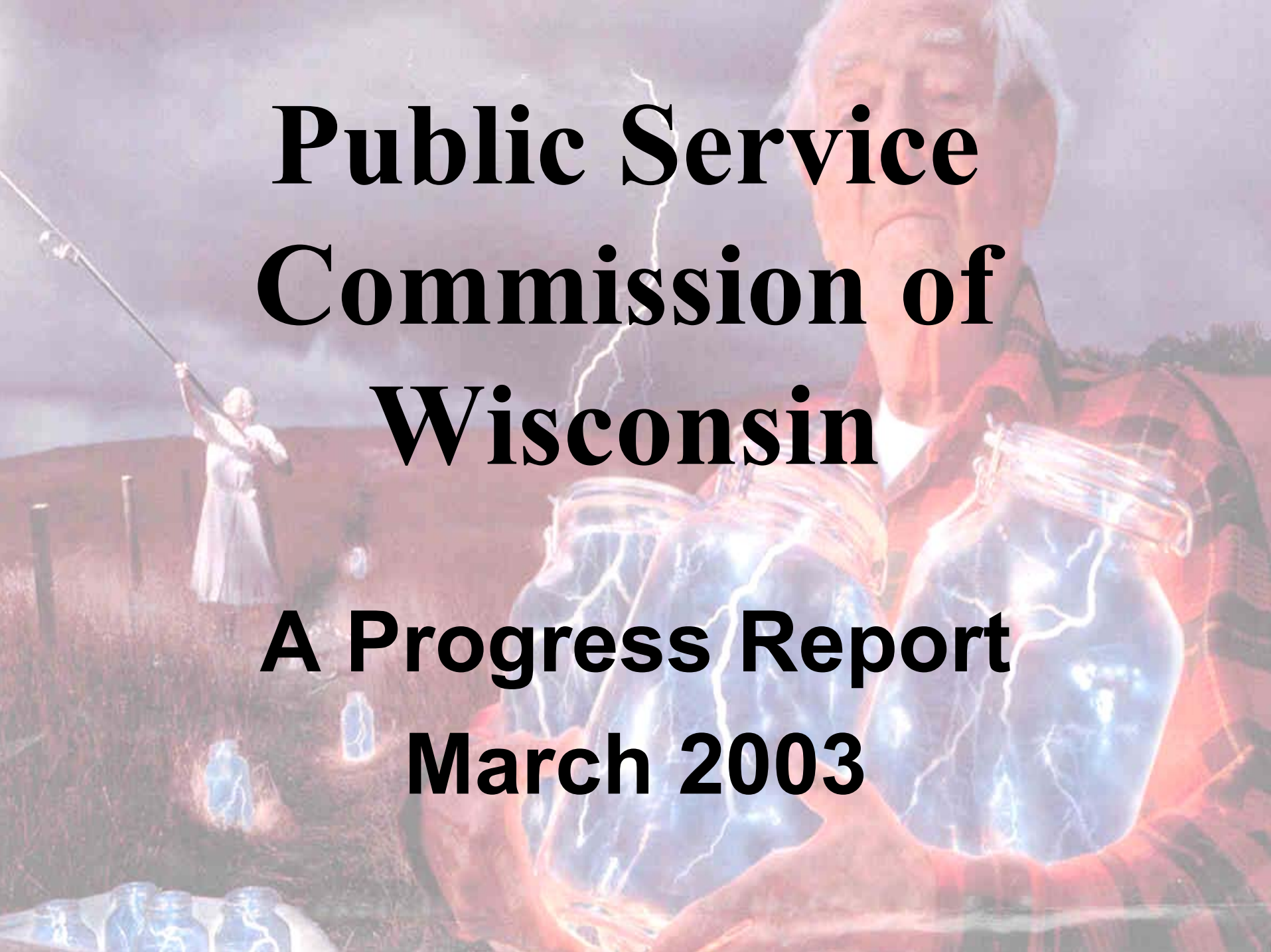


Public Service Commission of Wisconsin

A Progress Report
March 2003

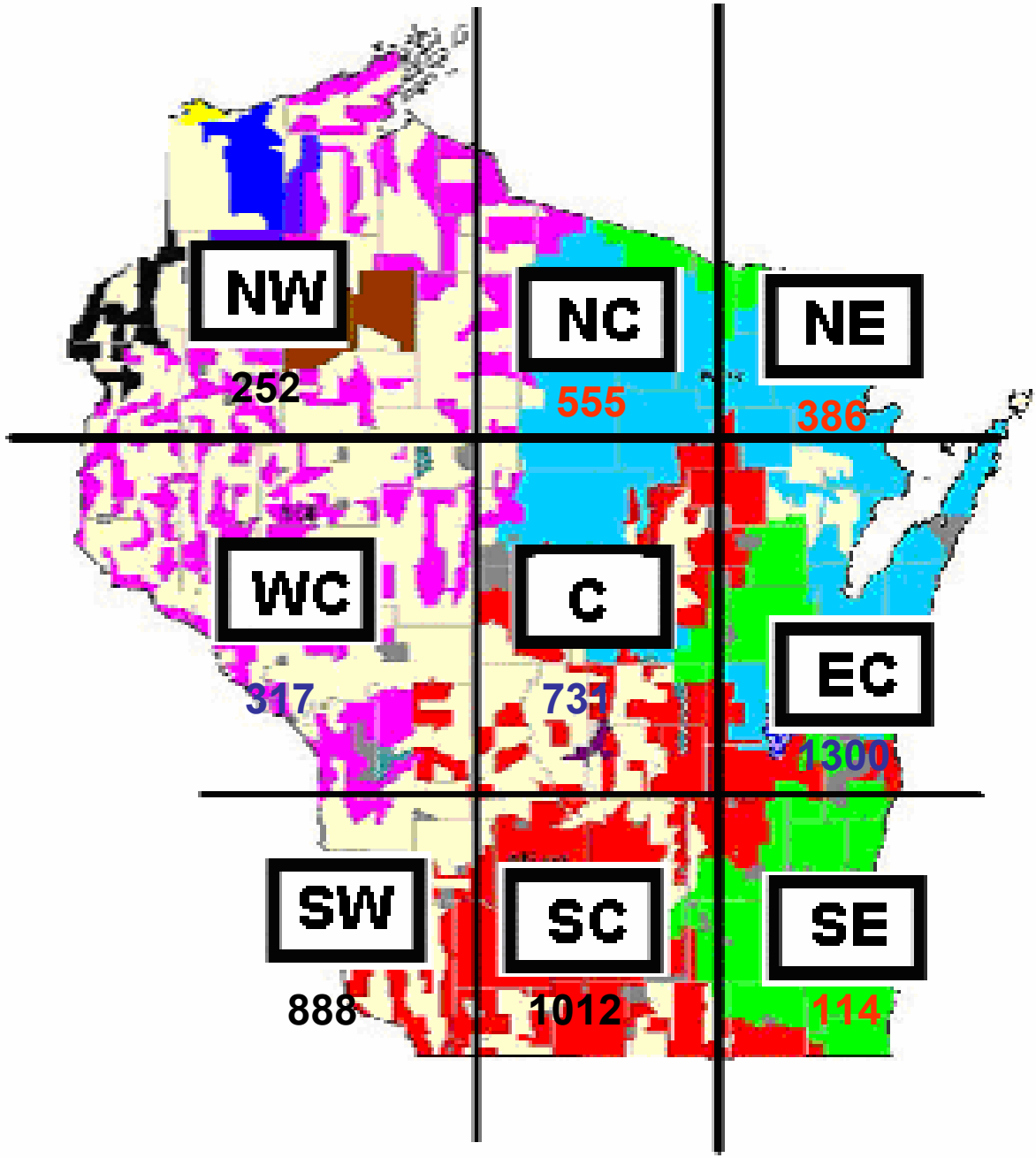
PSC Database

IOU and Coop

Wisconsin locations

And number of farms

6237 total



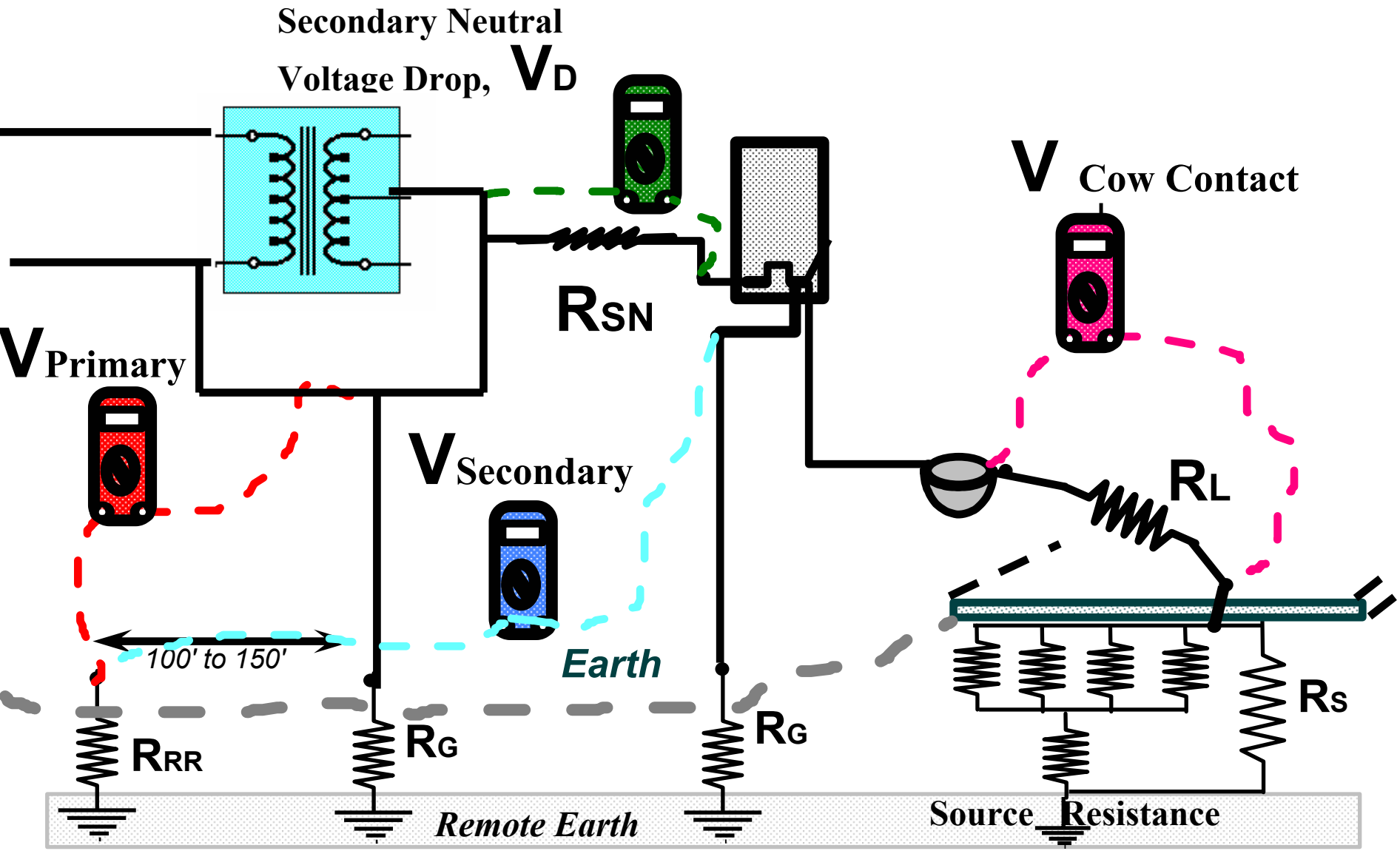
682 unknown location

What is stray voltage??

- PSC Docket 115 definition:

  Stray voltage is a special case of voltage in which the neutral to earth voltage is present across points (generally grounded metal objects) in which a current flow is produced when an animal comes into contact with them. …These two contact points can include any two conductive points which the animal may simultaneously contact to complete a circuit which allows current to flow. Stray voltages are low-level voltages and should be distinguished from painful shocks felt by humans.

COW CONTACT VOLTAGE AND NEV MEASUREMENTS:



PSCW “level of concern”

- **From the 1996 PSCW docket 05-EI-115, the “level of concern” is defined as 2 milliamps, AC, rms (root mean square), steady-state or 1 volt, AC, rms, steady-state across a 500-ohm resistor in the cow contact area.**

(“steady-state” is defined by the Institute of Electrical and Electronics Engineers (IEEE) as “the value of a current or voltage after all transients have decayed to a negligible value”)

More…….

- **The State of Wisconsin deems that this level of voltage/current is an amount of electricity where some form of mitigative action is taken on the farmer's behalf, although only some small percentage of cows may actually perceive its presence. The "level of concern" is not a damage level. Instead, it is a very conservative, pre-injury level, below the point where moderate avoidance behavior is likely to occur and well below where a cow's behavior or milk production would be harmed.**

