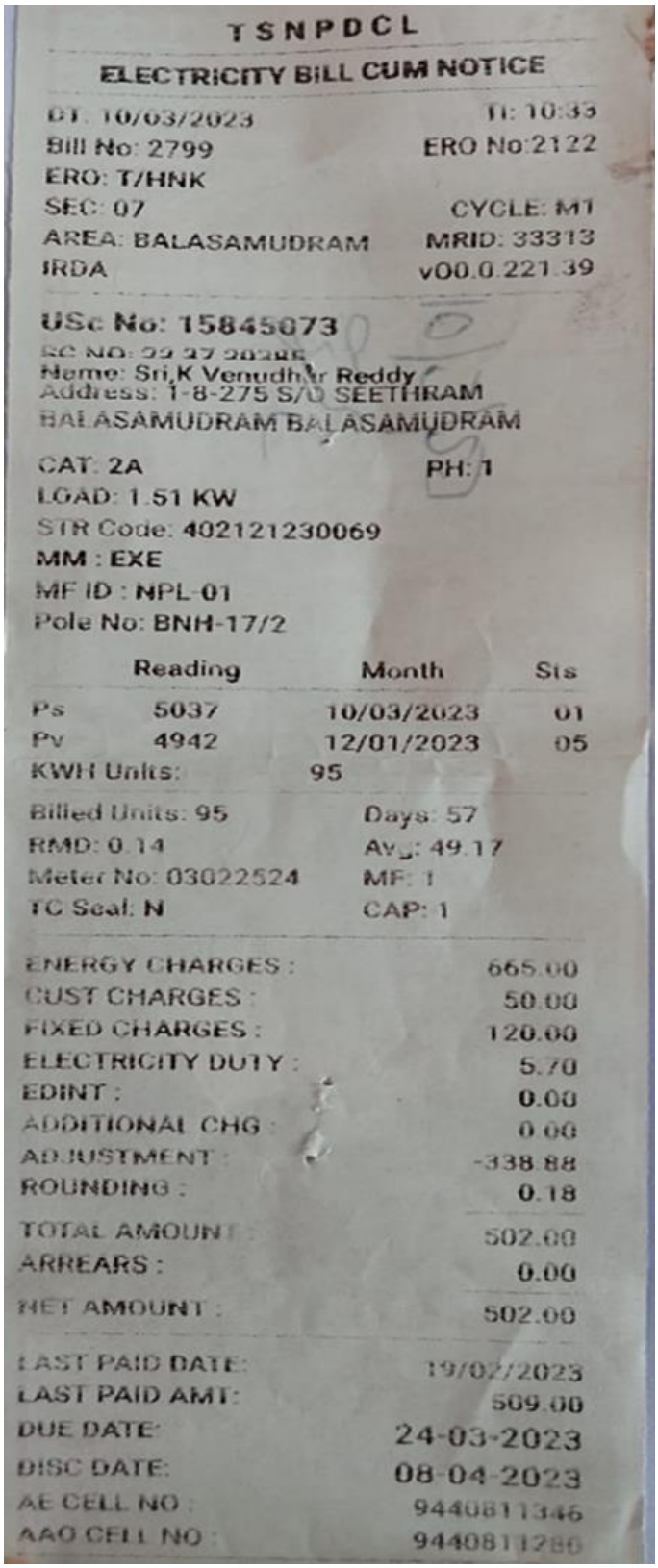
ADDR:1-8-305
BALASAMUDRAM
CAT: 1B(2)
LD: 3.00 PH:1
STR CODE :402121230032
POLE NO :BSM-67

READ	MON	STS
PS: 18337	10/10/2022	01
PU: 18200	21/09/2022	01
KWH UNITS:		137

RMD : 2.36
AVG:216.32 DAYS:19
MNo:03411938 CAP:20
MTR MAKE:NPL-01
TC seal:N
MF:1.00 PF:0.00

ENERGY CHARGES:		722.10
FIXED CHARGES:		30.00
CUST CHARGES	:	100.00
ED	:	8.22
ED INT	:	0.00
ROUND AMOUNT	:	-0.32
TOTAL AMOUNT	:	860.00
AS ON:01-04-22:		0.00
AFTER:01-04-22:		0.00
NET AMOUNT	:	860.00
ACD DUE	:	0.00
AGL SERVICES DUES	:	0.00
	:	0.00
LAST PAID	:26/09/2022	
LAST PAID AMT:	1756.00	
DUE DATE	:24/10/2022	
DISC DATE	:08/11/2022	
SUBSIDY/UNIT	:	2.49
SUBSIDY AMT	:	341.13

AAO/ERO/ERO/TOWN/HANAMK
AE Phone :9440811346
AAO Phone:9440811280
TOLLFREE1912/18004250028
http://tsnpdcl.in/



TSNPDCL

ELECTRICITY BILL CUM NOTICE

DT: 10/03/2023 TI: 10:33
Bill No: 2799 ERO No:2122
ERO: T/HNK
SEC: 07 CYCLE: M1
AREA: BALASAMUDRAM MRID: 33313
IRDA v00.0.221.39

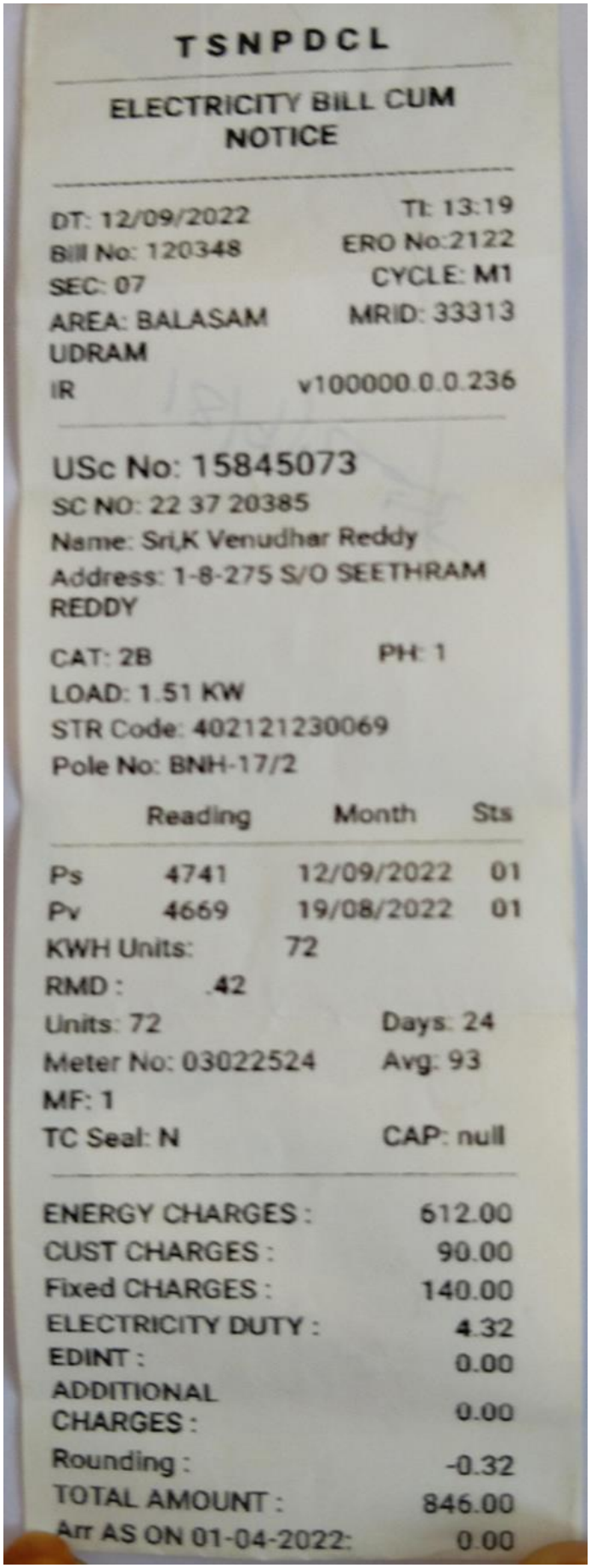
USc No: 15845073
SC NO: 99 37 30345
Name: Sri K Venudhar Reddy
Address: 1-8-275 S/O SEETHRAM
BALASAMUDRAM BALASAMUDRAM