More……

- **The "level of concern" is further broken down into two parts.**
  - **The first part is a 1-milliamp contribution from the utility, at which level mitigative action must be taken by that utility to reduce its contribution to below the1-milliamp level.**
  - **The second part is a 1-milliamp contribution from the farm system, at which level mitigative action should be taken by the farmer.**

STRAY VOLTAGE IS NOT…

- **ELECTROCUTION**
- **LIGHTNING**
- **IT DOES NOT CAUSE**
  - **–BURN MARKS**
  - **–SORE HOOVES**
  - **–ABSCESSES**
  - **–MUSCLE DAMAGE**

STRAY VOLTAGE CAN …

- **CAUSE BEHAVIOR CHANGES OF RELUCTANCE AND AVOIDANCE**

NEUTRAL-TO-EARTH VOLTAGE (NEV)

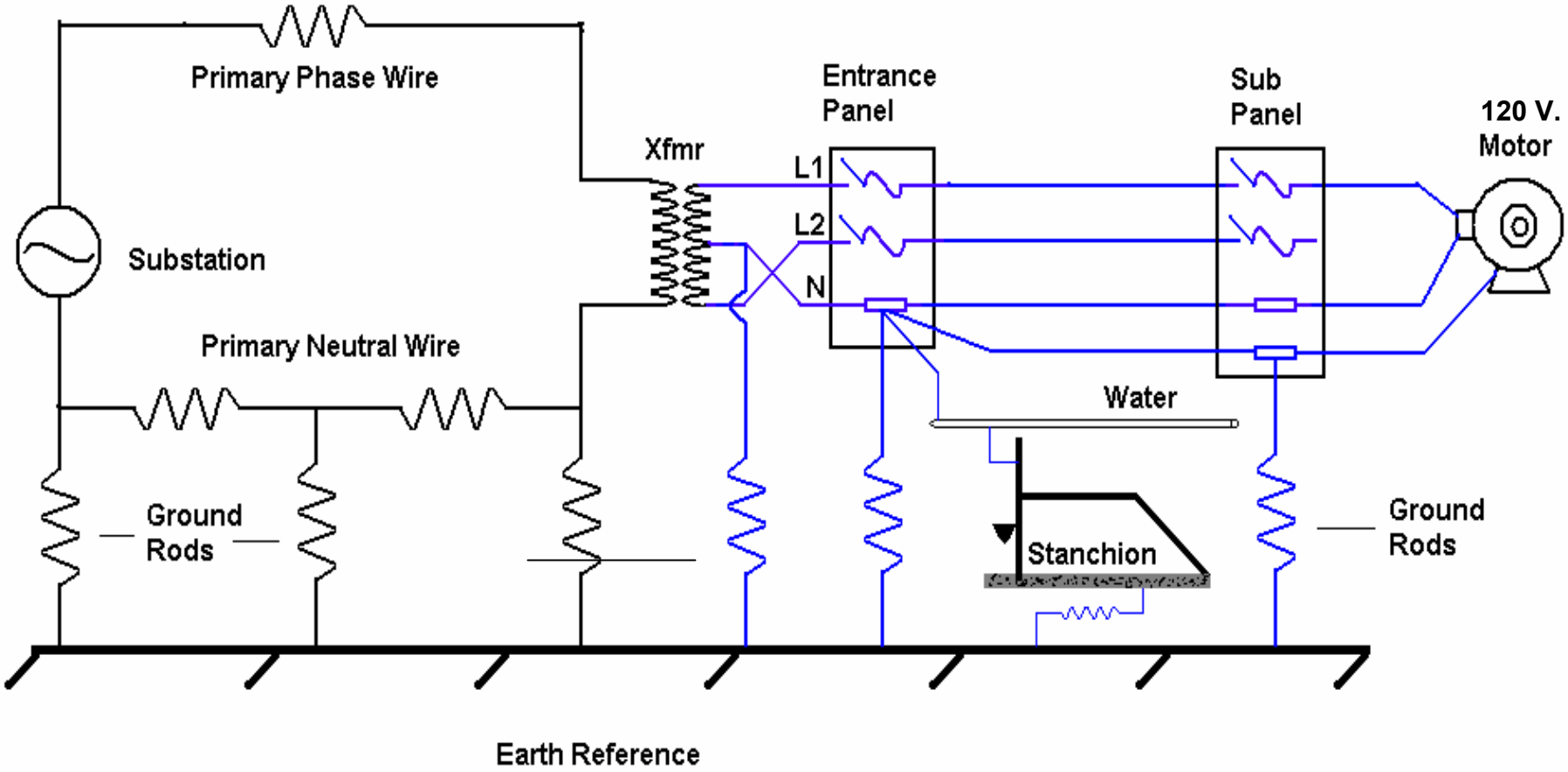
- **Voltage measured between a neutral conductor and a remote reference rod.**
  - **The voltage drop across the neutral-to-earth resistance.**
- **This is the main source of stray voltage**
  - **Primary contribution.**
  - **Secondary contribution.**

GROUND CURRENT

- System return current, either normal or abnormal, that flows on the conductive pathways between the neutral conductor and the earth.
- Can be on grounded conductors or grounding conductors and appurtenant structures.
- It is a natural consequence of using a multigrounded neutral electric system.

EARTH CURRENT

- Once a current leaves a grounding conductor or structure, it becomes an earth current.
- System return current, either normal or abnormal, that flows in the earth from or to existing electrodes.
- Away from metallic structures in the earth, it is very small.



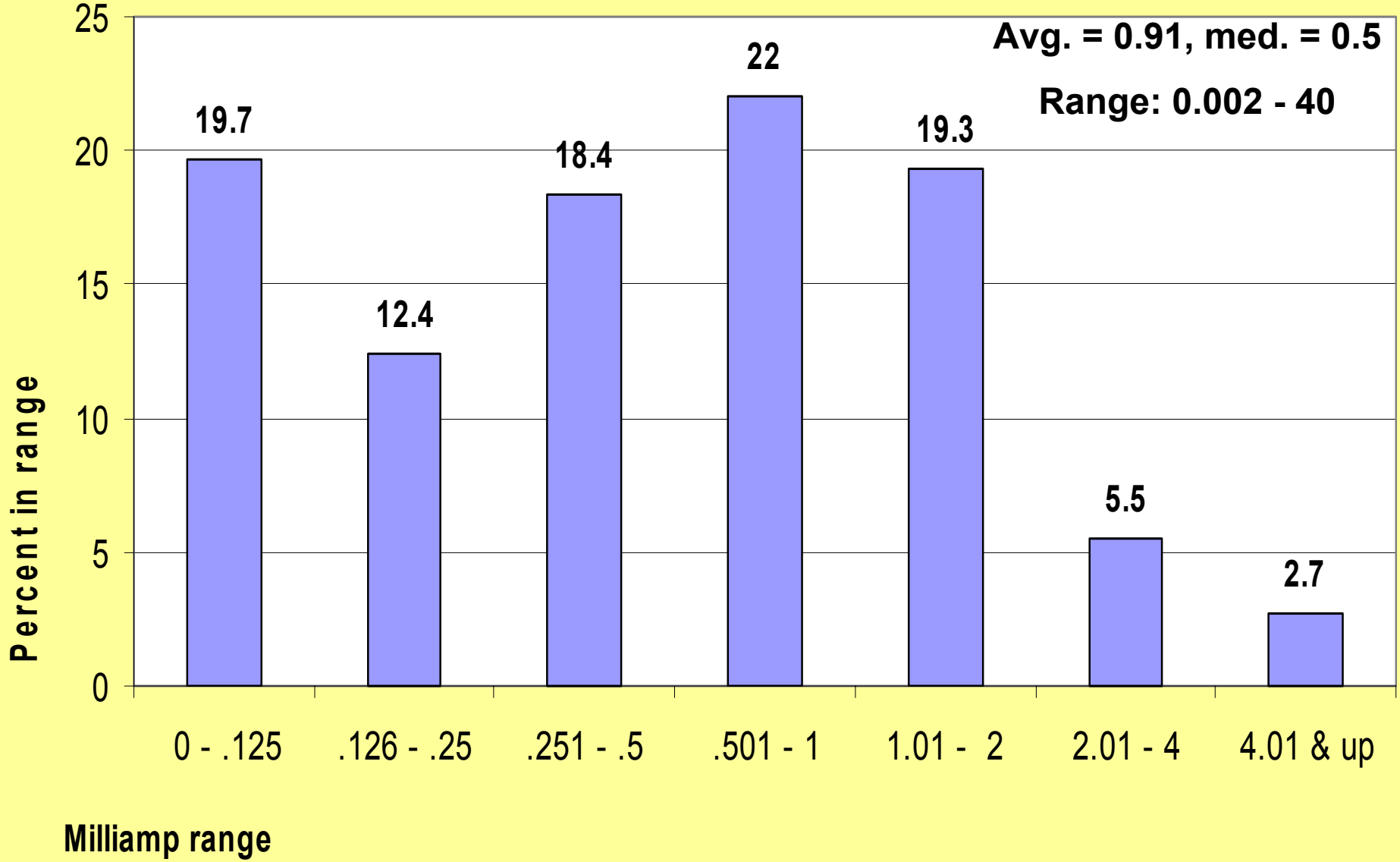
Utility & Farm Circuit

What are the numbers telling us?

- What are the overall characteristics of cow contact voltages and currents?
- What are the overall characteristics of NEV voltages?