CAT: 2A PH: 1
LOAD: 1.51 KW
STR Code: 402121230069
MM : EXE
MF ID : NPL-01
Pole No: BNH-17/2

	Reading	Month	Sts
Ps	5037	10/03/2023	01
Pv	4942	12/01/2023	05
KWH Units:		95	

Billed Units: 95 Days: 57
RMD: 0.14 Avg: 49.17
Meter No: 03022524 MF: 1
TC Seal: N CAP: 1

ENERGY CHARGES :	665.00
CUST CHARGES :	50.00
FIXED CHARGES :	120.00
ELECTRICITY DUTY :	5.70
EDINT :	0.00
ADDITIONAL CHG :	0.00
ADJUSTMENT :	-338.88
ROUNDING :	0.18
TOTAL AMOUNT :	502.00
ARREARS :	0.00
NET AMOUNT :	502.00
LAST PAID DATE:	19/02/2023
LAST PAID AMT:	509.00
DUE DATE:	24-03-2023
DISC DATE:	08-04-2023
AE CELL NO :	9440811346
AAO CELL NO :	9440811280



TSNPDCL

ELECTRICITY BILL CUM NOTICE

DT: 12/09/2022 Tt: 13:19
Bill No: 120348 ERO No:2122
SEC: 07 CYCLE: M1
AREA: BALASAM MRID: 33313
UDRAM
IR v100000.0.0.236

USc No: 15845073

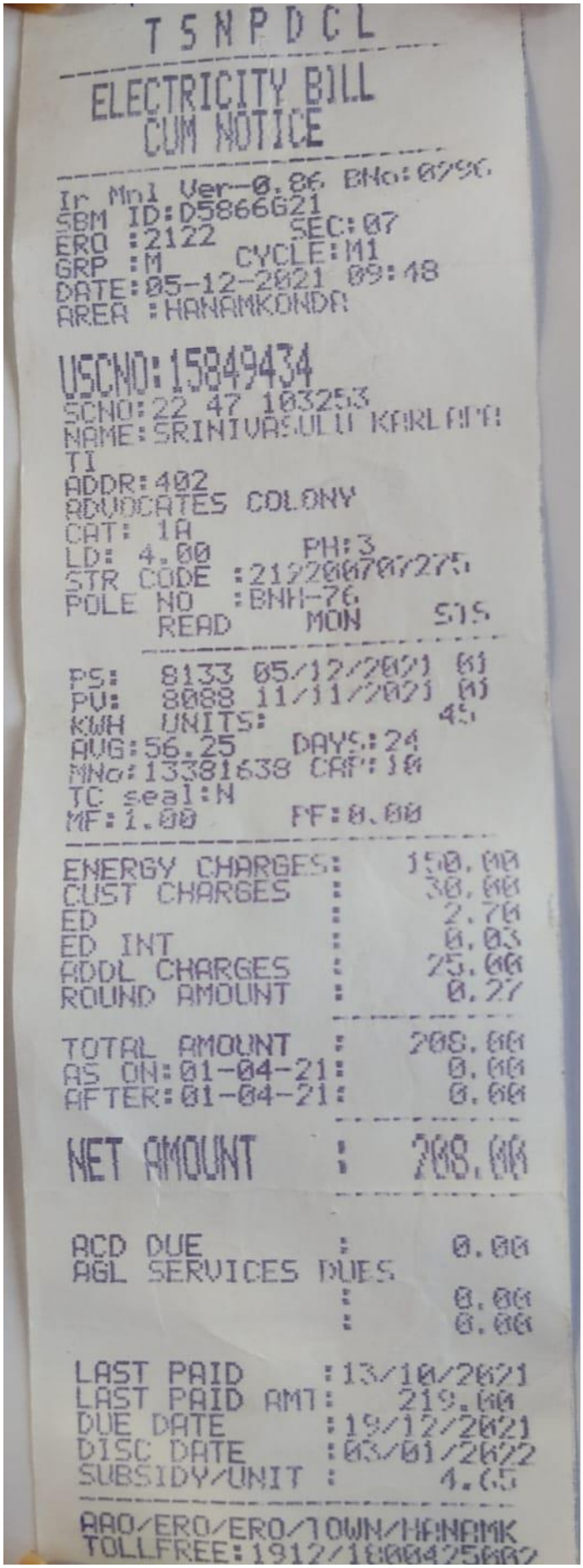
SC NO: 22 37 20385
Name: Sri,K Venudhar Reddy
Address: 1-8-275 S/O SEETHRAM REDDY

CAT: 2B PH: 1
LOAD: 1.51 KW
STR Code: 402121230069
Pole No: BNH-17/2

	Reading	Month	Sts
Ps	4741	12/09/2022	01
Pv	4669	19/08/2022	01

KWH Units: 72
RMD : .42
Units: 72 Days: 24
Meter No: 03022524 Avg: 93
MF: 1
TC Seal: N CAP: null

ENERGY CHARGES :	612.00
CUST CHARGES :	90.00
Fixed CHARGES :	140.00
ELECTRICITY DUTY :	4.32
EDINT :	0.00
ADDITIONAL CHARGES :	0.00
Rounding :	-0.32
TOTAL AMOUNT :	846.00
Arr AS ON 01-04-2022:	0.00



TSNPDCL

ELECTRICITY BILL
CUM NOTICE

Ir Mnl Ver-0.86 BNo:0/96
SBM ID:D5866621
ERO :2122 SEC:07
GRP :M CYCLE:M1
DATE:05-12-2021 09:48
AREA :HANAMKONDA

USCNO:15849434
SCNO:22 47 103253
NAME:SRINIVASULU KARLAPU
TI
ADDR:402
ADVOCATES COLONY
CAT: 1A
LD: 4.00 PH:3
STR CODE :21920070727S
POLE NO :BNH-76
READ MON SIS

PS: 8133 05/12/2021 01
PV: 8088 11/11/2021 01
KWH UNITS: 45
AVG:56.25 DAYS:24
MNo:13381638 CAP:10
TC seal:N
MF:1.00 PF:0.00

ENERGY CHARGES:		150.00
CUST CHARGES	:	30.00
ED	:	2.70
ED INT	:	0.03
ADDL CHARGES	:	25.00
ROUND AMOUNT	:	0.27
TOTAL AMOUNT	:	208.00
AS ON:01-04-21:		0.00
AFTER:01-04-21:		0.00
NET AMOUNT	:	208.00
ACD DUE	:	0.00
AGL SERVICES DUES		
	:	0.00
	:	0.00

LAST PAID :13/10/2021
LAST PAID AMT: 219.00
DUE DATE :19/12/2021
DISC DATE :03/01/2022
SUBSIDY/UNIT : 4.65

AAO/ERO/ERO/TOWN/HANAMK
TOLLFREE:1912/1800425002

TSNPDCL

ELECTRICITY BILL
CUM NOTICE

Ir Mnl Ver-P.88 BNo:6899
Machine ID:SBP19150593
ERO :2122 SEC:07
GRP :M Cycle:M1
DATE:12/02/2022 10:25
Area:BALASAMUDRAM

USCNO:15853649

SCNO:22 37 21048
NAME:P,Narayana Reddy
ADDR:1-8-305
BALASAMUDRAM
Cat:1-1A Phase:1
Load:3.250KW
STR Code: 402121230032
Pole No.: BSM-67

	READING	MONTH	STS
Ps	2690	12/02/2022	01
Pv	2567	13/01/2022	01

Pres Exp KWH: 2157
Prev Exp KWH: 1936
KWH UNITS: 123
Exp KWH UNITS: 221
PREV C/F UNITS: 63
UNITS:0 DAYS: 30
MNo:X1169853 AVG: 0.00
Mfr1 MF:1.00
TC Seal:N CAP:1

ENERGYCHARGES:	50.00
CUST CHARGES :	25.00
:	7.38
ED :	0.00
ED INT :	0.00
ADDL CHARGES :	-0.00
ADJUSTMENT :	-0.38
ROUNDING :	
TOTAL AMOUNT :	82.00
AS ON 01-04-21:	0.00
AFTER 01-04-21:	0.00
NET AMOUNT :	82.00
ACD DUE :	0.00

AGL SERVICES DUES

:	0.00
:	0.00

NET C/F UNITS: 161
LAST PAID :26/01/2022
LAST PAID AMT: 84.00
DUE DATE :26/02/2022
DISC DATE :13/03/2022

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AE Phone :9440811346
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