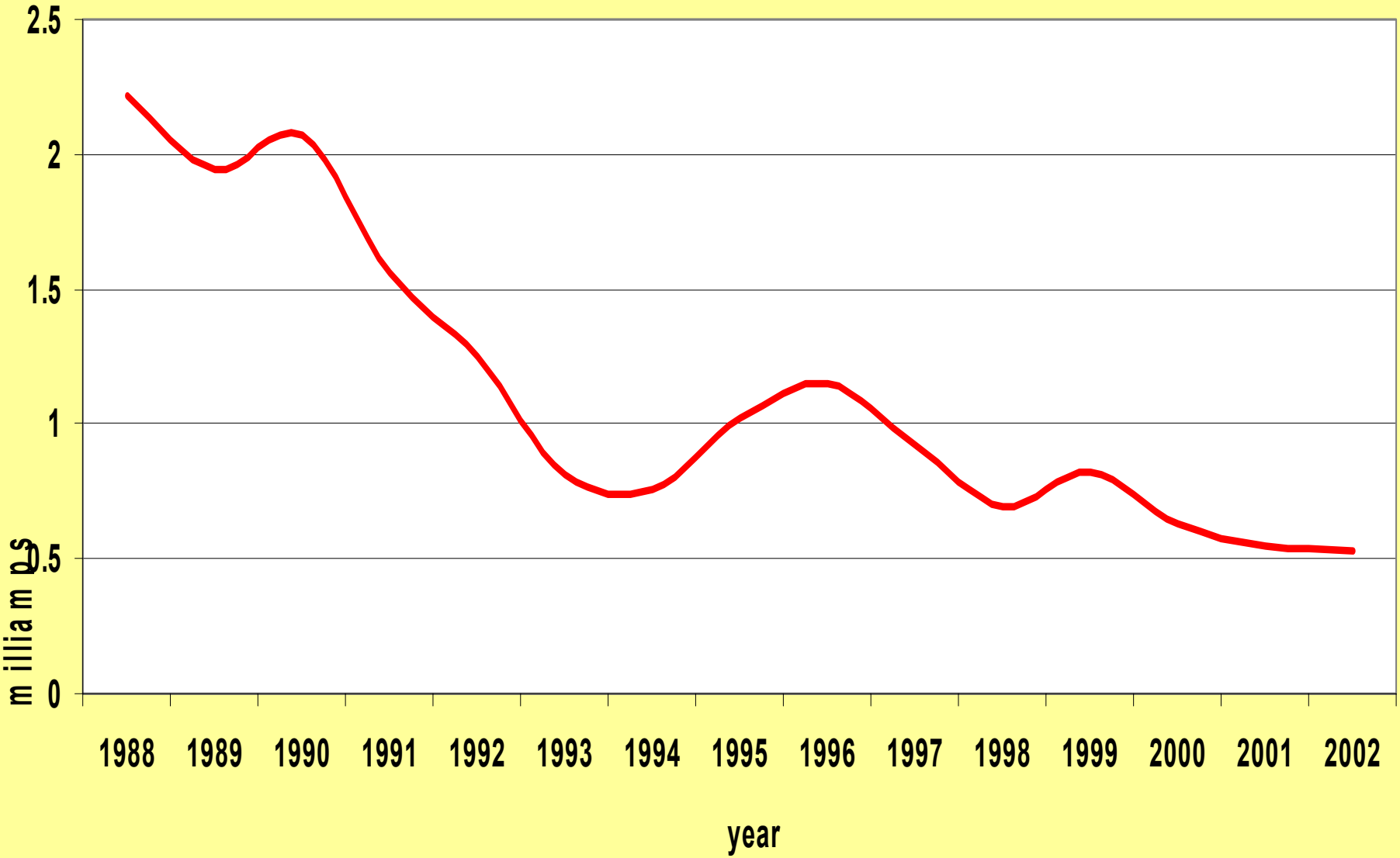
Distribution of Icc

N = 5797



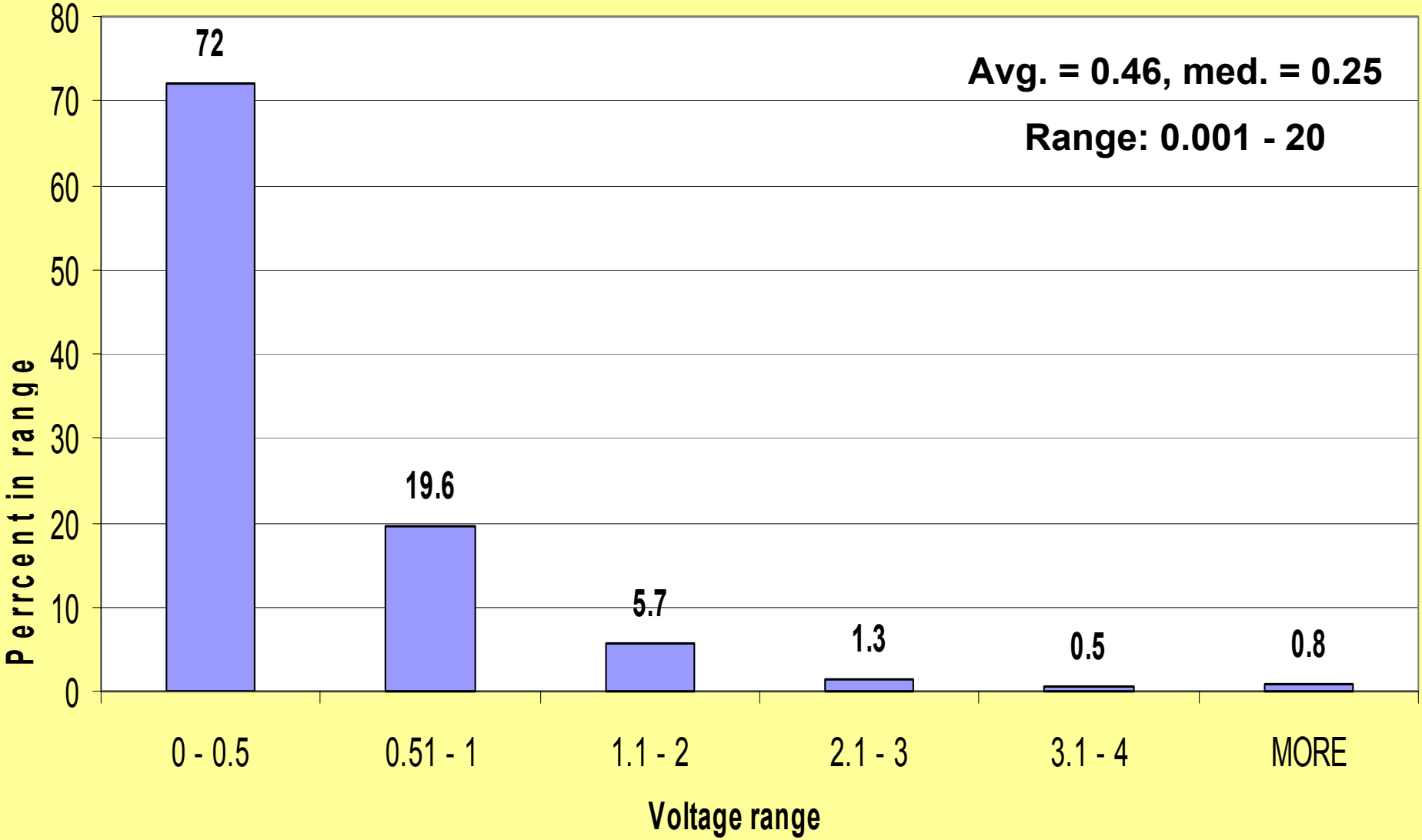
Trend in Icc

Change, 1988 – 2002: -76%



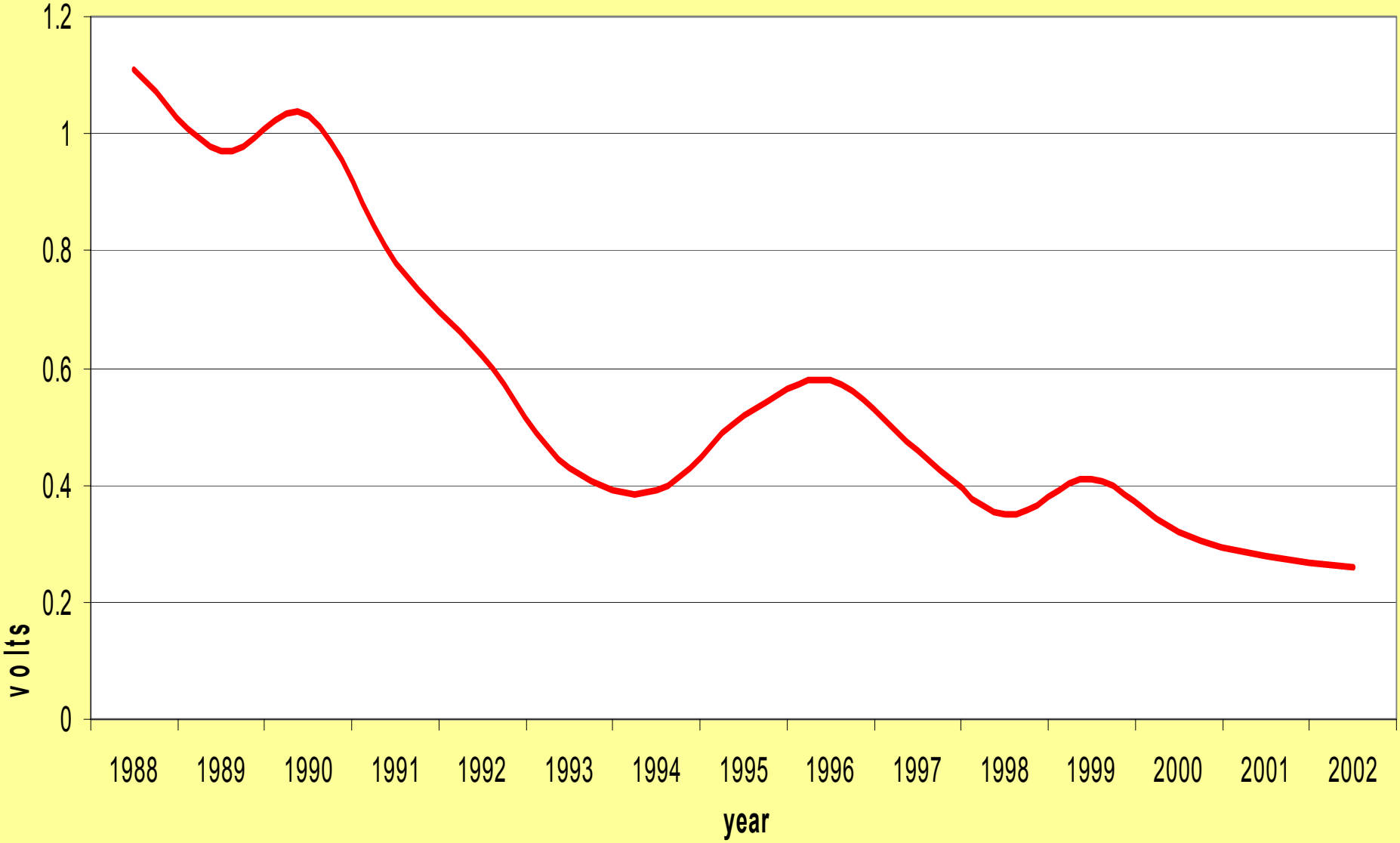
Distribution of Vcc

N = 5797



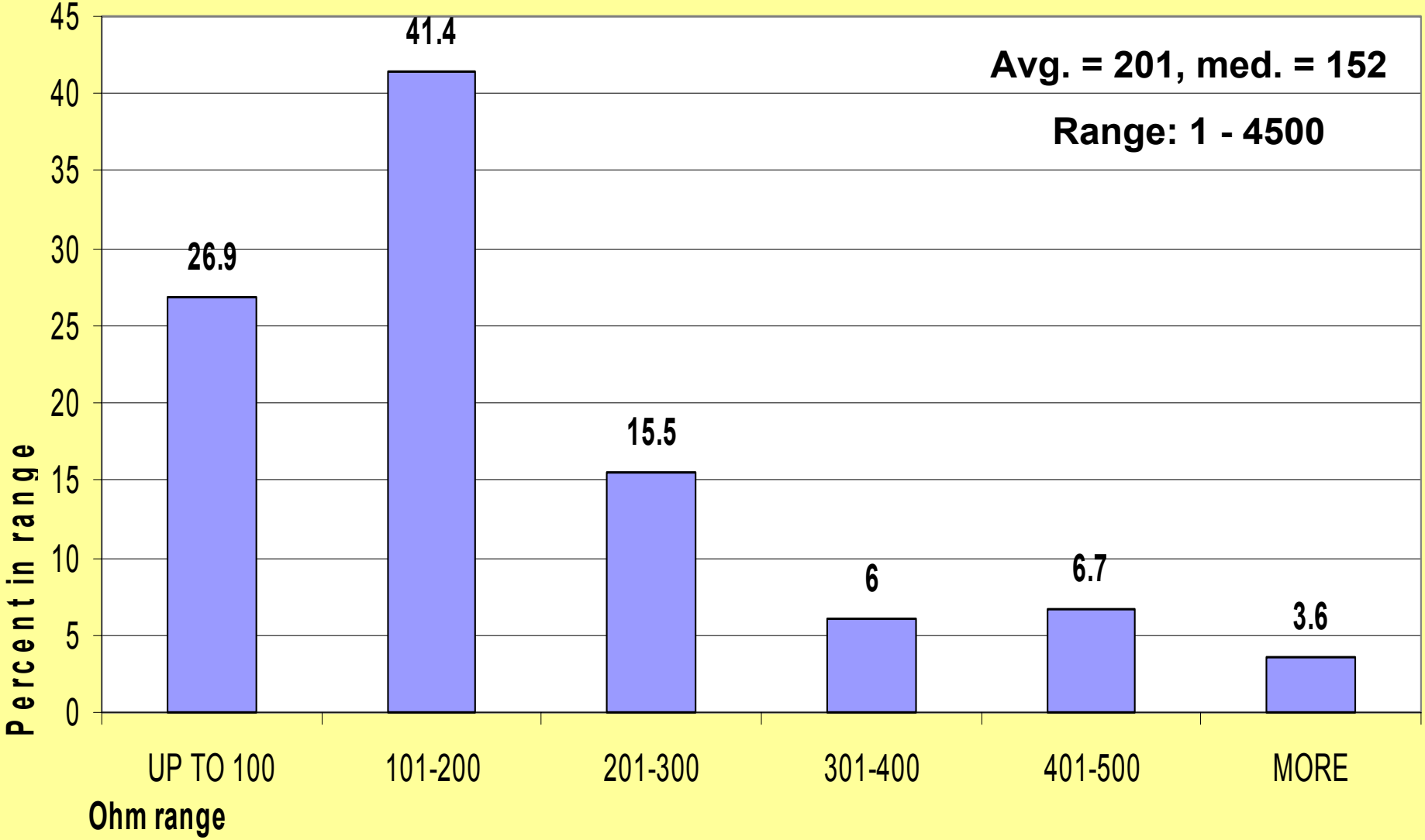
Trend in Cow Contact Voltage

Change, 1988 – 2002: -77%



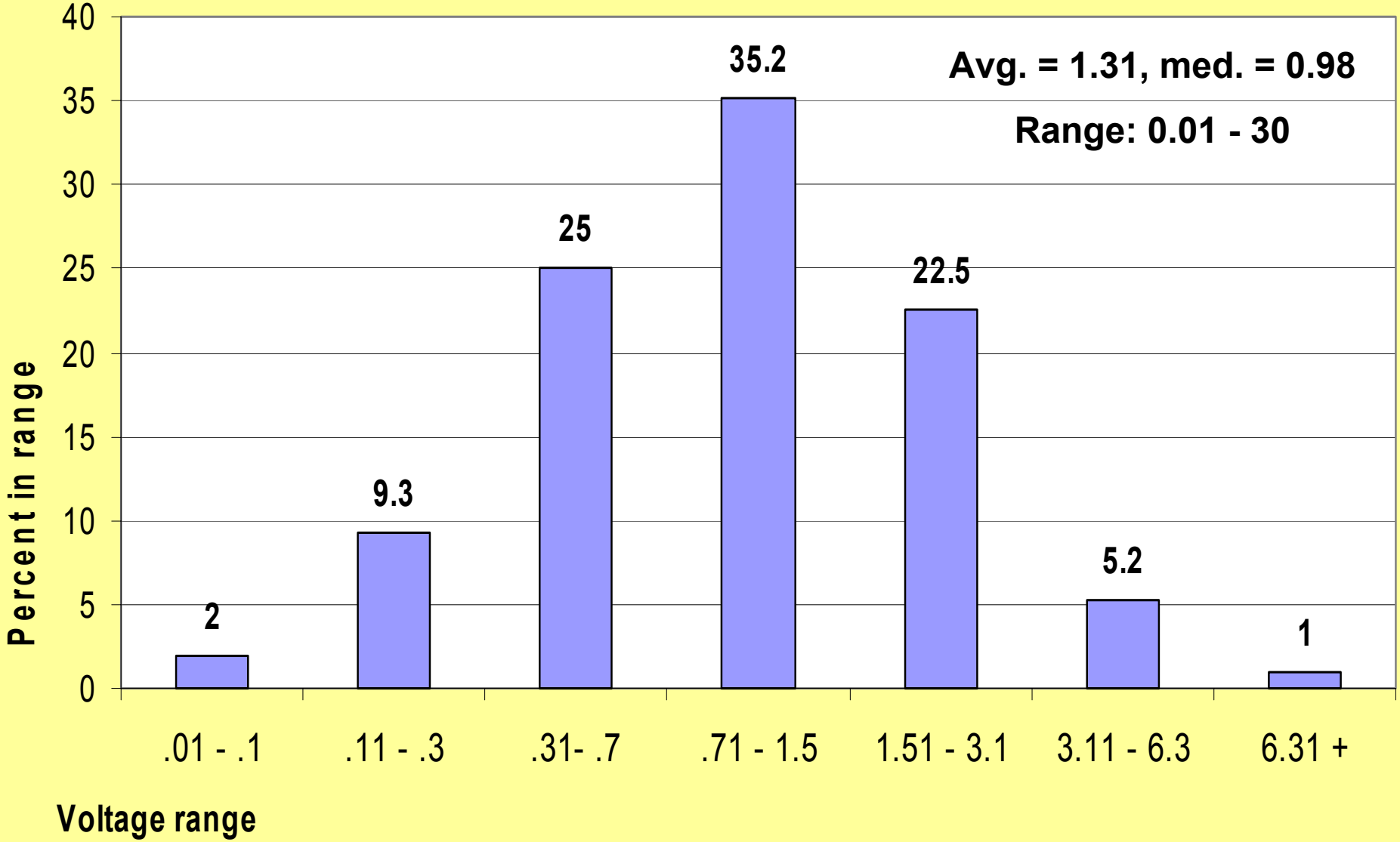
Distribution of source resistance

N = 5321



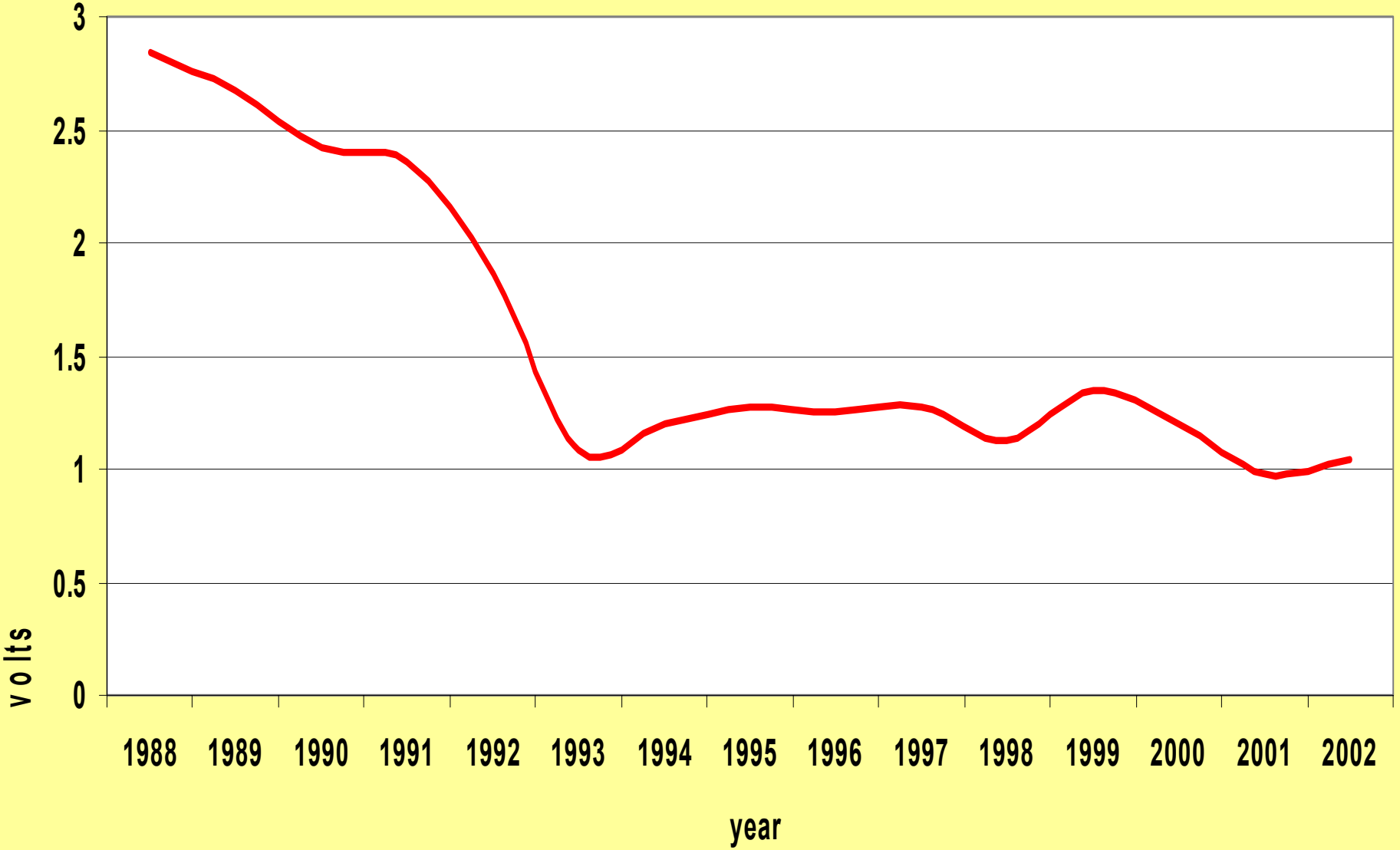
Distribution of Vpnref

N = 5663



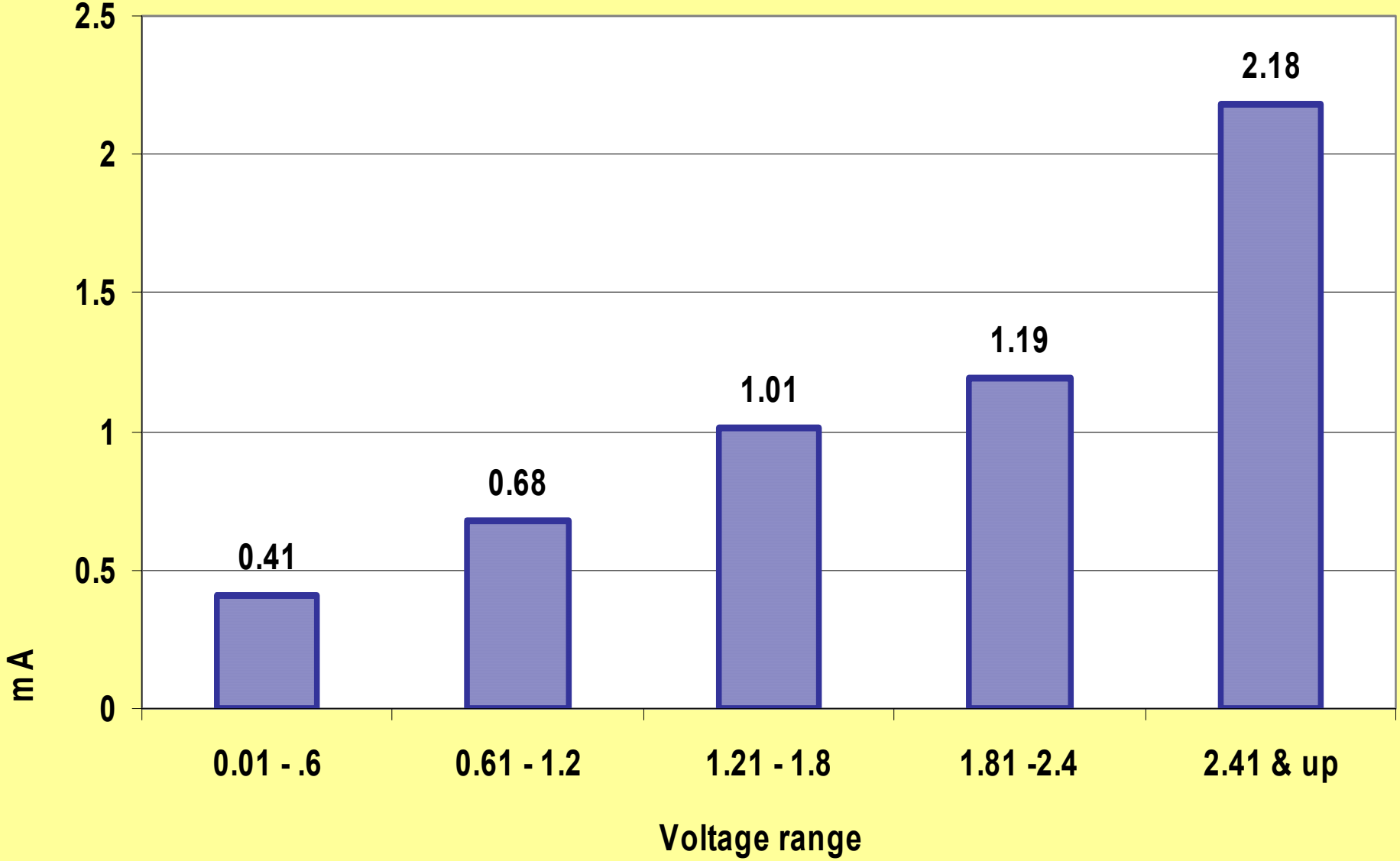
Trend in Vpnref

Change, 1988 – 2002: - 63%



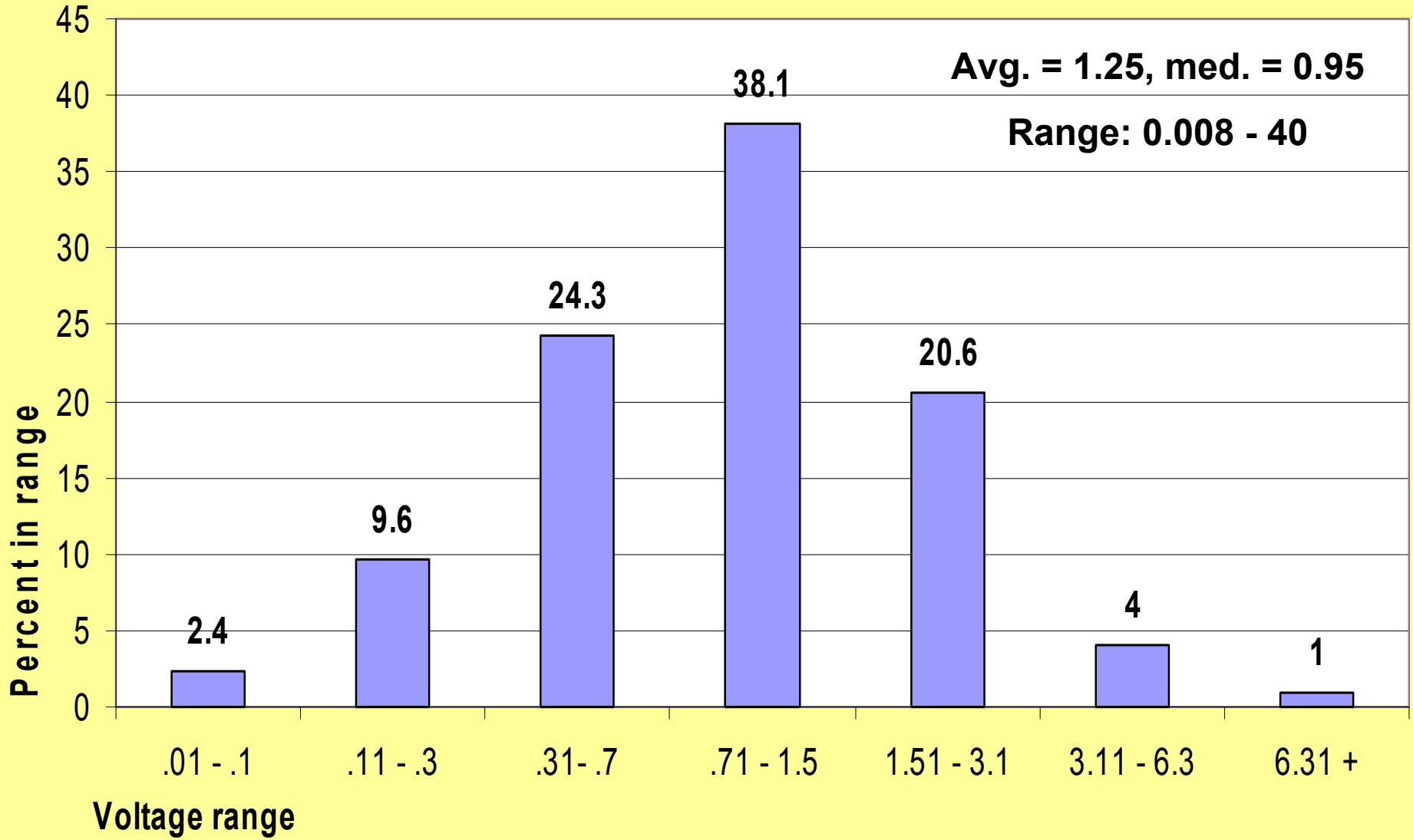
Avg. Icc vs. Vpnref

Correl Coeff. = 0.430



Distribution of Vsnref

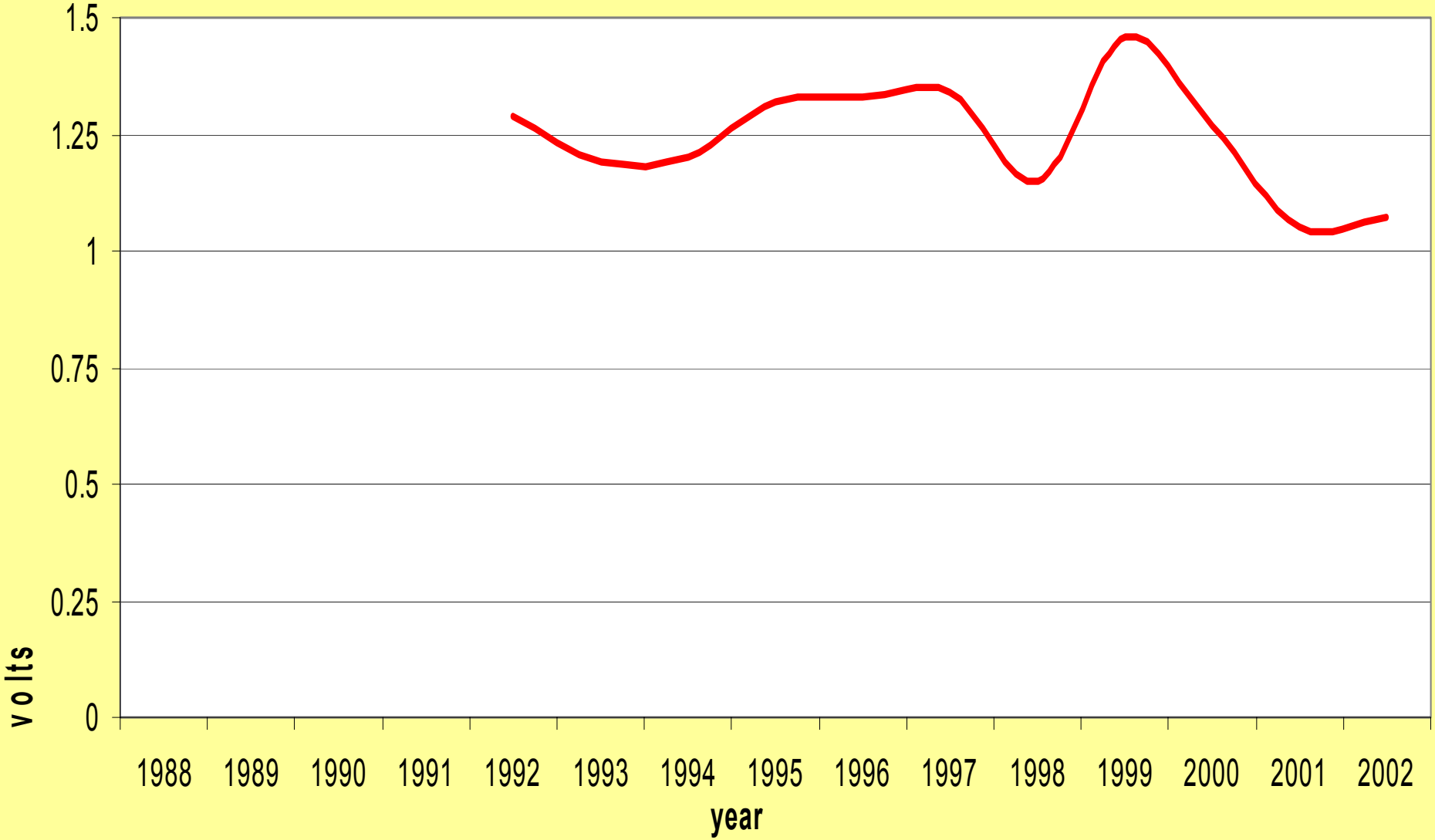
N = 5160



Trend in Vsnref

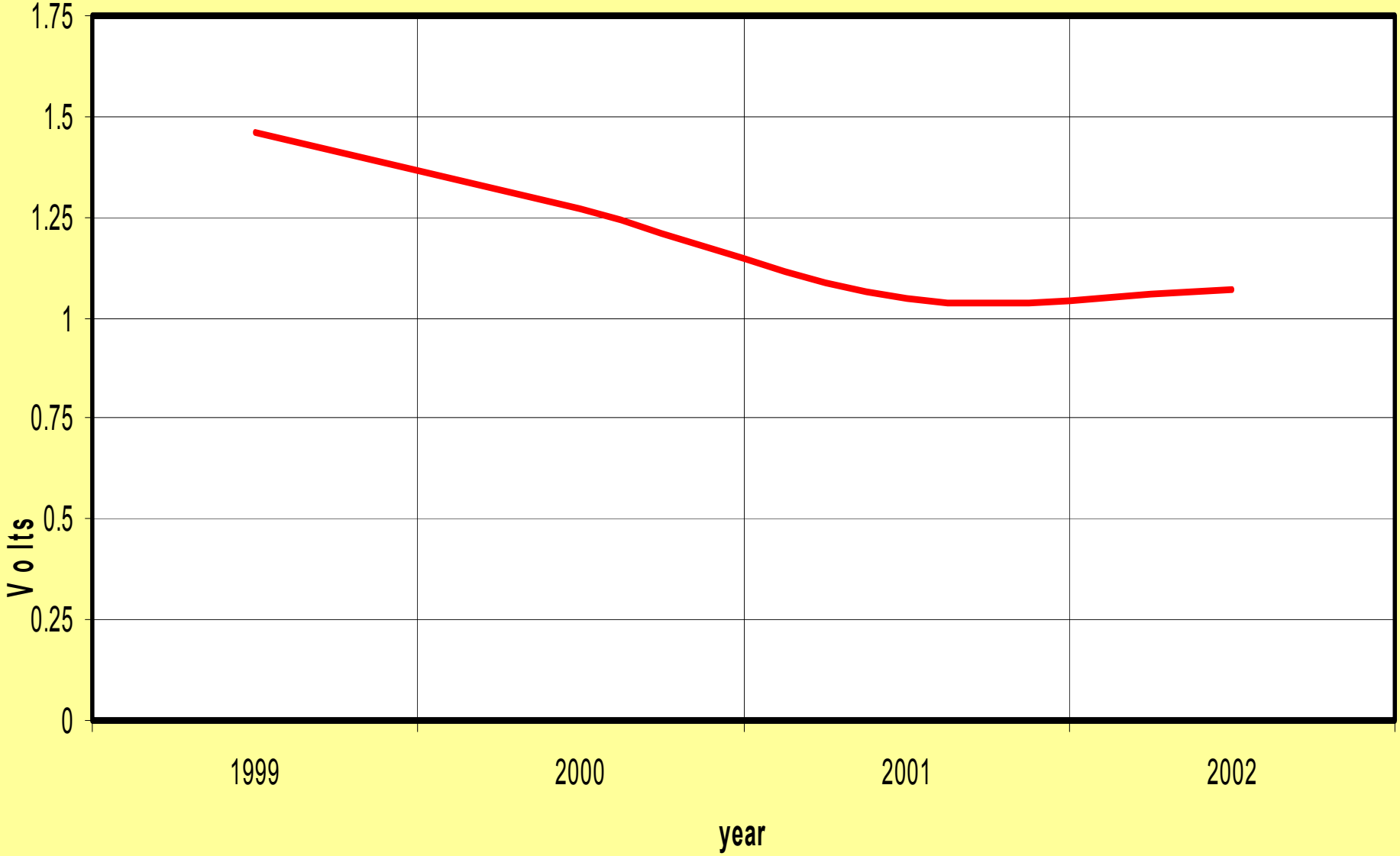
Change, 1992 – 2002: -17%

Change, 1992 – 1999: +13%



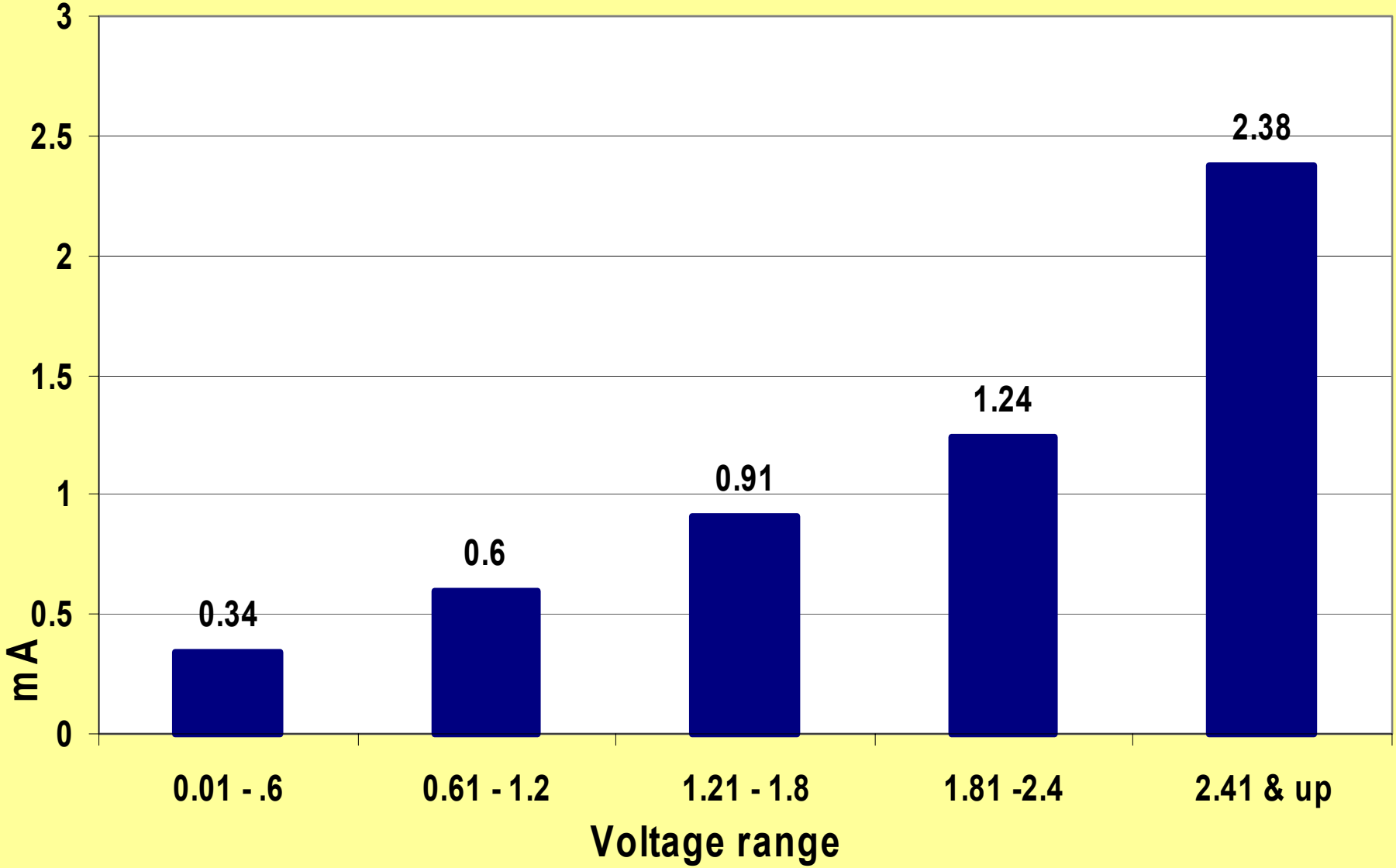
Secondary Neutral to Reference Voltage trend - last 4 years

Change, 1999 – 2002: -27%

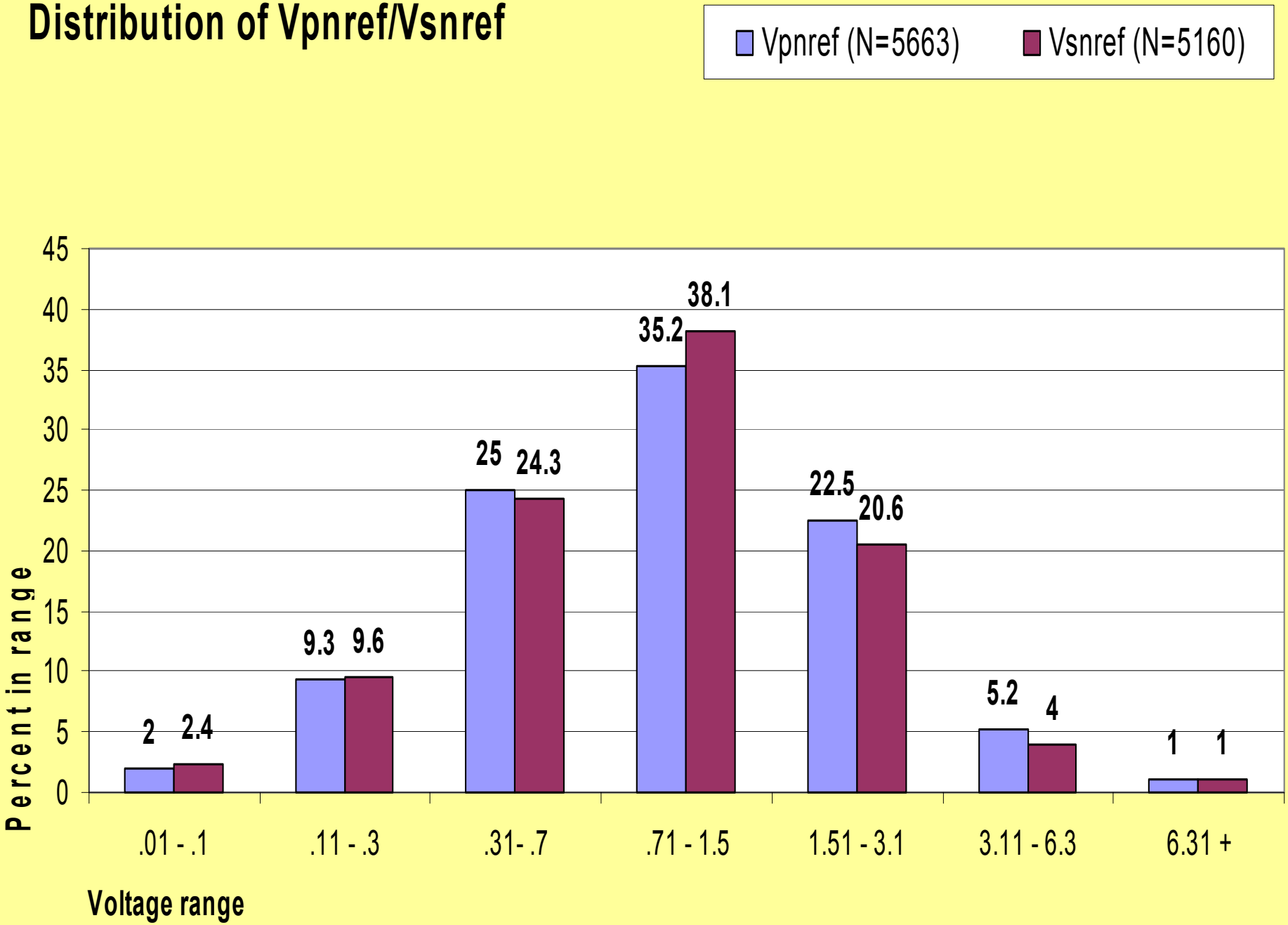


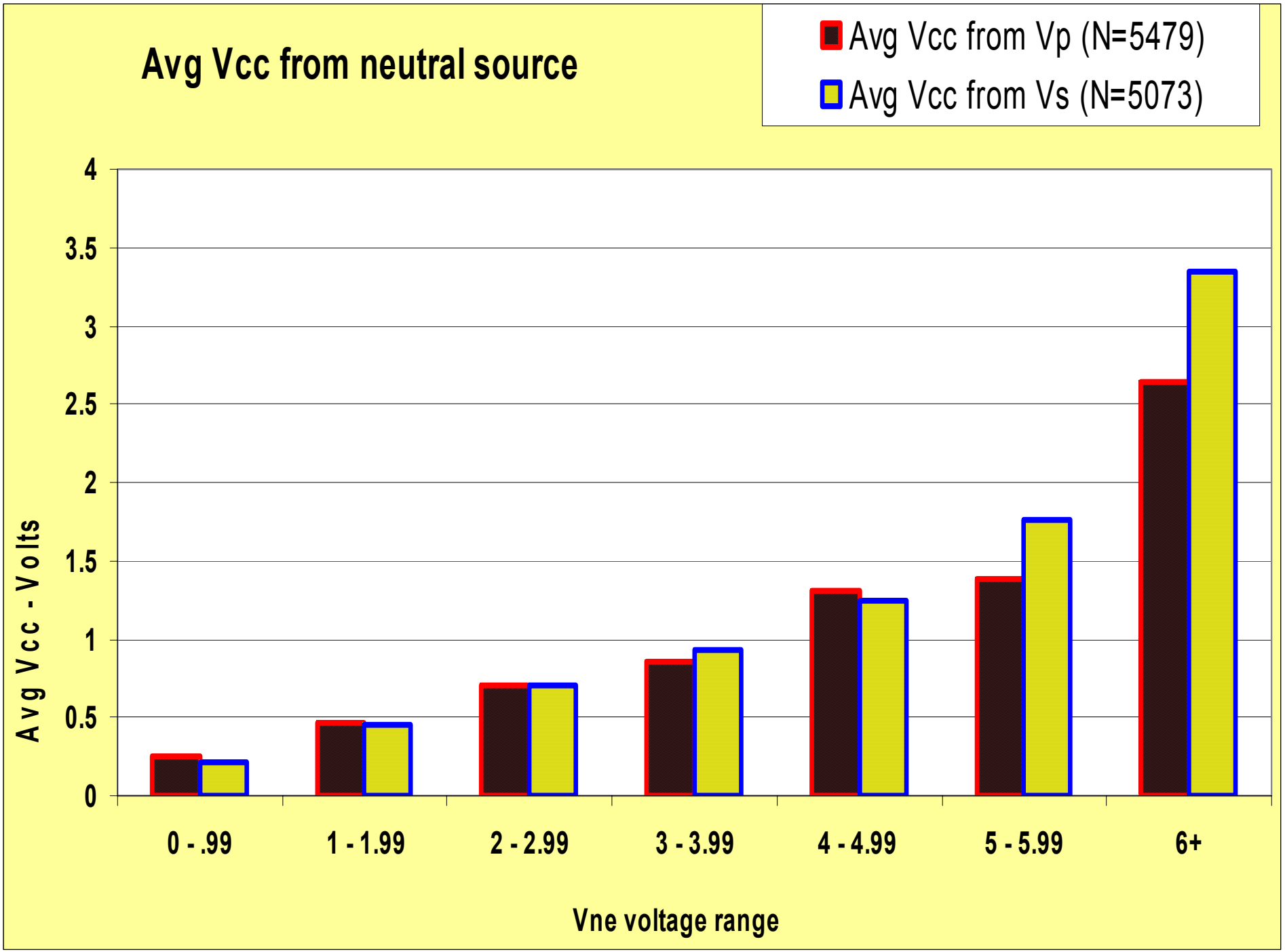
Avg. Icc vs. Vsnref

Correl Coeff. = 0.514



Distribution of Vpnref/Vsnref




Avg Vcc from neutral source
Avg Vcc from Vp (N=5479)
Avg Vcc from Vs (N=5073)
4
3.5
3
2.5
2
1.5
1
0.5
0
Avg Vcc - Volts
0 - .99
1 - 1.99
2 - 2.99
3 - 3.99
4 - 4.99
5 - 5.99
6+
Vne voltage range

STRAY VOLTAGE MITIGATION METHODS

Off-Farm Mitigation

- Adequate neutral conductor
- Adequate Grounding
- Addition of counterpoise
- Balancing 3-phase circuits

On-Farm Mitigation

- Good wiring
- Adequate Grounding
- 4 wire/ 5 wire
- Equipotential Plane
- EGS
- Balancing 120 volt circuits
- Fencers and Trainers

Nonconventional (sometimes scary) Methods

1. Rubber mats beneath animals
2. Redundant isolation transformers
3. Remotely relocating utility transformers
4. 3-Pole disconnects
5. Remove metal/neutral bonding in barn
6. Self-generation

Other (even scarier) Methods

1. “Circle of Life” - circular, bonded/unbonded counterpoise, buried/surface
2. Earth barrier of plastic or special rocks
3. Copper “G”s and eave tubes
4. Ley lines and vortexes
5. Remove on-farm grounds and bonds and cut utility grounds

RURAL ENERGY MANAGEMENT COUNCIL (REMC)

- **Advisory to DATCP**
- **18 members appointed by the secretary of DATCP**
- **Seven standing committees**

New WTCS farm rewiring training for rural electricians

- 18 CEU's
- Offered at many locations now, nearly all locations soon
- Basics of NEC for farms, what is SV and how to improve energy efficiency
- Case Study and final exam.
- Prerequisite for participation in utility sponsored grant/loan programs

Utility farm rewire programs

- IOU's and coops on board, municipals to be on board very soon.
- Combination of grants and loans.
- Specific rules for way money is spent.
- All work to be inspected by state elec. inspector or equivalent.
- All work done by 'trained' electricians.

CONCLUSION

- **Stray voltage is not a mystery.**
- **It can be and has been reduced to insignificant levels and controlled.**
- **It is a maintenance item that cannot be ignored.**


QUESTIONS??